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On cover: The international and national telex transit exchange, type ARM 20, at Barcelona, Spain.

The Telex Network in Spain

E. NILSSON, TELEFONAKTIEBOLAGET L M ERICSSON, STOCKHOLM

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The telex service in Spain comes under Ministerio de la Gobernación Dirección General de Correos y Telecomunicación, which is responsible for the telex and gentex traffic and for the postal service in Spain.

After calling for tenders from the world's main suppliers the Administration signed a contract with L M Ericsson in 1964 for modernization of the Spanish telex network, the main specifications for which were as follows:

Subscribers connected to L M Ericsson's new crossbar exhanges ARM and ARB (register and marker controlled) should be able to send selection information from the teleprinter keyboard.

The older step-by-step exchanges of Siemens type TW 39 should be modernized from dial selection to keyboard selection, and printed service signals should be introduced.

The outgoing international traffic should be on a fully automatic basis with destination codes in accordance with CCITT Recommendation F 69.

Charging of automatic outgoing international traffic should be done by toll ticketing.

National traffic on radio channels with error correction (ARQ) should be automatic.

Introduction

The 1964 contract comprises 8 transit centres type *ARM 20* and *ARM 50*, of which 3 are also international, and 68 terminal exchanges type *ARB 111* and *ARB 101* for althogether 3790 subscribers. This contract has been follow-

Fig. 1
Palacio de Comunicaciones, Madrid
Madrid's telex exchange is installed in this building

ed by two supplementary orders. At the end of 1969 the network consisted of 4235 subscribers connected to *ARB* and another 2930 lines on order, totalling 7165, and 1375 subscribers connected to modernized *TW 39* exchanges, all in all 8540 subscribers.

Spain occupies about 505,000 km² of the Peninsula. The capital, Madrid, which lies on a high plateau in the centre of the country, is the administrative centre and has a population of around 2.6 million. The other 32 million inhabitants of the country live chiefly round the coasts, and there is a high population density especially in the eastern and southern areas.

From the telex aspect the country is divided administratively into the following independent regions, six of which on the mainland and two in the Canary Islands.

Region	*City with ARM*	*Region*	*City with ARM*
① Central	Madrid	⑤ Southern	Sevilla
② North-eastern	Barcelona	⑥ Levante	Valencia
③ Northern	Bilbao	⑦ Tenerife	Santa Cruz de Tenerife
④ North-western	La Coruña	⑧ Las Palmas	Las Palmas

The various regions will be seen from the map (fig. 2), which also shows the main trunk network of v.f. telegraph channels, amounting to some 5000 channel terminals, delivered by L M Ericsson.

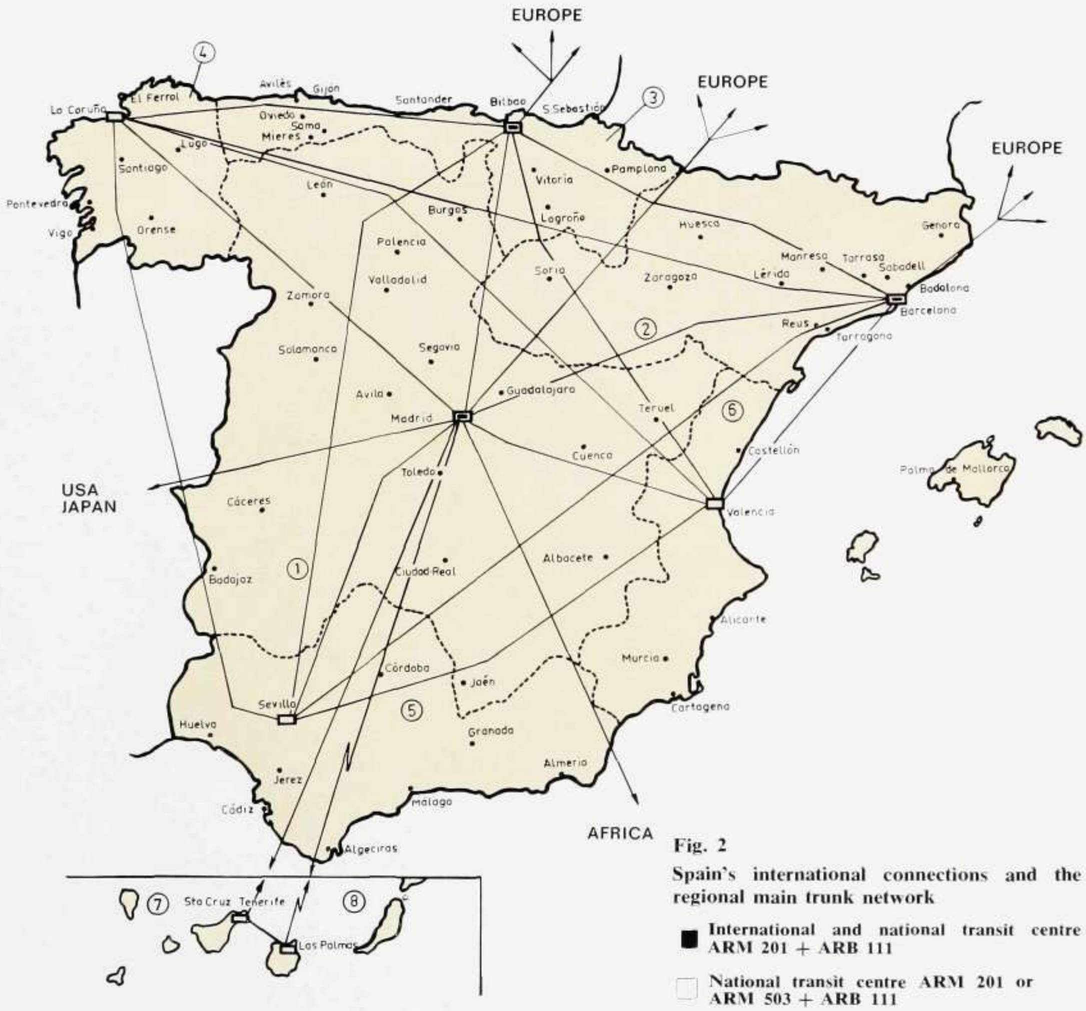


Fig. 2

Spain's international connections and the regional main trunk network

■ **International and national transit centre ARM 201 + ARB 111**

□ **National transit centre ARM 201 or ARM 503 + ARB 111**

● **Terminal exchange ARB 111 och ARB 101**

Every regional centre on the mainland consists of a transit centre *ARM 20*, to which a number of subscriber stages *ARB 111*, each for max. 400 subscribers, are directly connected, and also a number of terminal exchanges *ARB 111* and *ARB 101* connected via v.f. telegraph channels. The structure of the network within the various regions will be seen from the map (fig. 3).

The two transit centres at Las Palmas and Tenerife are of type *ARM 503* with a directly connected subscriber stage *ARB 111*. The transit centre at Las Palmas is connected to Madrid on error-corrected radio channels type ARQ with signalling in accordance with CCITT Recommendation *U23* and CCITT No. 3 Alphabet. The connection between Madrid and Tenerife takes place by v.f. telegraphy on a number of telegraph channels in the submarine cable between them. Between the transit centres at Las Palmas and Tenerife there is a radio link which works with the CCITT No. 2 Alphabet.

Through the alternative routing which is possible in L M Ericsson's transit centres the v.f. telegraph channel Tenerife-Madrid is regarded as main route and the *ARQ* channel Las Palmas-Madrid as alternative route.

As already mentioned the existing *TW 39* exchanges are to be modernized and integrated in the network. Apart from keyboard selection, printed service signals have been introduced in these exchanges.

Fig. 3
Connection of the terminal exchanges to the regional centres

System Characteristics

The specifications received by L M Ericsson for elaboration of a project for modernization of the Spanish telex network contained the following requirements apart from those mentioned above:

- *full flexibility* in numbering, traffic routing and charging, as also full independence between each of these factors
- *high total traffic* per subscriber
- *high concentration* of the initiated traffic to office hours
- *fully automatic international and intercontinental traffic.*

L M Ericsson's telex system complies fully with the specifications and also contains the following facilities and characteristics:

☐ *The crossbar switch is used as switching element* both in transit centres and terminal exchanges, one reason being its documented reliability. The material in its twin contacts also possesses excellent contact properties. This eliminates the selector noise which otherwise causes signal disturbances and results in wrong printed characters instead of the "clicks" which occur on a telephone connection.

☐ *A telegraph relay with mercury-wetted contacts of reed type is used.* The use of mercury as contact material eliminates all bounce in contacts, and repetition of the telegraph signals takes place with very low degree of inherent distortion.

☐ *The ARM transit exchanges are designed for full availability* even on the largest routes, which results in optimal circuit utilization.

☐ *Alternative routing* can be arranged to a very great extent, as ARM 201 offers one direct route and up to four alternative routes.

☐ *The provision of up to 15 class marks* permits full freedom to connect different classes of subscribers, e.g. telex, gentex, military, police, banks, news agencies, embassies, to a single network, which thus has a high degree of utilization. Of the 15 classes in the system two are used in the Spanish network, for telex and gentex.

☐ *Equipment for connection of PBX subscribers* has been very amply dimensioned since it must be possible to connect a large number of, for example, gentex stations which must be accessible on a common number. The individual numbers within the *PBX* group need not form a numerical sequence, which allows a more uniform distribution of the high-traffic gentex subscribers on the multiple of the terminal exchange.

☐ *Printed service signals* are transmitted to the *A* subscriber for call supervision in accordance with CCITT recommendations. The complete list of

- Hyphen
- Answer-back tripping signal
- Full-stop
- Plus
- Carriage return
- Line feed
- Letter shift
- Figure shift
- Space

Fig. 4
Symbols

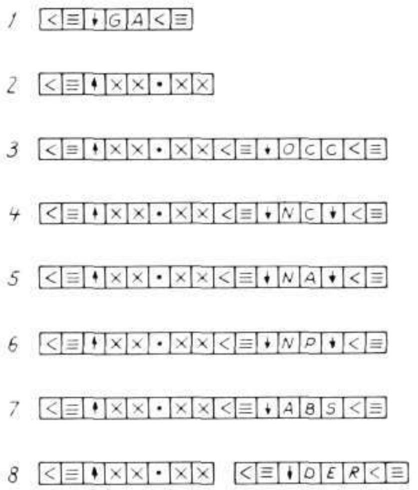


Fig. 5
Form and meaning of printed service signals

	Signal	Subscriber A reads
1	Proceed-to-select	GA
2	Time announcement, e.g.	09.11
3	Busy	09.11 OCC
4	No circuit	09.11 NC
5	Connection not admitted	09.11 NA
6	Not a working line	09.11 NP
7	Office closed, e.g. for holidays	09.11 ABS
8	Out of order	09.11 DER

these signals, which facilitate subscriber routines in handling of teleprinters, is as follows:

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

A printed service signal is always preceded by a time announcement. The form and meaning of the printed service signals will be seen from fig. 5.

- *Keyboard selection* is used for transmission of selection information to the register. This ensures the greatest speed and shortest occupation time for the common control equipment. By way of example a five-digit number can be dialled in about 7 s but takes only 0.75 s to key at a telegraphy speed of 50 bauds. In fully automatic international traffic this difference is still more accentuated, since international numbers may contain up to 14 digits.

- *Interworking with other international systems* has been made possible in accordance with the conditions set up in the specifications through the fact that the common control equipment in the three international centres can both receive and send telegraph code and dial code and also translate between them.

- *Automatic tripping of the B subscriber's answer-back* always takes place after a call-connect signal in order that the caller, both on international and national calls, can check that connection has been obtained with the called subscriber.

- *Balanced connection of single-current lines* is guaranteed through built-in adjustable balancing resistors in the line circuit. Disturbances from the telex network are thereby reduced to a minimum and no restrictions are placed on the mixing of telephone and telex lines in the local network. This ensures optimal economic utilization.

- The system includes a *queuing facility for calls to operators*. CCITT Recommendation F 65 specifies the delays desirable on answering of calls from the international network. To meet these requirements the system has been provided with queuing equipment to give incoming international traffic the priority required by CCITT.

Types of Exchange

The transit exchanges in the telex network are of types *ARM 201* and *ARM 503*.

ARM 201 is designed for large transit centres and covers the field between 100 and 8000 one-way circuits for long-distance traffic and connection of the subscriber stages in the home exchange. With fully installed marker capacity

Fig. 6
Suite with international telex registers REG-F

these exchanges can handle up to 70,000 calls per hour. In the Canary Islands, where it is calculated that the number of one-way circuits will be less than 1000, on the other hand, transit exchanges *ARM 503* are better suited.

Both these types of transit exchange are designed for full availability, which is of the greatest economic significance for exchanges to which expensive intercontinental, international and national long-distance circuits are connected.

The subscribers' stages and terminal exchanges are of two types, *ARB 111* and *ARB 101*.

ARB 111 is largest, catering for max. 400 subscribers. Several units of this type can be connected to the transit exchange multiple, either directly as subscriber's stage or via v.f. telegraph channels as terminal exchange.

The smaller type, *ARB 101*, is linked into the network as a concentrator with facility for connection of max. 20 subscribers. This type is always connected to the transit exchange via v.f. telegraph channels.

Signalling System

The Spanish telex network adopts the CCITT type *B* signalling system with keyboard selection and with printed service signals for call supervision.

With keyboard selection the teleprinter motor is started at the beginning of the call. A requirement for complying with the distortion limit recommended by CCITT for the teleprinter transmitter contact is that its motor has reached the proper speed. This is supervised in the switching equipment. When the maximum starting time recommended by CCITT has expired, an indication is sent to the subscriber in the form of a service signal *GA* (go ahead).

This form of proceed-to-select signal was chosen as, in this stage of the connection, the subscriber normally has his attention directed to the teleprinter and not to the control unit.

In the same way as for national signalling, the incoming traffic from the international network must follow CCITT's Recommendation *U1* with signalling type *B* and telegraph code transmission.

The outgoing international traffic, on the other hand, must comply with the signalling system in the destination country in accordance with CCITT recommendations. This means that the equipment in the three international exchanges in Madrid, Barcelona and Bilbao is designed to meet all signalling requirements which exist in the countries to which these exchanges are connected, e.g.

Spain, i.e. Spanish national network	Type *B* with keyboard selection, printed service signals and automatic tripping of Spanish *B* subscriber's answer-back.
Denmark, Switzerland, Germany, Austria, etc.	Type *B* with dial selection but without printed service signals and without automatic tripping of *B* subscriber's answer-back in the respective countries, which instead is done by the international centre in Spain.
Great Britain, Portugal	Type *B* with dial selection and printed service signals but without automatic tripping of *B* subscriber's answer-back, which instead is done by the international centre in Spain.
Jugoslavia	Type *B* with keyboard selection, printed service signals and automatic tripping of *B* subscriber's answer-back.
Italy	Type *B* with keyboard selection, printed service signals, automatic tripping of *B* subscriber's answer-back together with transmission of date and time.
Belgium, Holland, Norway	Type *A* with printed service signals, sending of register identity, automatic tripping of *B* subscriber's answer-back together with transmission of time.
France	Type *A* with printed service signals, transmission of day number and time. Tripping both of *A* and *B* subscriber's answer-back.
Canary Islands	Fully automatic *ARQ* traffic according to CCITT recommendation *U23* and also type *B* on submarine cable.

Numbering

The national numbering of the Spanish telex network is based on a linked 5-digit numbering scheme in which the first digit indicates the region and the second digit the terminal exchanges within the region. The significations of the first digit are tabulated below:

1 Call to operator
2 Central region
3 Northern region
4 Vacant
5 North-eastern region
6 Levante region
7 Southern region
8 North-western region
9 Canary Islands
0 International prefix

On outgoing fully automatic international traffic the number is made up of the international prefix "0", the 2 or 3 digit destination code of the respective country in accordance with CCITT Recommendation *F69*, and the national directory number of the *B* subscriber. In total the number may contain 14 digits and, since the country distination code is limited to 2 or 3 digits, there remain 11 of 10 digits for the national directory number.

Traffic destined to countries which cannot accept fully automatic traffic is passed through an operator in one of the three international exchanges. Calls to these places are made with a three-digit number.

Charging Principles

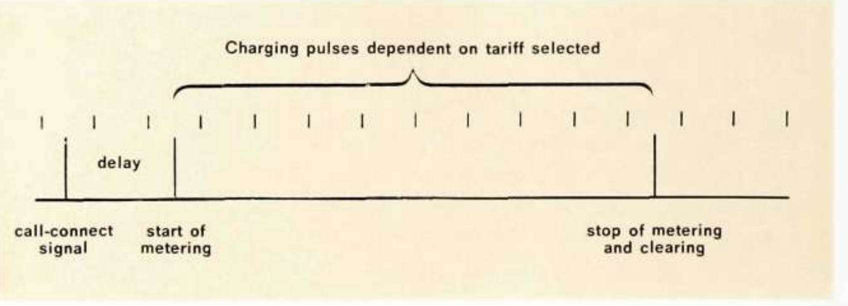
National Traffic

L M Ericsson's telex system can calculate the national tariff with the aid of

- the *A* subscriber's class
- the *A* subscriber's tariff zone
- the first two digits of the *B* subscriber's number

The charging principle is based on the geographical distance between the subscribers. Since the *A* subscriber's class is a factor in tariff determination, however, differentiated tariffs can be used for different types of subscribers. The karlsson metering method is employed, which means that periodic pulses are sent to the *A* subscriber's meter at a pulsing rate dependent on the distance between the tariff zone centres. With differentiated tariffs the pulsing rate differs for the same distance and is determined by the *A* subscriber's class. The administration has given the *A* subscriber the benefit of being able to check, free of charge, that the answer-back code from the *B* subscriber conforms with the selected number. This facility can be provided since the switching equipment is so designed that some delay can be obtained between the call-connect signal and transmission of metering pulses to the *A* subscriber. This delay can be selected within wide limits. In Spain the delay is 5—10 seconds. The cost for this facility can be kept low as the repeater in the *B* subscriber's exchange, after receipt of the call-connect signal, automatically sends a signal to the *B* subscriber's teleprinter for tripping of the built-in answer-back. As a result of this fully automatic control a delay as short as 5—10 seconds is sufficient. After this delay the periodic metering pulses are transmitted. The start of transmission of metering pulses is on a random basis.

The principle of karlsson metering will be seen from the following sequence diagram:



For national traffic, however, the Spanish Administration has been content with two groups of tariffs:

- Local group for messages between subscribers connected to the same telex exchange. The tariff in this group is one peseta (approx. US$ 0.012) per minute.
- Trunk group for messages between subscribers belonging to different telex exchanges. In this case the tariff is one peseta per 20 seconds.

International Traffic

Spain has fully automatic international traffic to the following countries:

Belgium, Brazil, Denmark, The Philippines, France, Hawaii, Italy, Japan, Canada, Mexico, The Netherlands, Puerto Rico, Switzerland, Sweden, Great Britain, Venezuela and West Germany.

Traffic to the following telex networks in the U.S.A. is also fully automatic: *RCA, ITT, WUI, TWX, WUD.*

Metering of this traffic is done with toll ticketing equipment, which also automatically punches the cards used for invoicing. The output units connected to this equipment consist of IBM punches for 80-column standard cards. Tre various columns on these cards are used as follows:

1—6	spare
7—8	day on which call is made
9—10	month in which call is made
11	immediate time information
12—21	*A*-subscriber's number, 5 columns used
22—28	spare
29—44	*B*-subscriber's number and destination code
45—49	hour, minute and 1/10 minute when the call-connect signal was received
51—54	duration of the message
55	cause of fault
56	number of buffer store
57	*A*-subscriber's class
58—60	tariff
61—65	spare
66—70	devices used in the toll-ticketing equipment
71—80	spare

Spain also has semi-automatic international traffic with another 98 countries. This type of traffic is supervised by an operator, who also prints the special charging ticket. Data for this purpose, such as the *A*-subscriber's number and *B*-subscriber's country code and directory number, are printed on one of the supervising operator's receivers. The duration of the call is obtained from the time meter associated with every cord circuit.

Operating Procedure

The trunking diagram of the Madrid exchange and the notations used in the sequel will be seen from fig. 7.

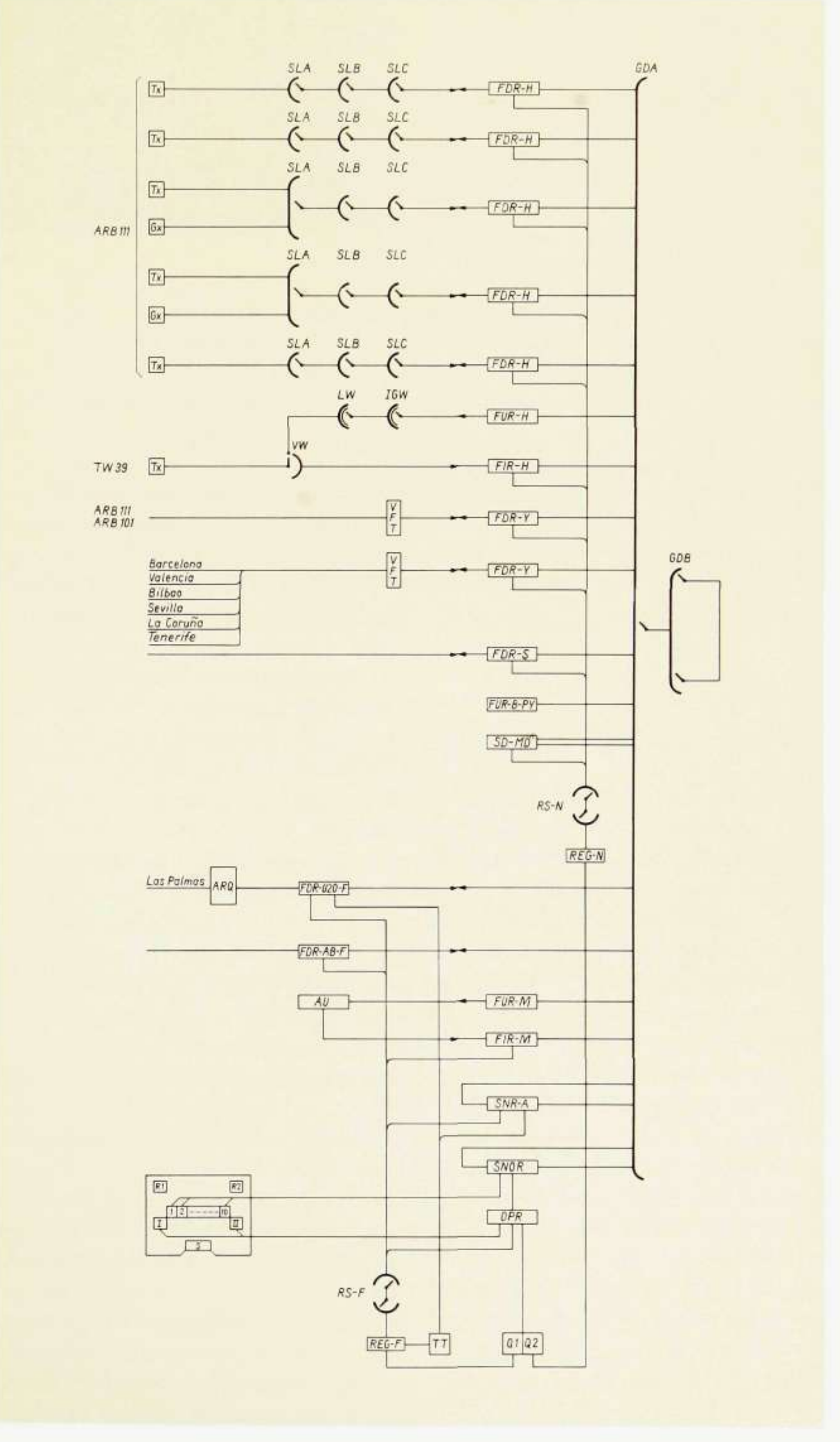


Fig. 7

Trunking diagram for Madrid international and national transit centre

Notations

TX	**Subscriber terminals, telex or gentex**
SLA, SLB, SLC	**Selector stages *in* ARB exchange**
VW, IGW, LW	**Switches in step-by-step exchange, type TW 39**
FDR-H	**Two-way local repeater, ARB stage**
FUR-H	**Outgoing local repeater, TW 39**
FIR-H	**Incoming local repeater, TW 39**
FDR-Y	**Two-way transit repeater**
FDR-S	**Two-way repeater for special services**
FUR-B-PY	**Outgoing repeater for test traffic**
SD-MD	**Automatic test equipment**
RS-N	**Register finder**
REG-N	**National register**
FDR-U20-F	**Two-way repeater for fully automatic ARQ traffic**
FDR-AB-F	**Two-way repeater for international traffic**
AU	**International cord switchboard**
FIR-M	**Incoming repeater from cord switchboard**
FUR-M	**Outgoing repeater to cord switchboard**
SNR-A	**Cord circuit for connection to toll ticketing**
SNOR	**Cord circuit relays for operator-supervised traffic**
OPR	**Operators' position relays**
R1, R2	**Receiving teleprinters**
S	**Keyboard**
1-10	**Cord circuit sets**
I-II	**Position equipments**
RS-F	**Register finder**
REG-F	**International register**
TT	**Toll-ticketing equipment**
Q1, Q2	**Queue equipment for operator-supervised traffic Q1 has priority over Q2**
GDA } GDB }	***Two-way group selector stage***

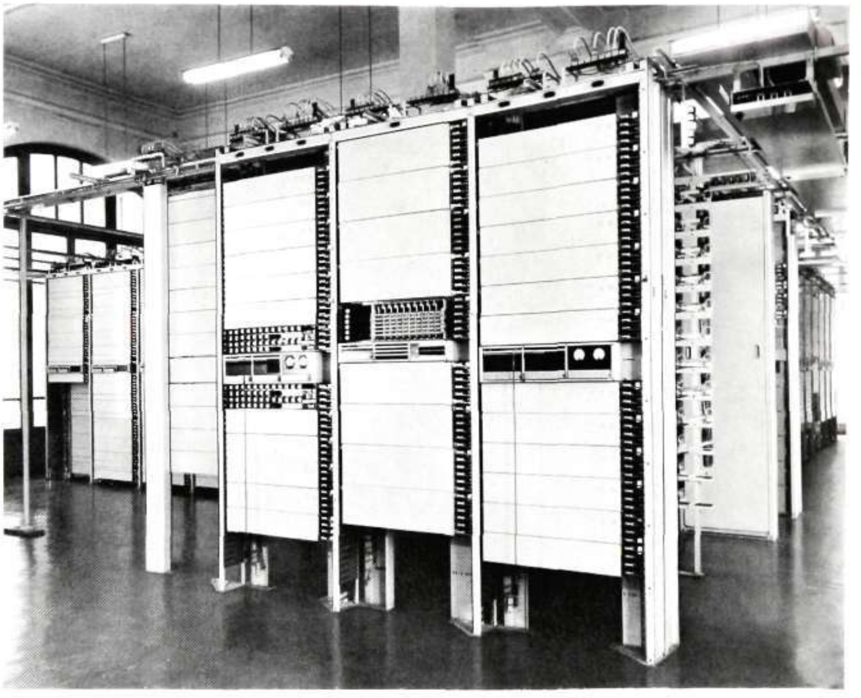


Fig. 8
Racks with repeaters (FDR) and interworking register finder (RS)

National Calls

A national call is initiated by pressing the call button on the control unit. The markers in the *ARB* exchange identify the *A* subscriber, after which the selector stages *SLA*, *SLB* and *SLC* are connected through to a local repeater *FDR-H*. The local repeater calls a national register *REG-N* in the home transit exchange, the tariff zone and class of the *A* subscriber are transmitted, after which a proceed-to-select signal in the form of service signal *GA* is sent to the subscriber. The latter selects the *B* subscriber's number on the teleprinter keyboard and initiates the selection by a figure shift signal, combination 30, in CCITT Alphabet No. 2. This signal informs the register that the following digits are to be stored.

When the register has received five digits, this is interpreted as an end-of-selection signal as a 5-digit linked numbering scheme is used in the Spanish national system. The route marker *VM-N* in the common control equipment at the transit centre is called for determination of the route and tariff. The tariff is determined on the basis of the data of *A* subscriber's tariff zone and class and of the first two digits of the *B* subscriber's number. The resulting tariff code is transmitted to the local repeater, *FDR-H*, in which the relay circuits for the tariff are set up. The local repeater in the *B* subscriber's terminal exchange, after receiving a call-connect signal from the *B* subscriber, transmits an answer-back trip signal which automatically trips the identification signal, the answer-back code. The *A* subscriber has 5—10 seconds to check that the answer-back code is that of the selected *B* subscriber. If so, charging starts and pulses are transmitted to the *A* subscriber's meter from the local repeater *FDR-H* at the pulsing speed corresponding to the set tariff. If connection has been made with a wrong *B* subscriber, the *A* subscriber can clear the call within the delay period and in such case metering does not start. This check is easy to make since all answer-back units in Spanish telex network contain the subscriber's directory number and abbreviated name. The described switching process results in a connection which, with reference to the trunking diagram in fig. 7, seizes the following devices: subscriber control unit, selector stages *SLA*, *SLB* and *SLC* in *ARB* exchange, local repeater *FDR-H*, transit centre selector stages *GDA*, *GDB*, link, *GDB*, *GDA* and the local repeater *FDR-H* in the *B* subscriber's exchange, *SLC*, *SLB* and *SLA* up to the *B* subscriber. For the signalling schemes for this connection reference should be made to Ericsson Review no. 1 1968.[7]

Subscribers connected to step-by-step exchanges of type *TW 39* have been given the facility both of keyboard selection and printed service signals through removal of the normal connection between the preselector *VW* and group selector *IGW*. This is possible through the fact that *VW* has been connected to a repeater *FIR-H* which, via the register finder *REG-N*, is connected to the same type of national register *REG-N* as the other subscribers in the network.

On incoming calls to *TW 39* exchanges the selection information incoming to *REG-N* in the form of telegraph code must be translated into dial pulses. The translation is done automatically in *REG-N*; if and when this shall be done is determined by the route marker *VM-N* by analysis of the *B* subscriber's number.

The call is steered by the route marker *VM-N* to the repeater *FUR-H* which is connected between the transit centre group selector stage *GDA* and the *IGW* of the *TW 39* exchange. Setting up of the call takes place in principle in the same way as for calls between *ARB* exchanges.

The described process applies in all respects also to the traffic to the Canary Islands, which is handled automatically on the *ARQ* channels with signalling in accordance with CCITT Recommendation *U23* between Madrid and Las Palmas and on the v.f. telepraph channels to Tenerife.

International Semi-Automatic Call

The call is initiated with the call button on the subscriber's control unit and, after through-connection in the *ARB* exchange, the proceed-to-select signal *GA* is received from the national register *REG-N*. The *A* subscriber keys on the teleprinter keyboard the three-digit code of the destination country, e.g. 122 for Norway. The register calls a free *SNOR*, which is connected to a queue equipment *Q2* for outgoing international traffic. On seizure of the latter a waiting signal *INTLX MOM* is transmitted. This indicates to the subscriber that the call is set up to the international transit centre equipment and is waiting there for an answer from the operator. On receipt of an answer the call is connected to the cordless switchboard. This switchboard can be supplied with two position equipments, I and II in the switchboard symbol, and up to 10 cord circuit sets 1—10. The cordless switchboard also has space for two receivers *R* and a keyboard S. The call is indicated by a lamp signal on the free position equipment and the position's answer-back signal is transmitted automatically when the operator answers. This may have the following appearance: *INTLX MAD 01*, where "*INTLX*" denotes the international exchange and "*MAD 01*" indicates that Madrid's operator no. 1 is answering the call. This answer-back code is followed directly by a signal which trips the *A* subscriber's answer-back unit, which contains the subscriber's directory number, an optional code consisting of seven letters and country alphabetical code.

The answer-back unit recommended by CCITT contains 20 positions. In Spain these are arranged as follows:

[<] [≡] [↑] *N1 N2 N3 N4 N5* [↓] [−] X_1 X_2 X_3 X_4 X_5 X_6 X_7 [→] [E] [↓]

The symbols used in this example will be seen from the legend of fig. 4.

N1—*N5* directory number

X_1—X_7 7 optional positions for subscriber's alphabetical code

E country code (España)

When the operator answers, one of the receivers is automatically connected and the *A* subscriber's answer-back text can be directly read. Every position equipment has a keyset for transmission of the most common signals. From this keyset the operator transmits a proceed-to-select signal *GA* and the subscriber books the call by transmitting the country code and the *B* subscriber's national number. The operator sends the signal *MOM*, after which an international register *REG-F* is seized and the connection is set up. The following route is established on the trunking diagram (fig. 7): *TX* — *SLA, SLB, SLC* — *FDR-H* — *GDA, GDB* — link — *GDB, GDA* — *SNOR* — *FDR-AB-F*. When the *B* subscriber's answer-back signal has been received and the operator has set up the connection between the two subscribers, the connection is automatically supervised and, on receipt of a clearing signal, the timing of the message stops and the operator prints the charging ticket.

International Fully-Automatic Call

After a call as described in the preceding case the proceed-to-select signal *GA* is received from the national register and the subscriber transmits the destination code of the country concerned. The national route marker *VM-N* is called and the connection is set up to a free cord circuit *SNR-A*, which has connection both with the toll ticketing equipment (TT) and with the international register *REG-F*. *REG-F* sends an answer signal in the form of the text *INTLX* and a signal for tripping of the *A* subscriber's answer-back. The directory number in the latter is transmitted to *REG-F* and on to the ferrite core store in the toll ticketing equipment. The destination code which the *A* subscriber sent to *REG-N* has been transmitted to *REG-F* and, after reception of a new proceed-to-select signal *GA*, the subscriber continues the transmission of the *B* subscriber's number to *REG-F*. In this case the register *REG-F* must receive an end-of-selection signal in the form of a + on account of the different lengths of numbers. *REG-F* calls the international route marker *VM-F* and the call is set up to a repeater to the destination country. The following connection is now established through the transit centre: *TX* — *SLA, SLB, SLC* — *FDR-H* — *GDA, GDB*, link — *GDB, GDA* — *SNR-A, GDA, GDB* — link — *GDB, GDA* — *FDR-AB-F*. Data for time of answer and time of clearing are printed on the ferrite core row corresponding to the connected cord circuit.

After receipt of a clearing signal the output device (card punch) of the toll ticketing equipment is called and the stored information is transmitted to a punched card, which is then processed in a punched card machine. Data for the call collected on the card are used both for charging and for traffic statistics.

Summary

As will have been apparent, both the international transit centres and the national transit and terminal exchanges in L M Ericsson's telex system have complied in all respects with the high requirements placed by the Administration in its tender specifications. In particular the great flexibility of the system in interworking with other networks has been of great significance for the establishment of the comparatively large number of international connections; fully automatic traffic with 18 countries and semi-automatic with 98. For the structure of the national network the facility, in particular, of handling of fully automatic traffic between the Canary Islands and Madrid alternatively on v.f. telegraph channels in the submarine cable and on the *ARQ* channels has given the same traffic facilities to all Spanish subscribers.

The modernization of the existing *TW 39* exchanges has given these subscribers keyboard selection and printed service signals. This was made possible through the breaking of the circuit between the preselector *VW* and the group selector *IGW* and, on outgoing traffic, gives the *TW 39* subscribers access to a national register *REG-N* via the repeater *FIR-H*. On incoming traffic the necessary translation of the selection information from telegraph to dial code is done automatically in the register.

A coming article will deal with the operational results in the Spanish telex network.

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L M Ericsson's Booster Converters for Power Supply

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A power plant for telecommunication equipment is required to give an uninterruptible supply with limited, specified voltage variation. The plant should also operate automatically in all operational conditions and require no maintenance.

L M Ericsson's various power supply systems have been described in Ericsson Review No. 4, 1968.[1] *The system which satisfies in the best way the above requirements is the recently developed converter system. Apart from rectifiers, which are used in all conventional D.C. supply systems, the converter system contains another type of converter, a booster converter. The article describes the design of the booster converters and presents different aspects of their application.*

In most uninterruptible D.C. power supply systems storage batteries are used as standby. During a failure of the incoming power the voltage of the storage battery falls considerably, in the case of lead cells, for example, from 2.2 V/cell to 1.85—1.75 V/cell depending on the length of the discharge period and the magnitude of the current. In order to keep the distribution voltage within specified limits, most power supply systems contain some device for compensation of this voltage drop. A conventional solution consists of extra battery cells and a cell switch.

In the converter system booster converters are used instead of extra battery cells. These converters are supplied from the battery, while their output is connected in series with the battery, between it and the distribution output (fig. 1). Booster converters add their output voltage to the battery voltage when required, so that the operating voltage in the telecommunication equipment is sustained irrespective of the state of discharge of the battery.

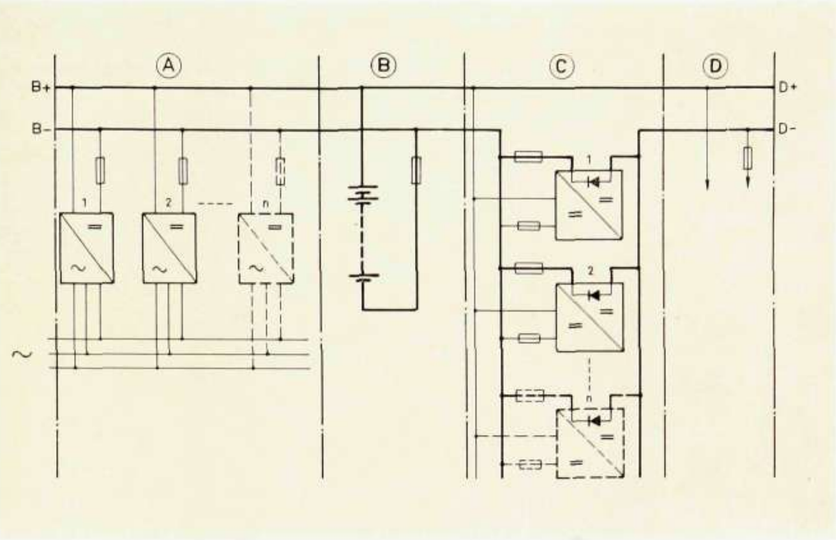
The converter system has the following advantages:

- A cell switch system must contain charging equipment fo rthe end cells and a separate charging circuit for the battery. This is because the large number of cells in the cell switch requires so high a charging voltage that charging of batteries in parallel operation with the telephone exchange cannot be permitted.

- In a converter system the number of cells is small, e.g. 23 cells in a 48 V system, and the batteries can be charged in parallel with the load. The need for a battery switch and for switches on the output side of the rectifiers is eliminated. The need for busbars or cables for the separate charging circuit is also eliminated. Charging can be simply done automatically. The

Fig. 1
Block diagram of converter system

A	**Rectifiers**
B	**Battery**
C	**Booster converters**
D	**Distribution**
B+, B-	**Battery poles**
D+, D-	**Distribution terminals**



booster converter is static, i.e. contains no moving parts. Contrary to cell switches and end cells, it is free from wear and requires no maintenance. Its start and stop are performed automatically.

- The introduction of booster converters involves an additional cost. This should be weighed against the saving provided by the elimination of cell switches, end cells with charging equipment, separate charging circuit, as well as switches in rectifiers and in the battery circuit. The booster converter system also offers a saving through the reduced battery dimensions, since the batteries can be used for very low final discharge voltage. The converter system can be simply extended, contrary to a cell switch system, which must be dimensioned for the final capacity of the exchange. The initial cost can therefore be limited.
- The converter system saves operating costs both through reduced energy consumption, which will be explained later, and through the fact that the system is automatic and maintenance-free. An economic analysis which takes account of all these factors often turns out in favour of the converter system.

Function of the Booster Converter in the System

The booster converter is available in two types, one with non-regulated, the other with regulated output voltage.

The non-regulated converter delivers a fixed output voltage and is in this respect comparable to extra battery cells.

The regulated converter, which is a further development of the non-regulated type delivers a variable output voltage and enables the distribution voltage to be kept constant on mains failure irrespective of the state of discharge of the battery.

During normal operation, when the battery voltage is kept at floating level by the rectifiers, the converters are not in operation. The current, however, passes through the output circuit of the converters, which contains semiconductor diodes among other equipment. The converters thus introduce a voltage drop of about 1 V between battery and distribution.

The voltage across the battery and the distribution in the converter system during a period of A.C. power failure is shown in fig. 2.

LM Ericsson Booster Converters

The standard sizes of the booster converters will be seen from table 1.

Table 1

	System voltage				
	48 V		24 V	36 V	60 V
	Non-regulated	Regulated	Regulated		
Rated voltage	7	0—8	0—4	0—6	0—11
Rated output current A	40	40	40	40	40
	100	100	100	100	100
	—	160	160	160	160
	—	315	315	315	315
	400	—	—	—	—
	—	630	630	630	630

The requirements on power supply equipment and components stated in Ericsson Review No. 3, 1969,[2] have been followed in the design of the booster converters.

Booster Converters with Fixed (Non-Regulated) Output Voltage

The output voltage level of the converter is chosen in such a way that it maintains the distribution voltage above the least permissible level in the case of discharged battery without causing an impermissible overvoltage on the exchange equipment in no load condition and with maximum input voltage (fig. 2). Two or more converters can operate in parallel. When several converters are operating in parallel the load is practically equally distributed between them. Fig. 3 shows a cabinet with two booster converters, 48 V/7 V, 100 A.

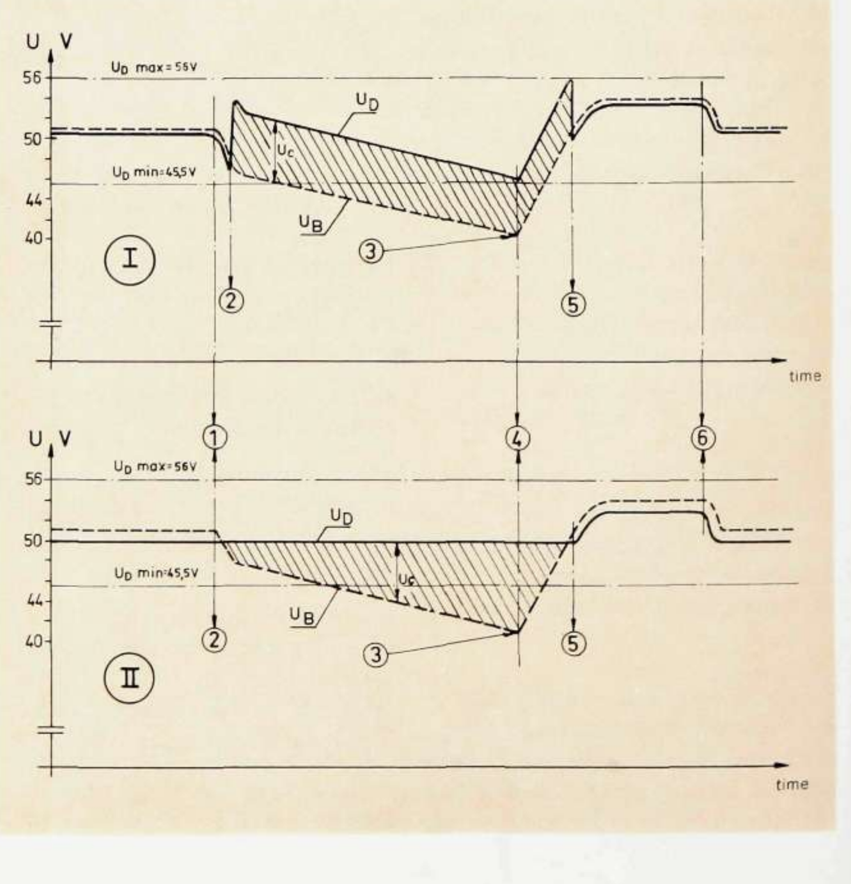


Fig. 2

Voltage across battery and distribution in a 48 V system during AC power failure

I	Non-regulated converter
II	Regulated converter
U_B	Battery voltage
U_D	Distribution voltage
U_C	Converter output voltage
U_{Dmax} U_{Dmin}	Limits for permissible variations in distribution voltage
①	A.C. power failure
②	Start of converter
③	Discharged battery
④	Return of A.C. power
⑤	Stop of converter, start of automatic recharge of batteries
⑥	End of charge

Fig. 3

Two non-regulated booster converters, 48 V, 100 A, placed in the same cabinet. In the open front door there is among other equipment, a monitor unit for each converter and oscillator unit.

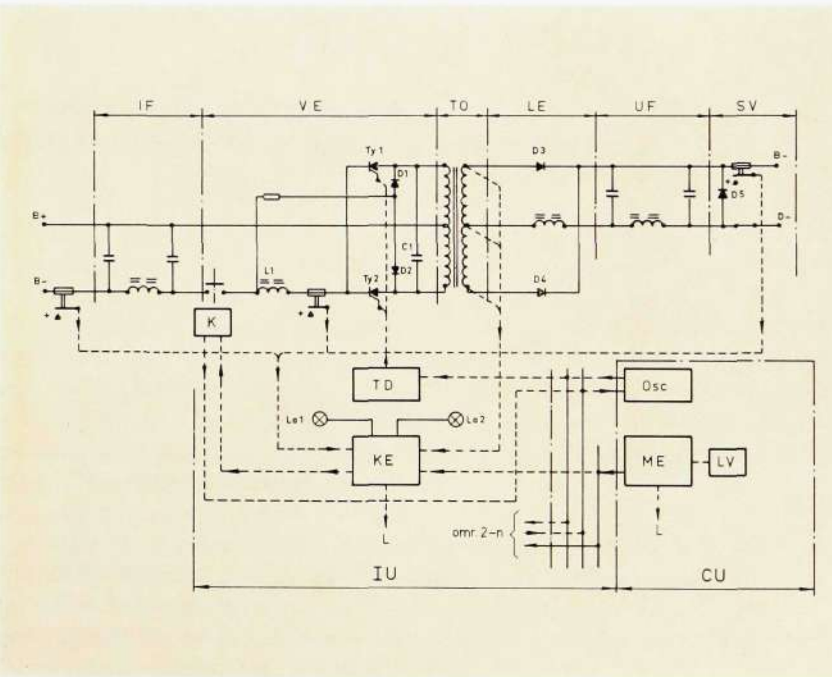
Main Circuit

The principle of the main circuit will be seen from fig. 4. The inverter unit *VE* contains a thyristor inverter with two thyristors *Ty1* and*Ty2* which conduct alternately. The connection used is a parallel inverter on the McMurray-Bedford principle. The commutation, i.e. alternate blocking of thyristors and change of current path, is effected by the capacitor *C1* and choke *L1*. The inverter is supplied with battery voltage via the input filter *IF* and generates a trapezoidal A.C. voltage of 400 Hz frequency. This voltage is applied across the primary of the transformer *TO*. After rectification in the rectifier unit *LE* and smoothing in the output filter *UF* an output voltage is obtained which can be added to the battery voltage.

Fig. 4

Simplified circuit diagram of non-regulated converter

IF	**Input filter**
VE	**Inverter unit**
TO	**Transformer**
LE	**Rectifier unit**
UF	**Output filter**
SV	**Bypass**
K	**Contactor**
Ty1, Ty2	**Thyristors**
D1, D2	**Commutating diodes**
C1, L1	**Capacitor and choke for commutation**
D3, D4	**Rectifier diodes**
D5	**Bypass diodes**
TD	**Firing unit**
KE	**Monitor unit**
OSC	**Oscillator, 400 Hz**
ME	**Command unit**
LV	**D. C. voltage monitor**
L	**Alarm**
La1	**Converter in operation**
La2	**Converter released**
B+, B -	**Battery poles**
D -	**Distribution negative**
IU	**Individual equipment for each converter**
CU	**Central equipment for parallel-connected converters**



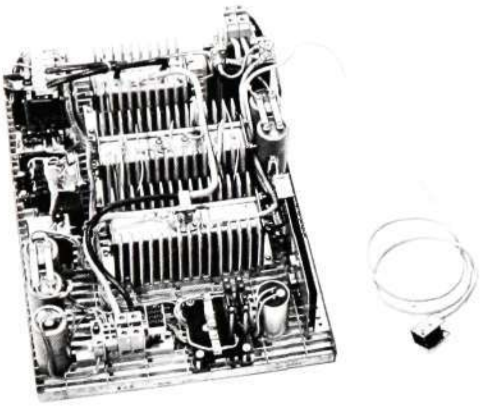


Fig. 5
Grating unit for non-regulated converter 48 V/7 V, 40 A

A bypass diode *SV* is connected across the output terminals of the converter, its function being to conduct current past the secondary circuit of the converter when the inverter unit is not in operation, i.e. during normal service of the power supply system.

The firing of the thyristors is effected by the firing unit *TD*. Firing units in several parallel-operating converters are driven synchronously by an oscillator *Osc*, which delivers a square-wave voltage of 400 Hz frequency.

Start and stop of the converter are performed by the converter *K*, which is placed after the input filter. The battery voltage is thus steadily applied to the input filter. Starting of a converter consequently causes no current surge for charging of the input filter capacitors.

An example of the mechanical design will be seen from fig. 5, which shows a 40 A booster converter.

Monitory Circuits

Start and stop of the converter are controlled by a D.C. voltage monitor *LV* via the command unit *ME*. *LV* senses the distribution voltage. The monitor has two operating levels, one for start of the converter at low voltage (e.g. 47 V in 48 V system) and one for stop of the converter at a sufficiently high voltage (e.g. 56 V in 48 V system).

The command unit *ME* with monitor belongs to the central supervisory equipment for a power supply plant. It controls and supervises all parallel-connected converters. Apart from control of the start and stop of the converters the command unit checks that all converters are operating after a start signal. An alarm signal is issued on failure of a converter to start and on starting of a converter without preceding mains failure.

Each converter has a relay set, monitor unit *KE*, with the following functions:

- to control closure and opening of the contactor *K* on order from the central command unit
- to supervise the state of operation of the converter by sensing whether there is A.C. voltage or not on the secondary wiring of the transformer *TO*
- to supervise all fuses.

Protection

The converter is provided with fuses at the input and output terminals. The fuse on the output is placed at the terminal to be connected to the battery *B−*. Another output terminal is equipped with an isolator switch. If the isolator switch and the fuses are removed, the main circuit of the apparatus is electrically separated from the plant. The thyristors are protected by fast acting fuses with characteristic matched to the thyristor rating. Electromagnetic fuses protect the monitory circuits. On blowing of a fuse the converter is shut down and an alarm signal issued.

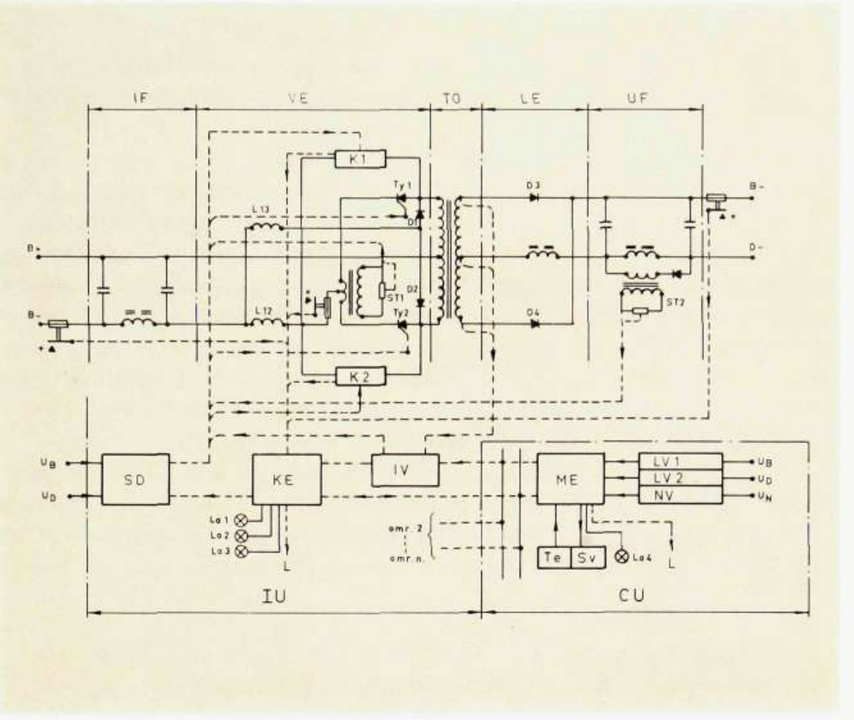


Fig. 6

Simplified circuit diagram of regulated converter

IF	**Input filter**
VE	**Inverter unit**
TO	**Transformer**
LE	**Rectifier unit**
UF	**Output filter**
B+, B-	**Battery poles**
D-	**Distribution negative**
U_B	**Battery voltage**
U_D	**Distribution voltage**
U_N	**Mains voltage**
K1, K2	**Commutating units**
Ty1, Ty2	**Main thyristors**
D1, D2	**Commutating and feedback diodes**
D3, D4	**Rectifier diodes**
ST1, ST2	**Current transformers**
L12, L13	**Commutating chokes**
IU	**Individual equipment for each converter**
CU	**Central equipment for parallel-connected converters**
SD	**Control unit**
KE	**Monitor unit**
IV	**Internal overvoltage monitor**
ME	**Command unit**
LV1	**D. C. voltage monitor for start and stop levels**
LV2	**D. C. voltage monitor for overvoltage protection**
NV	**Mains voltage monitor**
Te, Sv	**Test and response signal**
L	**Alarm**
La1	**Converter in operation**
La2	**Converter released**
La3	**Overvoltage (internal alarm)**
La4	**Overvoltage (central alarm)**

Components

All semiconductors with the exception of the bypass diodes *SV* are of silicon. The thyristors in the inverter *VE* are of a type specially designed for use in inverters, i.e. with controlled turn-off time.

The bypass diodes *D5* are of germanium. When a converter is not in operation, i.e. under normal conditions, the bypass conducts the entire distribution current owing to the low voltage drop of the germanium diodes. The secondary circuit of the converter is thus cut off and its transformer not exposed to D.C. magnetization. This circumstance is of significance for start of the converter.

Booster Converters with Variable (Regulated) Output Voltage

The principle of the regulated converter is shown in fig. 6. The converter can change its output voltage continuously between zero and a maximum value. In a 48 V system the maximum value is 8—12 V depending on the load. The voltage regulation takes place in the inverter, which generates a voltage of constant frequency, 400 Hz, and variable pulse width. Apart from the constant voltage regulation the converter is equipped with constant current regulation, which enters into operation when the input current of the converter tends to increase above the rated value. This feature, called current limitation, protects the converter against overload.

The regulated converter also has other protective devices, such as fast acting electronic overload protection with restart and overvoltage protection.

An unlimited number of converters can operate in parallel. The current limitation then ensures that no converter is overloaded.

Main Circuit

In addition to the main thyristors *Ty1* and *Ty2*, the inverter unit contains commutation circuits *K1*, *K2* consisting of auxiliary thyristors, chokes and capacitors.

The pulse width, i.e. the conducting time of the thyristors *Ty1* and *Ty2*, can be continuously controlled between a few and ninety per cent of the half-cycle time. This is achieved as follows. During every half-cycle the control unit *SD* sends two pulses, the first to the main thyristor *Ty1* for example, the second to its commutation device *K1*. The commutation circuit turns off the thyristor *Ty1*, i.e. switches it to blocking condition. The time interval between the pulses determines the conducting time of the thyristor and thus the pulse width of the output voltage.

The commutation circuit was developed to meet especially strict requirements of wide control range and reliable commutation. The device allows reliable blocking of thyristors even under heavy overload and permits the use of fast acting electronic overload protection.

Monitory Circuits

The start and stop of the converter are normally controlled by a D.C. voltage monitor *LV1* which senses the battery voltage and by a mains voltage monitor *NV* which senses the supply voltage of the rectifiers. The control takes place via a command unit *ME* common to the plant.

On a failure of A.C. power a start signal is sent from the mains voltage monitor, i.e. without awaiting a voltage drop across the battery. When the battery is discharged without A.C. power failure, e.g. at a load exceeding the available current from the rectifiers, the start of the converter is initiated by the D.C. voltage monitor. In this case the start occurs after a slight battery voltage drop (1.5 V below normal level). The stop of the converter occurs when the two following requirements have been satisfied: A.C. voltage restored and battery voltage returned to normal level.

Starting of a converter always takes place with minimum pulse width. The control unit thereafter continuously increases the pulse width to the value required by the voltage regulation. Stopping of the converter is done by removing the trigger pulses, first from the thyristors *Ty1*, *Ty2*, and then from the commutation circuits *K1*, *K2*. Starting and stopping are thus effected electronically and without need for a contactor.

The command unit supervises all parallel-connected converters and issues an alarm signal in the event of a fault or of abnormal operating condition such as failure to start, unwarranted converter operation, or overvoltage.

As the converters are off during the major part of the time, test of their performance is of great importance. The command unit includes equipment for this purpose. The test is made with a push-button which starts all converters. In test position the level of regulation of the converters is elevated by about 2 V. A corresponding rise of voltage read on the distribution voltage voltmeter indicates that the converters have started and are under load. The test can also be remotely controlled. Indication takes place in this case in the form of a response signal which is issued if all parallel-working converters have started.

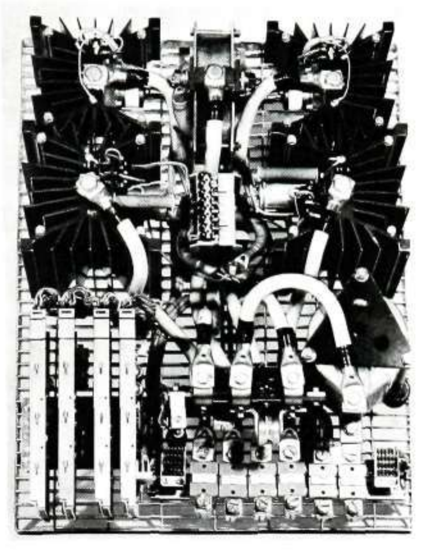


Fig. 7
Inverter unit in booster converter 48 V, 630 A

Protection, Alarm

Supervisory circuits are gathered in a monitor unit *KE*. The converter is equipped with the following protective and supervisory devices:

a) *Overload protection*. The converter is protected against overload by the current limitation of the control system. It is also equipped with fast acting electronic protection against heavy over-currents which may occur, for example, on short-circuits in the distribution. The fast acting overload protection is actuated from the current transformer *ST1* (at about twice the rated current) and from a pulse transformer *ST2* which senses the derivative di/dt of the current. The protection acts in the manner that it inhibits firing pulses to the main thyristors *Ty1* and *Ty2* at the same time as it causes the commutation units *K1* and *K2* to block the main thyristors. The main thyristor, which was conducting, is turned-off. The operating time of the protection is about 200 μs. The protection keeps the converter blocked about 0.3 s. The converter thereafter restarts automatically (with minimal pulse width). If the overcurrent has not disappeared, the converter is blocked once again. After being blocked a number of times the converter is definitely stopped.

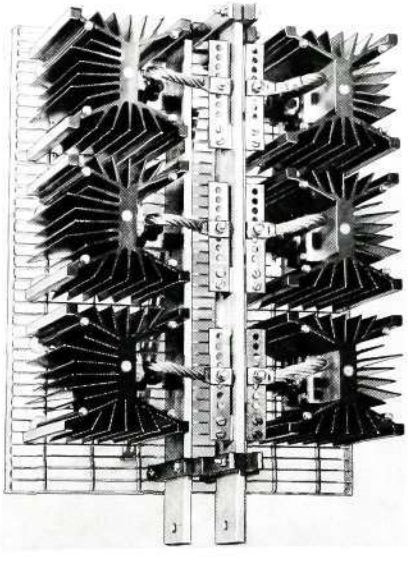
b) *Overvoltage protection*. On overvoltage in the distribution caused for example by a fault in the converter regulation system, fast acting overvoltage protection enters into operation. The D.C. voltage monitor *LV2* (set to 56 V in a 48 V system) blocks the converter electronically. The protection actuates the converter in the same way as the fast acting overload protection. The overvoltage protection functions selectively, i.e. switches off only the faulty converter. The selection is performed by the internal voltage monitor *IV*.

c) *Fast acting fuses* with characteristic matched to the semiconductor ratings are used for the main thyristors *Ty1* and *Ty2* and for thyristors in the commutation units *K1* and *K2*. Electromagnetic fuses are used for monitory and control circuits. All fuses have auxiliary contacts for the shutdown of the converter.

d) *An alarm signal* is issued on unwarranted start, failure to start, and on an interruption in circuits caused by removal of a printed circuit board or a plug from its jack.

e) *Radio interference suppressor*. Capacitors on the input and output side damp radio frequency interference.

Fig. 8
Rectifier unit in booster converter 48 V, 630 A



Mechanical Design

In respect of mechanical design and dimensions both non-regulated and regulated converters are based on the same standardized modular system as is used for L M Ericsson's other central power supply equipment and described in Ericsson Review No. 4, 1968.[1] The floor cabinet has a front door (figs. 3 and 11) and can be placed against a wall, which results in a considerable saving of floor space. The converters consist of one ore more grating units (figs. 5, 7 and 8). These units are placed on guide-rails in a floor cabinet (figs. 9 and 11). They can thus be easily inserted and removed. Whenever possible the units have been designed to allow both horizontal mounting (in deep floor cabinets) and vertical mounting (in shallow wall cabinets). This applies, for example, to the 40 A non-regulated converter (fig. 5).

The grating units are interconnected by cables or busbars. When space

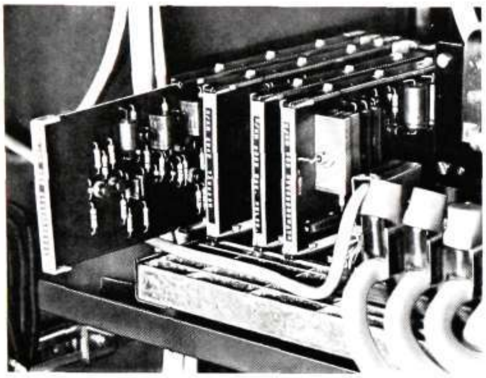


Fig. 9
Control unit for regulated converter (placed in 630 A converter)

allows, different items of equipment can be combined in one cabinet, e.g. two converters in parallel (fig. 10) or a rectifier and a converter. The mechanical design offers a flexible system easily adapted to various combinations of equipment.

The monitor unit *KE* is located in the hinged door. The unit is connected by plug and jack, which permits separate testing and simple replacement.

Oscillator and firing unit in the non-regulated converter, as well as control unit in the regulated converter, are built up on plug-in type printed circuit boards (fig. 9). Oscillator, firing unit and the gates of the thyristors are interconnected with screened cables.

Two lamps for each converter marked with the text "Converter operating" and "Converter released" and a non-locking push-button "Reset of alarm" are located on the front of the door (fig. 10). The regulated converter is equipped moreover with an overvoltage lamp and a button for overvoltage reset, placed inside the converter.

The frame is of welded steel with closed rectangular section. The hinged front is lined with 1.5 mm sheet steel. The rear and side linings are of 2 mm aluminium sheeting.

Comparison between Non-Regulated Booster Converter, Regulated Booster Converter and Cell Switch

A 48 V system with a lead acid battery of 23 cells is assumed.

Fig. 10
Power supply plant 48 V with two non-regulated booster converters 100 A, two rectifiers 100 A and distribution bay. The distribution bay contains control and supervisory units and fuses for outgoing cables.

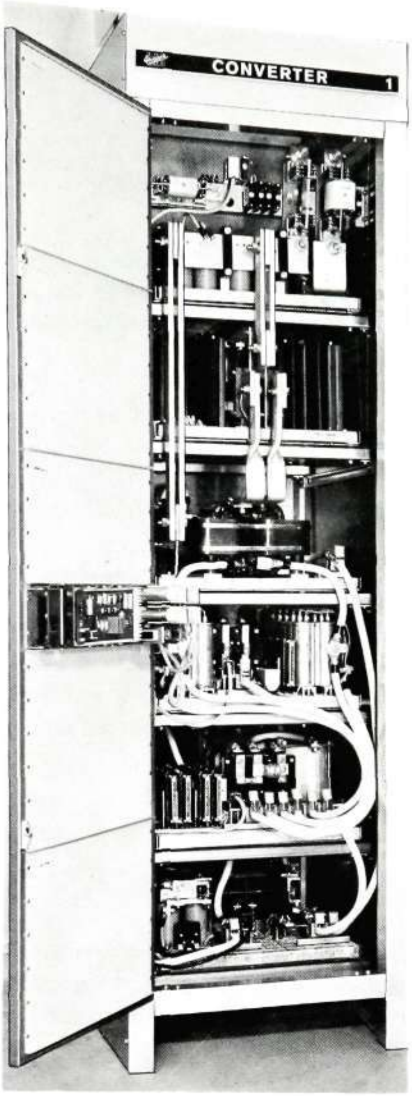


Fig. 11
Booster converter 48 V, 630 A, with regulated output voltage

Power Losses

In a system with floating of batteries a constant cell voltage of 2.22 V/cell is required. This condition determines the output voltage from the rectifiers to 51 V, both for cell switch and converter system.

In normal service, when the converters are not in operation, the losses in bypass diodes correspond to about 1 V voltage drop or about 2 % of the total energy consumption. At the same time the distribution voltage is reduced by 2 %, which reduces the current consumption in the exchange by 2 % and energy consumption by 4 %. The converter system thus implies an energy saving of 2 %.

With 0—1.5 V voltage drop in the distribution cables the voltage supplied to the telecommunication equipment rack is 48.5—50 V in the converter system, 49.5—51 V in the cell switch system. The converter system thus has the additional advantage that the voltage across the telecommunication equipment deviates less from the nominal value, 48 V, for which the equipment is designed.

The losses in the converters when in operation constitute about 5 % of the power output from the battery. The converters are passed by only about 17 % of the power delivered by the battery. The average efficiency of the converters is 70 %. Consequently the losses in the converters are 0.17 (1—0.7) = 0.051, i.e. approx. 5 % of the total power output.

The converter system, accordingly, gives rise to additional losses of 5 % during periods of A.C. power failure and an energy saving of 2 % during normal operation, i.e. the major portion of service time.

Voltage Variations

The permissible voltage variation for L M Ericsson's 48 V system is specified as 45.5—56 V.

Both non-regulated booster converter and cell switch work in extreme cases within the whole of this range.

Regulated booster converters, on the other hand, always maintain the distribution voltage at normal level even with wholly discharged battery. The small voltage variations in a system with regulated booster converters contribute to greater reliability and longer life of the telecommunication equipment.

Voltage Changes on Switching In and Out

The function of the cell switch implies a step change of 4—6 V with very steep front (of the order of hundreds of V/ms). In some applications this may involve a risk of malfunction.

A system with non-regulated booster converters exhibits roughly the same stepwise change but with a far less steep front (approx. 1 V/ms).

Booster converters with regulated output voltage cause practically no step changes of voltage.

Facilities for Test during Normal Operation

Test of cell switches is made by temporary disconnection of the mains voltage to the rectifiers, so that the battery voltage falls. A complete test of the cell switch system involves considerable switching operations by means of mechanical switches in rectifiers and battery circuit.

Non-regulated booster converters are also tested with a simulated A.C. power failure. When the mains voltage returns, the rectifiers start and the converters stop. The equipment for automatic battery charging usually starts when the converters have stopped. After a few minutes' charge the plant returns automatically to normal operation.

A regulated booster converter can be tested very simply without disconnection of the supply voltage to the rectifiers. With the aid of a test button all converters in a plant are started simultaneously. During the test the converters raise the voltage in the exchange by a couple of volts. The test can easily be remotely controlled, a response signal meaning that all converters are in operation.

Technical Data

The more important technical data for booster converters are presented in table 2. By way of example the largest units of non-regulated and regulated type have been chosen. Table 3 presents characteristic operating data for the converter system.

Table 2. Technical data for booster converters

			Non-regulated	Regulated
Converter type		—	Non-regulated	Regulated
Rated voltage of system	$U_=$	V	48	48
Rated output current	$I_=$	A	400	630
Input voltage, permissible variations		V	38—56	38—56
Conversion frequency		Hz	400	400
Output voltage				
at rated output current and discharged battery (input voltage 41 V)		V	5.0	9.0
variation during all operating conditions		V	5.0—7.6	0—9
Noise voltage, psophometric value	*max.*	mV	2	2
Accuracy of regulation, % of distribution voltage		%	—	±1
Dynamic regulation characteristics (with step change of load of 25 % $I_=$)				
transient voltage deviation	max.	V	—	1
response time	max.	ms	—	100
Current limitation		—	no	yes
Noise level			—	—
Permissible ambient temperature				
operation		°C	0 to +45	0 to +45
non-destructive		°C	-10 to +55	-10 to +55
Dimensions				
width		mm	800	600
height		mm	1100	2200
depth		mm	800	800
Weight		kg	190	300

Table 3. Operating data for converter system

Rated voltage	V	48	48	Remarks
Converter type	—	Non-regulated	Regulated	
Distribution voltage				*
variation, normal operation	V	50.5—51	50—50.5	
variation, normal operation permissible per L M Ericsson specifications	V	48.5—52	48.5—52	
variation during all operating conditions	V	46—56	50—53.5	
variation during all operating conditions permitted per L M Ericsson specifications	V	45.5—56	45.5—56	
at start of converter		47	50	
at discharged battery (41 V)		46	50	
at stop of converter		56	50	
Efficiency of the system at rated current output from converters	%	95	93—97	

*) Values in central power supply plant; in telecommunication equipment the voltage will be lower owing to voltage drop in the distribution cables, which may vary from 0 to 1.5 V.

Summary

With the booster converter principle an uninterruptible power system has been created with narrow voltage limits as well as low transients and noise voltages.

The equipment is static, consequently there is no mechanical wear and the maintenance requirements are reduced to a minimum.

The converter system in combination with equipment for automatic battery charging permits fully automatic operation and can be used at unattended exchanges.

The converter system allows use of the batteries to very low final discharge voltage. The energy consumption is about 2 % less than in conventional systems.

The system with converters can be easily extended, which implies saving in initial installation cost.

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Objective Determination of Solderability

G. BECKER, TELEFONAKTIEBOLAGET LM ERICSSON, STOCKHOLM

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A procedure is described for measuring the soldering time to within one hundredth of a second according to the IEC method. Extensive tests have shown that the soldering time for a material follows a statistical distribution. The requirements of production and control set limits for the solderability of a material, which can be coordinated with the solderability curve obtained from the statistical distribution. This makes it possible to introduce solderability requirements in specifications. It is then also possible to meet the high requirements placed today on soldered connections.

This article has been earlier published in "Schweissen und Schneiden" no. 7, 1968.

Mass production and the high requirements placed today on electronic equipments mean that all soldering must be of high quality. This is achieved at present by visual inspection of the individual soldered connections and, when required, by repairing them. It is naturally desirable that the soldering properties of the individual objects to be soldered are so satisfactory from the start that the quality of the soldering is assured. In other words, one must know the soldering properties of a material well before it is used in production.

The Problem

The importance of having a material of so high a quality level that subsequent inspection is unnecessary is apparent from the fact that one defective soldered connection per 10,000 is usually considered normal. Sometimes, however, only one defective soldered connection in 100,000 is allowed. The ultimate goal is not a single defective soldered connection. One thus needs quality levels from 1 in 1000 to 1 in 5,000,000.

A quality level even of 1 in 10,000 requires very great testing resources; 1 in 100,000 is usually not economically defensible. Random checks are not satisfactory, as only a 100 % control gives the necessary reliability. One may also question whether it is practically possible, among 100,000 soldered connections, to find a single connection that is defective.

In the course of the years a number of methods for investigation of solderability have been developed. Factors have been determined such as

- wetting angle
- area of spread of the solder
- capillary rise of the solder
- the wetted area in immersion tests
- the wetting time

Fig. 1

Apparatus for determination of the solderability of a material

① Needle for stopping the time measurement
② Specimen (soldering tag of a relay spring)
③ Solder globule
④ Thermocouple
⑤ Speed setting

The first three methods involve difficulty in measurement and are time-consuming. In practice, therefore, a control method of this kind is unsuitable. Nor does one obtain a simple value as measure of solderability. Another disadvantage within the electronic industry is that the shape and size of parts to be soldered renders a study of the spread of the solder impossible. Although it is important to know the spread of a given material, it is more important for industry to know how quickly a part is wetted and how quickly the solder spreads. The wetting speed is an important factor. TEN DUIS[1] developed a method for measuring this factor, by means of which the solderability of a part could be determined in advance. This method has since formed the basis for various national standards. As TEN DUIS' article does not indicate any time measurement or method of evaluation corresponding to the requirements to-day, tests have been made which are reported below.

Test Equipment

General

For tests which would permit determination of solderability a test apparatus (fig. 1) was constructed in accordance with IEC's proposal. According to IEC only wires should be tested for solderability. The specimen-holder of the apparatus, however, is replaceable, so that other shapes of specimen and measurements can also be made. The soldering head, on which the solder is placed, is likewise replaceable both in order to be able to test at temperatures above 235° C and to use specimens of other kind than wires.

Time Measurement

The method for measurement of time has been greatly improved. Hitherto time has been determined visually and manually. Errors of 0.1—0.3 s in the time measurement have been unavoidable. But it has proved necessary to determine the time to within 1/100 s. In the existing instrument the time is measured electronically. At the moment when the specimen enters into contact with the liquid solder, an electric pulse is triggered and the time measurement starts. At a distance of 0.3—0.5 mm above the specimen there is an electrically conductive needle (fig. 1) which, as soon as the solder has flowed around the specimen and covered it, is touched by the solder and the measurement stops. The time at that moment is the measure of the solderability of the specimen. This method allows measurement of 1/100 s. The time is noted by a line printer.

The assumption for use of this method of time measurement is that the material is easily soldered. If the wetting process is uneven or interrupted, it must be observed visually and the time stopped by hand. Soldering defects, which previously could generally be tolerated in practice, cause difficulties in measurement. This is the case when the entire surface of the specimen is not wetted by the solder, but only about 75 %. In the test apparatus this may mean that the needle is not touched by the solder, so that no time measurement is made, or that the needle is touched without the wetting process having taken place in a satisfactory manner. To avoid erroneous measurements the wetting process must be followed in every test.

Testing Temperature

The testing temperature is normally 265° C, in exceptional cases 330° C or 400° C. The temperature of the solder globule is set with an iron-constantan thermocouple in the soldering head and an electric temperature regulator with an accuracy of ± 1° C. The temperature of the solder globule is also checked occasionally with another thermocouple.

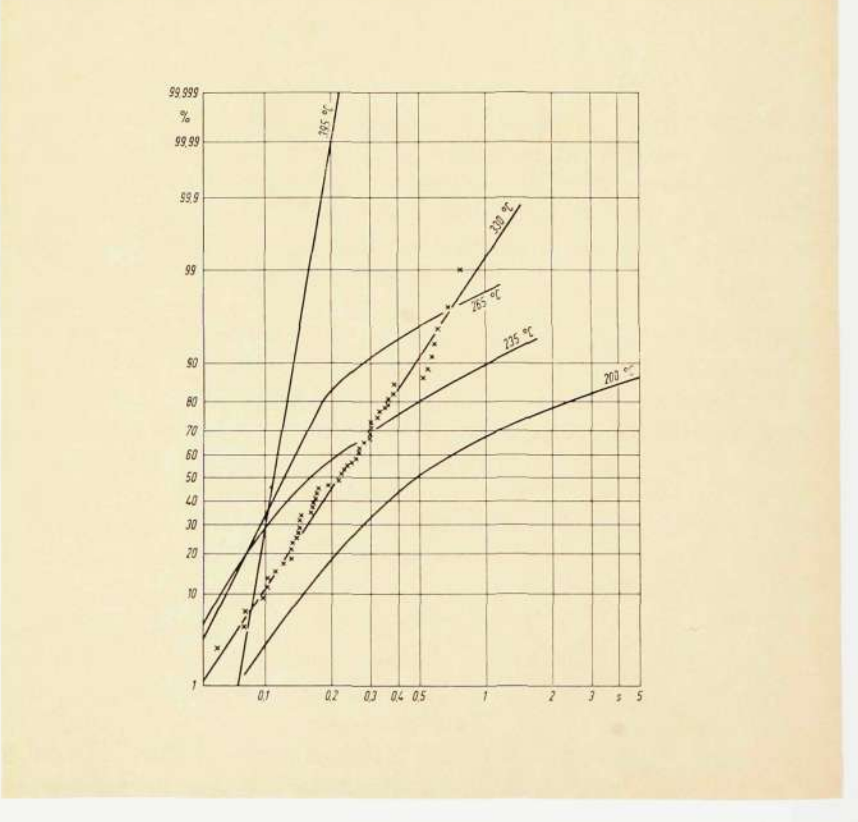
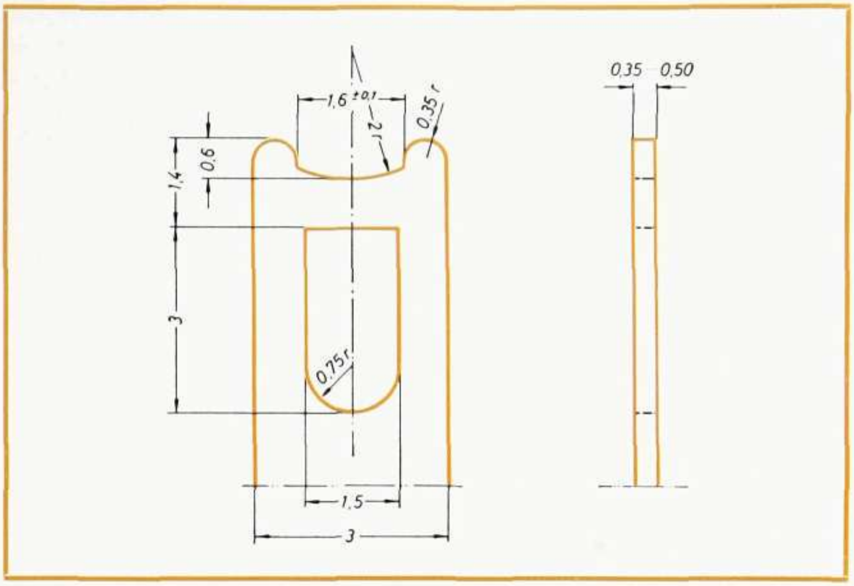


Fig. 2
Influence of soldering temperature on soldering speed

Specimen: tinned nickel brass, 0.6 mm diameter, non-aged
Solder: 60/40 SnPb, manufacturer A, see fig. 4
Quantity of solder: 165 mg
Flux: colophony dissolved in ethyl alcohol
Speed of immersion: 16 mm/s

Fig. 3

Dimensional sketch of the soldering tag of a relay spring (the top of the tag is tested for solderability)



The rate of heating of tinned specimens of different material and shape is measured with thermocouples and an oscillograph at a present test temperature of 265° C. Tests have shown that the lowest possible soldering temperature (183° C) of the specimen when a soldering process is possible is attained after 0.06 s. After 0.12 s the original rate of heating falls from 1700 to about 35 degrees/s; the subsequent rise of heat thus takes place slowly. Within the course of 1 s the temperature increases from 210° C to 245° C. This means that the solderability after 0.16 s is tested at an almost stationary temperature.

As expected, after 3—5 s there is a 5—45 degree difference of temperature between the surface of the specimen and the molten solder depending on the nature of the material and the dimensions of the specimen, and also on the quantity of flux. The solderability is dependent, among other factors, on the temperature and time. This means that, at too low testing temperatures, too low a solderability is measured, which therefore does not correspond to reality (fig. 2). In view of the fact that today the ordinary soldering temperature, using a soldering iron, is between 250 and 400° C, for printed circuits about 250° C, a test temperature of 265° C may be considered realistic.

Rate of Immersion of the Specimen

To obtain reproducible results the specimen must be introduced into the solder at a defined rate. Attempts with 4, 7, 9, 13, 16 and 38 mm/s and two shapes of specimen (wire of 0.6 mm diameter and soldering tag, fig. 3, both tinned) showed the most suitable rate of immersion to be 9 ± 1.5 mm/s. A rate of immersion of 4 mm/s results in too long wetting times, 38 mm/s in too short times and too great a variance.

The specimen-holders differ in weight. In order to be able to use the stipulated rate of immersion, the speed setting device — an air brake — is adjustable.

Workpieces, Solders and Fluxes

Specimen Material and Shape

The specimens consisted of brass and nickel-brass in the form of soldering tags (fig. 3), both untinned and hot tinned with 60/40 SnPb solder. Tests were also made with tinned round and rectangular copper wire (0.4 mm diameter, 0.30×0.85 mm) and tinned tin bronze wire (diameter 0.6 mm). Investigations were also made of wires of different shapes and sizes, and of the soldering properties of different solders (fig. 4) and fluxes. The specimens were immersed in slightly activated colophony flux and then dried. Care was taken not to touch the test point with the fingers.

Condition of Specimen

The specimens were investigated as received, i.e. between one week and one month after surface treatment, and after ageing to IEC 68-2, Test C V, 21 days (40° C, 90—95 % relative humidity). As regards tinned surfaces this method of ageing corresponds — as the tests have shown — approximately to 1 year's storage at 15—25° C with the surfaces protected from weather and wind. Silver and gold coatings were aged under the following conditions: according to the Kesternich test and 3 h, 0.01 % H_2S, 75 % relative humidity.

Solder

The solder was 60/40 SnPb in pellet form weighing 165 mg per pellet in accordance with IEC regulations.[2] The pellet had been coated with slightly activated flux.

Test Results

The main result of the tests is that the measured soldering time for a number of specimens from a uniform quantity usually follows a logarithmic normal distribution. The wetting time necessary for soldering of a given material is not a concrete value but lies within a time interval. This means that two specimens which, for example, need 0.1 and 2 s soldering time,

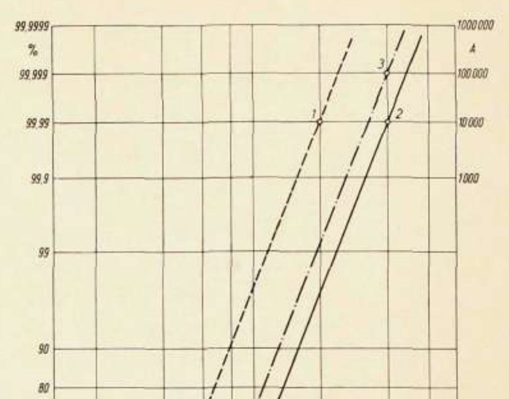


Fig. 4

Soldering properties of 60/40 SnPb solder from different manufacturers

Test: soldering tag as in fig. 3, tinned (60/40 SnPb solder), non-aged
Testing temperature: 265°C
Solder: 60/40 SnPb, manufacturers A and B
Solder B in remolten form becomes solder C
Quantity of solder: 165 mg
Flux: colophony dissolved in ethyl alcohol

respectively, may derive from a single quantity. A time obtained for 1—7 specimens permits no definite conclusion concerning the solderability of the quantity available.

In the logarithmic normal distribution diagram the measured soldering times result in a curve, the solderability curve. On this curve can be read the time required for a given percentage of all solderings. One can also determine in advance the number of defective soldered connections to be expected in the final product and relatable to unsuitable material.

With the described method it is possible to determine unambiguously the solderability of a material. This has a number of consequences which are significant when drawing up material specifications, in material testing, development and investigation of materials, and also for the soldering technique. The results of the measurement can be evaluated in different ways. The method described below, however, has proved to be the simplest and the one which provides the most complete data.

Deviation of Solderability Curve from the Normal Distribution

In the time rage < 0.2 s deviations in the course of the solderability curve have been noticed which may be related to distrubance of heat transfer. One reason for this may be an excess of flux or too slow and irregular immersion of the specimen in the solder.

Deviations from the normal distribution at times > 2 s occurred only when the solderability of the material was insufficient. In such cases soldering times up to 10 s were recorded.

Random Sampling

The solderability of a material generally follows a logarithmic normal distribution. Certain rules for random sampling can therefore be set up.

The number of tests which should be made depends chiefly on the intention of the measurement. As every measurement implies fixing and removal of the specimen and requires a certain time (for 50 measurements without preparation and analysis about 0.75 h), an attempt is made to limit the tests to a number such that definite conclusions can be drawn from the result in every particular case.

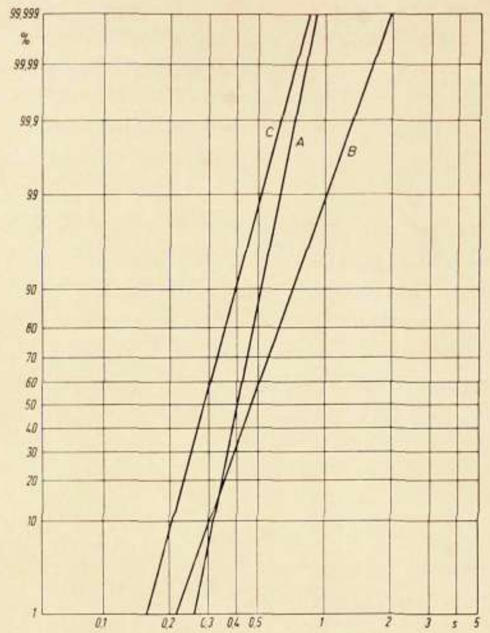
If the solderability of an unknown material in this respect is to be investigated, it generally suffices to make 12 tests in order to be able to decide whether more thorough testing would pay. The solderability is taken as being the next highest value of $\mu + \sigma$ for the series. This means that in normal cases 86 % of all specimens show a soldering time less than or equal to this value. With a material of which the solderability is known from previous measurements and the manufacturing procedure for which is reproducible, 12 tests should suffice for assessment.

But if the solderability is to be established with sufficient accuracy for a material to be used in production, more than 50 tests must be made. In order to some extent to limit the measurements and simplify the evaluation, only 50 tests were made. In the diagram the values are then arranged in rising order, starting at the 1 % line and going on via the 3, 5, 7 % to the 99 % line on which the 50th, i.e. the largest value, is plotted. See also fig. 2.

Fig. 5

Diagram explaining the proposed limits for solderable material

1. Limit between solderable material and material of limited hand solderability
2. Limit between limited solderability and non-hand-solderable material
3. Limit between solderable and non-machine-solderable material



Material Specifications

As it is possible exactly to determine the solderability of a material, it is also possible to work out specifications for solderable material, whether in aged condition or not. One of the assumptions made is that the soldering times are in practice identical to those obtained in tests.

It is usually required that a soldered connection can be produced manually within 1 s. In 10,000 connections there must not be more than one defect. Both these requirements must be fulfilled if the desired quality is to be attained (fig. 5). The quality level is thus determined by the data concerning soldering time and the number of defective soldered connections in relation to the total number of soldered connections. In complicated cases soldering times up to 2 s can be permitted for the same level of defects (fig. 5). Such material is of limited solderability. A material which in solderability tests exceeds 2 s soldering time and/or the defect level must be considered unsuitable for soldering.

For mechanized soldering other requirements may be set up. As the fatigue of the operator or the influence of the piecework system need not be taken into account, the soldering time can be extended to 2 s. On the other hand the visual check of soldering is eliminated. In this case, therefore, one can distinguish only between solderable and non-solderable materials. At the same time the defect level must be raised to 1 in 100,000, which gives point 3 (fig. 5).

In general the solderability of a material can be defined as follows:

The solderability of a material shall be such that not more than one soldering per A solderings requires a soldering time longer than B s at D° C.

Fig. 5 shows defined points with assumed solderability curves. They indicate that in mechanized soldering — although a larger number of faultless soldered connections is required — the quality level of the material may be inferior to that for hand soldering as longer soldering times are allowed. On this account, therefore, a material which is suited for mechanized soldering may under certain circumstances only be of limited solderability by hand. On the other hand a material is perhaps no longer solderable by mechanized means, but is of limited solderability by hand.

The earlier defined points were established on the following assumptions:

- the material must be metallic
- no non-metallic layers must be tested
- the diameter of the specimen must not be more than 0.8 mm
- no specimens must be tested which are larger than the soldering tag (fig. 3)
- the random test must comprise 50 specimens.

If other conditions exist, the limits must be chosen accordingly.

If these requirements are set up and if it is possible to supervise them, the solderability can be taken to be a defined property in material and production specifications. Maximum soldering times, defect level and soldering temperature must be specified. Data of manufacturing method and thickness of layer may therefore be unnecessary since, in any case, they generally provide unsatifactory information concerning the solderability of a material.

Use of Solderability Curves in Practice

An advantage of the solderability curve is that — compared with other statistical methods — it provides more information. If among 50 samples there is one which exhibits 2.2 s soldering time, i.e. does not comply with the requirements, in another procedure this would result in rejection of the material. It may happen, however, that some materials, owing to the impossibility of obtaining quick replacements, must be used nevertheless. The solderability curve then provides a means of assessing the measures necessary for ensuring the optimal soldering results in each particular case. One can investigate whether the expected number of defects can be accepted. The curve also shows the soldering times required in relation to permissible defects. If the soldering time has been established, one must decide whether it can be realized. If not, a compromise can be made between soldering time and expected number of defects. Only when these three courses prove unsatisfactory must the material be rejected.

When a new mechanized soldering process was first introduced there were a large number of defective soldered connections. It proved that the material did not comply with the demands. By the present method it was possible to raise the quality level from 1 in 1000 to 0 defect in more than 15,000,000 connections.

This was made possible by accurate determination of the solderability of the material, which in turn led to changes in the manufacturing process. All this could be done without difficulty thanks to the solderability test. An advantage was that the termination could be designed in a manner convenient for soldering while at the same time providing the means for simple and quick testing — and other checks.

It is sometimes difficult to attain the desired quality level as, in soldering, it is not only the workpiece, solder and flux that decide the result but also a number of other factors such as the design of the termination, the heating process and soldering temperature, training of the operator, working site, and last but not least suitable combinations of materials.

Apart from random tests of solderability it is necessary to make a visual inspection of the material. Only in this way can one observe sections which appear critical and subject them to more thorough testing.

Summary

By the method proposed by TEN DUIS[1] and the present evaluation procedure it has been possible to make investigations which previously could be done only by determining the area of spread of the solder. In this way important results were achieved which could later be confirmed by measurement of the wetting time. The time measurement method, however, allows more accurate conclusions which are of great importance especially for practical use, e.g.

- the influence of artifical ageing methods on the solderability of metallic coatings on different materials and their conformity with real ageing
- the influence of thickness of layer on the solderability of different metals
- the influence of the diffusion barrier layers on the solderability
- the solderability of different gold coatings
- the influence of soldering temperature on soldering speed (fig. 2)
- suitability of different solders.

References

1. TEN DUIS, J. A.: *An Apparatus for Testing the Solderability of Wire.* Philips Tech. Rev. *20*(1958/59): 6, p. 158—161.

2. *Basic Environmental Testing Procedures for Electronic Components and Electronic Equipment, Part 2: Tests—Test T: Soldering.* Genève 1968. (IEC Publication 68-2-20.)

ERICSSON News
from All Quarters of the World

27 Million Kronor Order from Egypt

Mr. K. H. Badir, Minister of Communications, signs the Egyptian contract. Sitting (left) Mr. Björn Lundvall, President of LME, and (right) the Chairman of UARTO, Mr. Anis El Bardai.

L M Ericsson has signed a contract totalling 27 million kronor with UARTO (United Arab Republic Telecommunications Organization) for delivery of transmission equipment to Egypt.

The equipment comprises coaxial cable with associated repeater equipment, terminal equipment, and spare parts and instruments. It is to be used for long distance telephony in Upper Egypt and will form a link over the 900 km distance between Cairo and Assuan. Altogether 28 towns will be connected to the new link.

In January 1969 L M Ericsson received an order from UARTO for extension of trunk exchanges in Cairo, Alexandria and elsewhere, totalling 12 million kronor.

Orders for 28.7 Million Kronor for Iraq and Lebanon

The telephone administrations in Iraq and Lebanon have ordered from L M Ericsson switching equipment and outside plant to a total value of 28.7 million kronor.

The order from Iraq is a step in the extensive programme of expansion of the national telephone system and comprises the delivery and installation of cable and other outside plant for the local networks in Baghdad and Mosul for altogether about 15 million kronor.

This is the second large order from Iraq in the course of 18 months. During the summer of 1968 outside plant was ordered for five cities including Baghdad to a value of some 14 million kronor.

Two contracts have been signed between the Lebanon Telephone Administration and L M Ericsson, totalling 13.7 million kronor.

One contract is for a trunk exchange in Beirut with 104 lines for international traffic.

The other comprises 9 local exchanges totalling 10,000 subscriber lines, of which four for Beirut, one for Tripoli, and four for rural areas. The contract also covers certain equipment for a further 11,000 subscriber lines.

In May 1969 a contract was signed for reconstruction and modernization of 11 local exchanges and two trunk exchanges and for seven new local exchanges, at a total value of 10.2 million kronor.

Second Order for Computer-Controlled Telephone Exchanges in Finland

Within the course of three years L M Ericsson has received two orders for computer-controlled telephone exchanges from Finnish telephone administrations.

The last contract was signed a short time ago in Turku, between representatives of the Turku Telephone Administration and L M Ericsson's Finnish subsidiary, O/Y L M Ericsson AB.

The order, totalling 12.2 million kronor, comprises the delivery and installation of a computer-controlled telephone exchange at Turku, with 8000 subscriber lines and a number of trunk lines, and three exchanges of other type for the Turku suburbs. The order is the largest received by L M Ericsson from a local Finnish telephone administration.

In 1966 L M Ericsson received an order from the Finnish PTT for a computer-controlled telephone exchange for Helsinki for the handling of national and international traffic.

From the signing of the contract in Turku Castle. (Sitting from left) S. Lönnström, L M Ericsson, V. Tähti, Turku Telephone Administration, P. Koponen and V. J. Leino, Turku-Municipality, Y. Ollus and O. Hjelt, O/Y L M Ericsson AB.

From the signing of the Malaysian agreement. (From left) Mr. Chew Kam Pok, Head of the Malaysian Telephone Administration, Mr. Tun Sambanthan, PTT Minister, Mr. Björn Lundvall, President of LME, Mr. A. Uvhagen and Mr. L. Edmark, LME, and the Swedish Chargé d'Affaires in Malaysia, Mr. A. Willén.

New Long-Term Agreement with Malaysia

Factory at Kuala Lumpur

A new long-term agreement has been signed between the Malaysian Telephone Administration (Telecoms) and L M Ericsson for delivery of all switching equipment for expansion of the national telephone network up to 1980.

The equipment is to be delivered from a factory at Kuala Lumpur, on which preparatory work has started. It is calculated that in the initial stage the factory will employ about one hundred persons.

Manufacturing Company in Singapore

An agreement has been concluded between Singapore Telephone Board (STB) and L M Ericsson for the creation of a joint company in Singapore for manufacture of telecommunication equipment.

The new company is to manufacture equipment for public and private telephone exchanges, telephone sets, and other telecommunication equipment. It is expected that around 250 persons will be employed by the time when the planned production has been attained. The new company will also take over the sales activities at present being conducted in Singapore by Ericsson Telephone Company Private Ltd.

Since the end of last century LME has delivered telephone equipment to Singapore, which was one of the first countries in the Far East in which telephone service was introduced. In 1964 Singapore Telephone Board decided to introduce L M Ericsson's crossbar system as standard. Since then L M Ericsson has received orders for 13 public telephone exchanges totalling 64,000 subscriber lines.

In 1967 LME also delivered equipment for an international transit centre in Singapore, which links the republic with subscribers in Asia, Australia, America and Europe.

Skandinaviska Banken Orders Large Data Communication System from L M Ericsson

L M Ericsson is to deliver to Skandinaviska Banken a data communication system to a value of 7.3 million kronor.

The equipments in this system, which is to work on line in real time, were developed and are being manufactured by L M Ericsson. They include two communication computers UAC 1610 and 13 regional line concentrators.

L M Ericsson's data communication system will provide a direct connection between some 350 branch offices of the bank throughout the country, with initially more than 600 cashiers' desks, and a central computer of type IBM 360 in the data processing centre in Stockholm. Communications from and to the cashiers' desks will be sent via a rented line network and the regional line concentrators to the communication computer and data processing centre.

The regional line concentrators will be used for concentrating messages from a number of lines to a single line. In this way the telephone lines will be more effectively used and the rental cost reduced.

The main function of the communication computer UAC 1610 is to relieve the central administrative computer of the major portion of the real time requirements placed by a large data communication network.

Four Automatic Exchanges to the West Indies

L M Ericsson has received a contract from Cable and Wireless (West Indies) Ltd. for delivery of four telephone exchanges for international traffic to a value of 5.5 million kronor.

Three of the exchanges are to be installed in Antigua, Barbados and Jamaica. The fourth is intended for an associated company of Cable and Wireless.

The exchanges are designed for semi-automatic traffic, i.e. the operators can dial direct to subscribers in other countries. This will be of special value for connections within the West Indies and with Europe and North America.

The intention is that the Jamaican exchange in Kingston will have a final capacity of 150 international lines, 120 trunk lines to local exchanges and 15 circuits to the Cayman Islands. The Barbados exchange will have 92 international and 70 trunk lines and 73 circuits to surrounding islands. The Antigua exchange will have a capacity of 108 international circuits, 77 circuits to surrounding islands, and 40 to St. Johns automatic telephone exchange.

A spokesman of Cable and Wireless states that the reason for placing the order with L M Ericsson was the company's great international experience of installations of this kind.

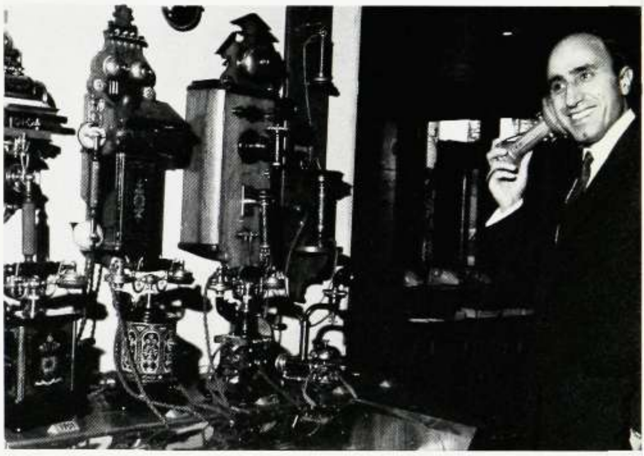
Cable and Wireless is a large telephone operating company working in more than 50 countries and its telephone network handles the transit traffic within the Brittish Commonwealth section of the West Indies.

One of the most popular exhibits at the large Office Equipment Fair "Kontor/Data 69" in Stockholm was the "paperless office" where L M Ericsson Telemateriel AB gave a concrete vision of what the office of the future may look like. With the aid of the telephone with all its variant types (non-loudspeaking with wireless headphone, loudspeaking, videophone etc.) the business executive can work in the most rational possible way in the large comfortable armchair. The screen of the videophone can be switched over to a computer which displays the desired information in the form of digits, graphs etc. The "paperless office" is thus a fact. There was a constant throng around the armchair during the eight days of the Fair. Amused and interested visitors tried out the chair and had the finesses demonstrated to them. All offers to purchase, however, had to be refused. The picture above (left) shows the artist Poul Ströyer's version of the LMS armchair.

In the American Financial World's competition for the year's best Annual Report in 1969 L M Ericsson obtained second place in its class for enterprises outside North America.

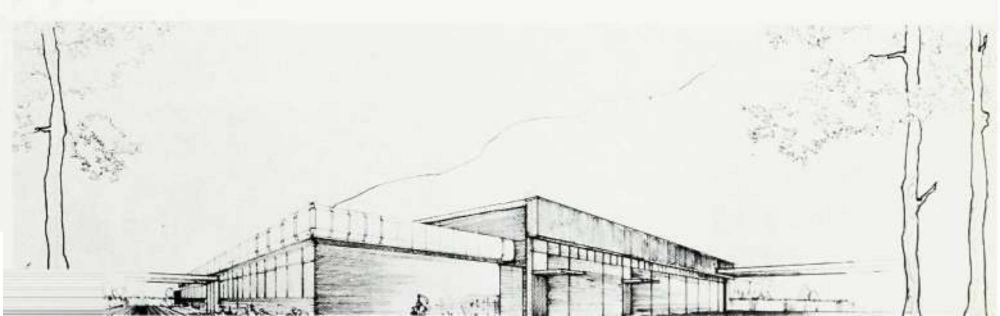
The Ericsson Annual Report was considered to be the best among those of private enterprises. The first place was taken by the Dutch KLM. Carl O. Lennmalm (left), recently appointed head of the Ericsson Corporation, New York, is seen receiving the diploma on behalf of L M Ericsson.

The old telephones in the L M Ericsson Exhibition Room always attract visitors. Here Mr. Mohammed Hoveyda from the PTT, Teheran, Iran, is pleased to see that the 1878 Ericsson telephone can still be used today.



The Institution of Telecommunication Engineers, India, arranged at their annual meeting a conference and exhibition of telecommunication equipment in Calcutta. The meeting was opened by General I. D. Verma, seen in the centre of the photograph with Mr. A. B. Bhattacharya, Head of Ericsson Sales Corporation, Calcutta, beside him.

The planned factory at Batu Tiga, about 25 km west of Kuala Lumpur, will have an area of 2600 m^2.



New Company Heads

Ivar Hilfing

Nils Söderqvist

United Kingdom

Ivar Hilfing, who until the end of 1969 was Head of Compañia Española Ericsson S.A., Madrid, has been appointed President of Swedish Ericsson Company Ltd, Centrum Electronics Ltd, Centrum Rentals Ltd and Production Control (Ericsson) Ltd in the United Kingdom. Mr. Hilfing succeeds Mr. Ake Nycander, who retires on pension on May 31 this year. Mr. Nycander will remain member of the board of the British companies until the end of 1970.

Spain

Mr. Nils Söderqvist was appointed Head of Compañia Española Ericsson S.A. as from January 1, 1970. Mr. Söderqvist had previously been Treasurer of the company.

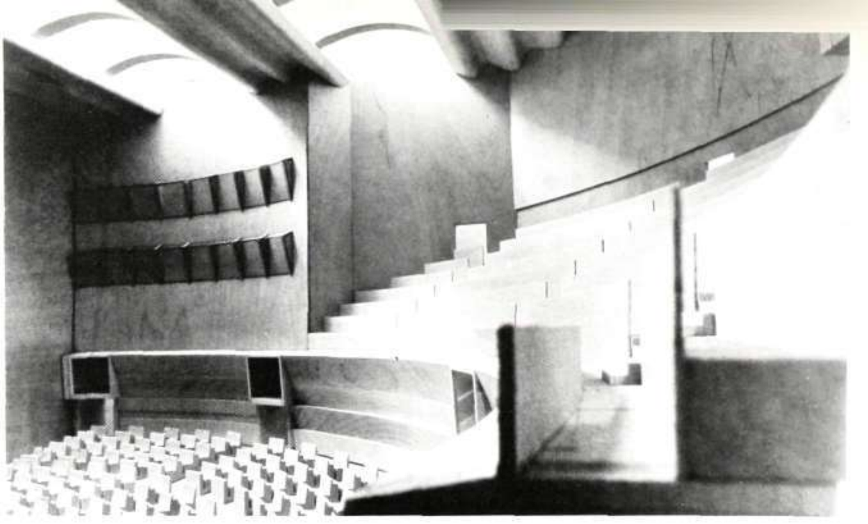
Luciano Marrubini

Italy

Mr. Umberto Levêque retired on pension from the post of President of L M Ericsson's Italian subsidiary FATME, Rome, in November 1969.

He was succeeded on November 15, 1969, by Mr. Luciano Marrubini, whose last post was with IRI-Finmeccanica.

The Vice President, Mr. Lamberto Albanese, has been appointed to serve as deputy to the President in the event of his absence.



L M Ericsson Equips the New Swedish Parliament

L M Ericsson will be responsible for all telesignalling equipment in the new Swedish Parliament. The photograph above shows a model of the Legislative Chamber as it will appear when the new single-chamber parliament moves in for the spring session in 1971. L M Ericsson Telemateriel AB is to install, among other equipment, a voting machine, intercom system, clocks, fire alarm, simultaneous interpretation system, paging system, closed circuit television, and a very large sound distribution plant including equipment of advanced design at every member's seat.

The equipment is to be installed and operating by January 1, 1971.

Ericsson Technics

The 25th Volume of Ericsson Technics is now complete after the appearance of No. 4, 1969. Nos 1 and 2 were reviewed in Ericsson Review No. 4, 1969. A brief report follows on the contents of Nos. 3 and 4, containing two papers each.

No. 3 starts with a paper by G. Kjellström, *"Network Optimization by Random Variation of Component Values"*. It presents a method of minimization of a discontinuous objective function of a set of design variables. Some examples are given of how the method can be used for optimization of electrical networks by direct variation of the components.

In the second paper, *"Performance of Phase- and Amplitude-Modulated Signals on a Gaussian Channel"*, by R. Ottoson, a combination of phase- and amplitude-modulated signals transmitted over a band-limited channel disturbed by white Gaussian noise is considered. By using phase modulation at two amplitude levels instead of one, it is shown that the gain in signal energy is 1—4 dB.

The first paper in No. 4 is *"Backscattering from a Dielectric-Coated Metallic Cylinder for Various Angles of Incidence"* by H. Wilhelmson and H. Cerda. Extensive computer calculations are reported for the backscattering of a plane electromagnetic wave by a dielectric-coated metallic cylinder. The results are presented in the form of graphs which show the backscattering cross-sections as function of the angle of incidence and of the external radius of the dielectric layer. Both principal directions of polarization of the incident plane wave are considered.

"Accuracy of Traffic Measurements in a Poisson Traffic Process. Arbitrary Distribution of Intervals between Observations and Fixed Number of Observations" is the title of the second paper in this number. The author, G. Lind, solves the problem of determining the accuracy of traffic measurements in a Poisson traffic process when making a fixed number of orbservations with independent, arbitrarily distributed intervals between them. The paper is a continuation of an earlier paper in Ericsson Technics No. 4, 1967, in which corresponding problems were solved for the case of a measuring period of fixed length. The results constitute a generalization of earlier known results for the case of constant intervals between observations. They are intended, among other purposes, to give guidance in the determination of the extent and arrangement of simulations of traffic processes.

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ERICSSON Review

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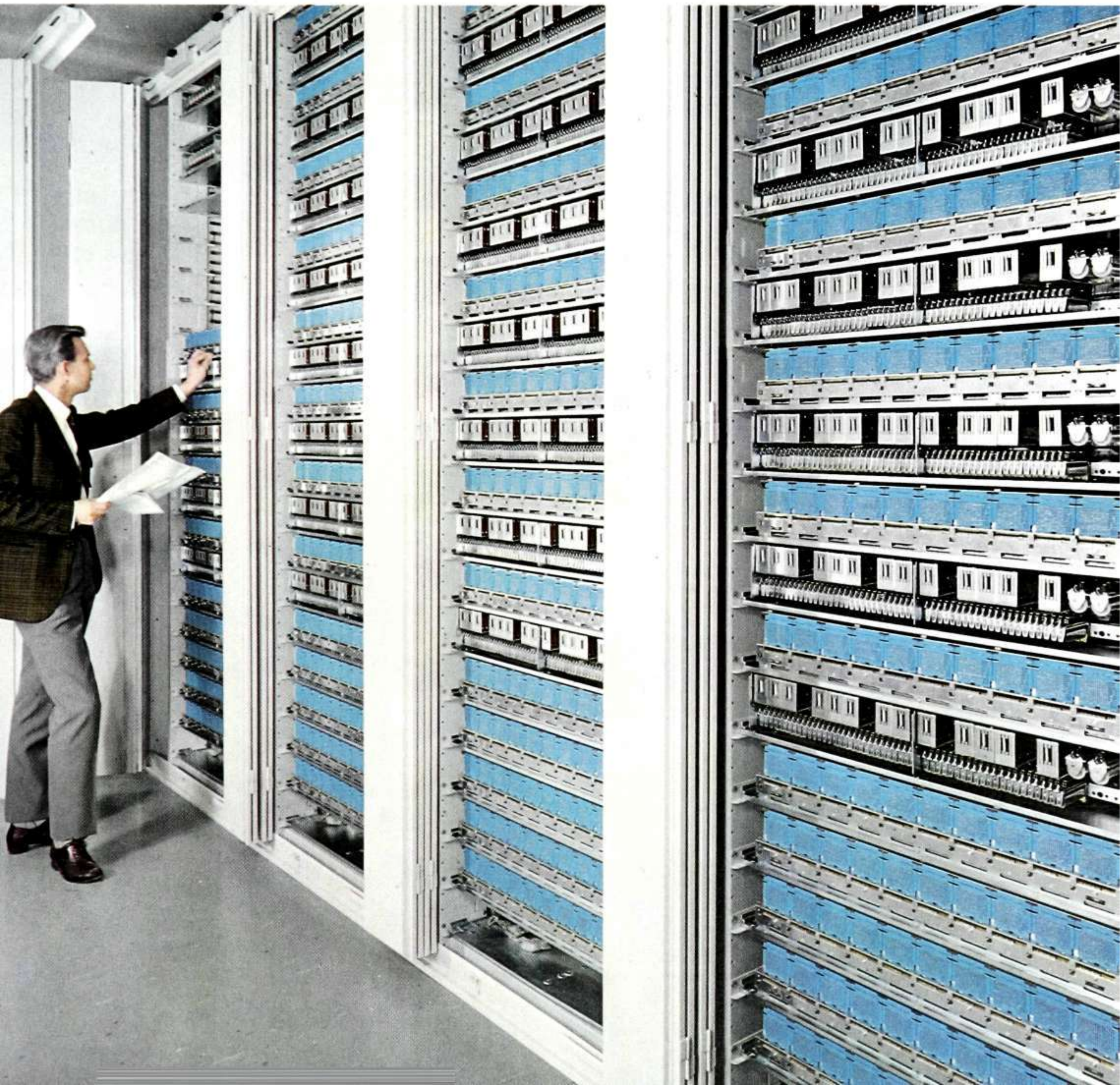
1970



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On cover: The subscriber stage in a stored program controlled telephone exchange type AKE 12, Tumba, Sweden.

Operating Experience from AKE 120, Tumba

A. SUNDBLAD, OPERATIONAL ENGINEER, SWEDISH TELECOMMUNICATIONS ADMINISTRATION, STOCKHOLM

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702

As reported in Ericsson Review No. 3, 1968, the new SPC exchange at Tumba with about 5,000 subscribers was cut-over on April 1, 1968. An entirely new principle of system design and technique had thereby been introduced in the Swedish telecommunications network. New facilities became available for subscriber service, operations and maintenance.

After nearly two years of operational experience it was thought desirable to appraise the system and to report on how the operation of the SPC exchange will be linked into the normal organization.

Tumba Zone

Tumba is the zone centre within the Tumba area. It has direction junctions with two group centres and six subordinate terminal exchanges within the area. It also has direct junctions with the zone centres in Stockholm, Västerhaninge and Södertälje and with the transit centres in Stockholm, Norrköping, Västerås and Malmö (fig. 1).

A point of interest in the traffic configuration is that only about 20 % of the total traffic is local. The situation of Tumba, about 20 km south-west of Stockholm, means that the main community of interest is directed to Stockholm. The total traffic load per subscriber is 0.06 erlang.

Before the introduction of the new SPC exchange, subscribers and junction circuits were connected to a 500-line selector exchange of type *AGF*. A short time after the cut-over the latter exchange was dismantled.

Tumba AKE 120

The exchange has today equipment for 6,400 subscribers and 800 junction circuits. An extension has recently been started to increase the capacity to 9,600 subscribers and about 1,400 junction circuits.

The exchange is equipped with functions and facilities which are normal for a zone centre in Sweden. This means, for example, that inductive pulse signalling is used for traffic with other zone centres and DC signalling within the zone. Since the cut-over the exchange has been equipped with MFC signalling for subscriber-dialled international traffic. This equipment was placed in service in the spring of 1969.

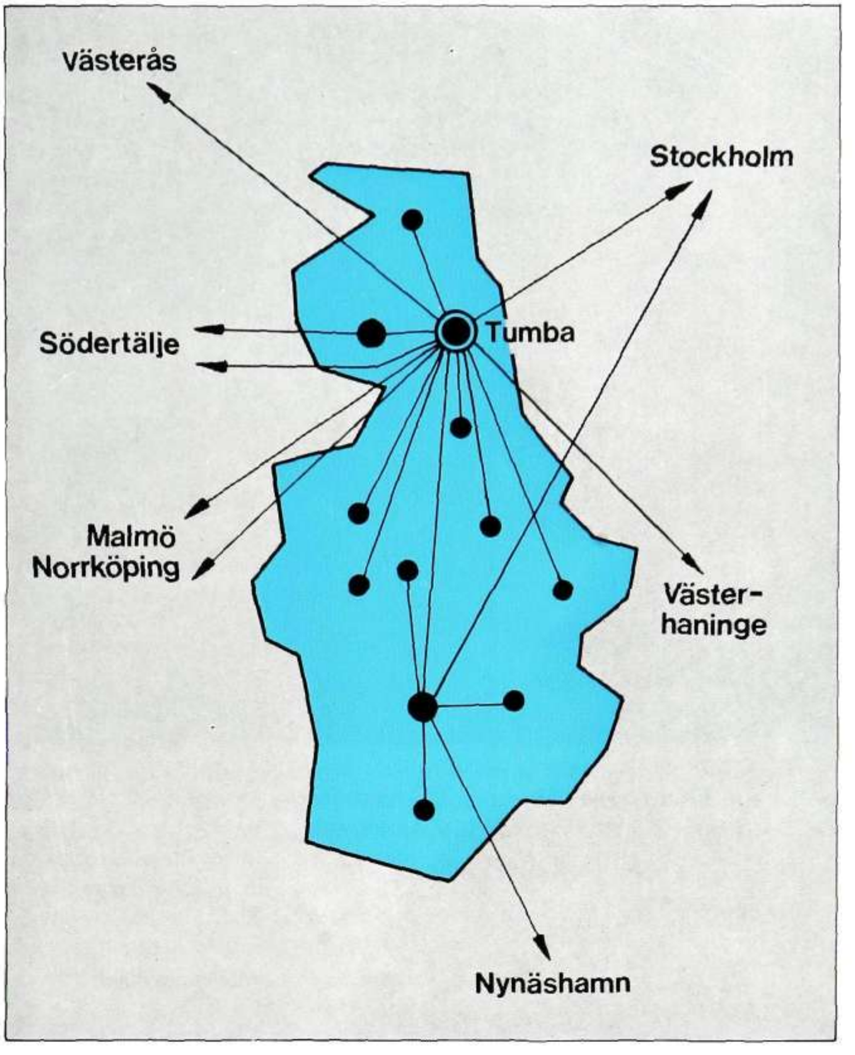
It should be noted that an entirely new technique is used for subscriber metering. The electromechanical meters have been abandoned and, instead, every subscriber has a memory word in the processor system for metering purposes.

Fig. 1
Tumba zone area

Zone centre

Group centre

Terminal exchange



Apart from normal subscriber services offered at conventional exchanges the following special subscriber services have been introduced at Tumba:

- Push-button dialling
- Abbreviated dialling
- Temporary transfer ("follow me")
- Alarm clock service
- Call back
- Transfer on busy

As a field test these services have been offered to a trial group of 500 subscribers. Follow-up of the test took place in the form of recurrent subscriber interviews among other means. The result will be used by the Administration when deciding on the introduction of future subscribers' services.

The Tumba exchange naturally differs in many ways from a conventional exchange. The supervisory, operational and testing work, for example, is concentrated to the control room (fig. 2). From this room the operating personnel communicate with the exchange on teleprinters, tape readers and tape punch. The receive fault alarms and indications of congestion in the form of printouts. Tests and rerouting can be ordered via the teleprinters.

During the spring of 1970 trials will be made with further centralization of the operations work. A data circuit has been connected to the Maintenance Centre in Stockholm. The programme for the circuit and for its associated

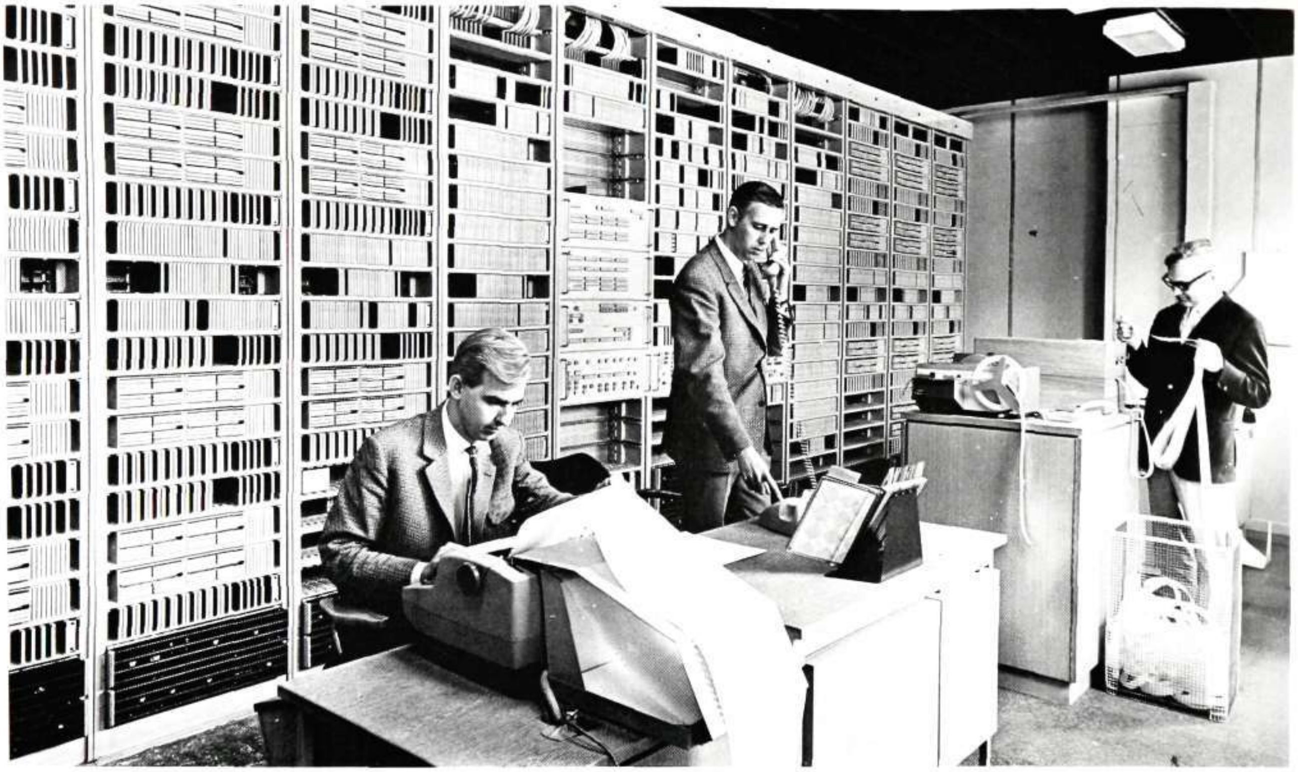


Fig. 2
Computer and control room

functions is inserted in the exchange computer. On this circuit information concerning the operational situation will be automatically transmitted to Stockholm, and remote control of the Tumba exchange will be made possible. The plans also include trials with the transmission of external programmes on the circuit direct to the Tumba computer. With this form of control of the exchange entirely new facilities for the organization of operations and maintenance will become possible.

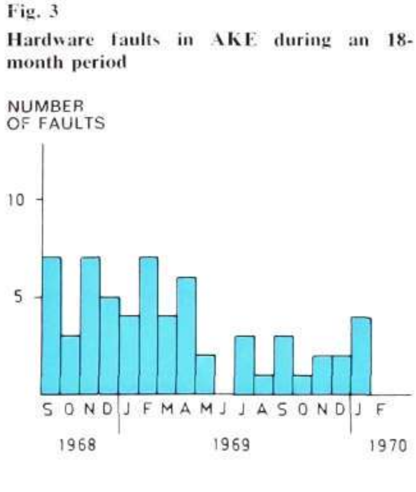
Operational Experience

Hardware Faults

During August 1968 an extension of the equipment was completed, comprising among other items a fourth 1600-line group. From that time up to the beginning of 1970 no extensive additions of hardware have been made.

During the period September 1968—February 1970 (18 months) 61 hardware faults occurred (fig. 3). This implies a fault rate for the entire exchange of $4.6 \cdot 10^{-3}$ faults/h corresponding to an MTBF (Mean Time Between Failures) of about 215 hours. The predicted fault rate for *AKE 120* at Tumba is $1.1 \cdot 10^{-2}$ faults/h, corresponding to an MTBF of about 90 hours.

Fig. 3
Hardware faults in AKE during an 18-month period



The period of observation is too short to draw any definite conclusions. It may be said, however, that the relatively low fault rate is due primarily to the fact that switches and electronic components have proved to be more reliable than calculated.

The following supplementary information concerning faults, specified by fault carriers, may be provided:

- About 550 code switches, 3 faults
- About 60,000 transistors, 6 faults
- About 150,000 diodes, 6 faults

No fault has occurred in resistors, capacitors or inductances.

The figures reported do not include faults owing to unsatisfactory handling.

Programme Handling Alarm (PAL)

Programme handling is continuously supervised. If the computer does not run through its assignments regularly, a programme handling alarm (PAL) is issued.

On receipt of PAL the computer takes the necessary action in order to be able to continue data processing from a clearly defined starting point. A distinction is made between major and minor PAL. The difference lies in the degree of clearing of memories in conjunction with restart. Minor PAL has no effect on connections set-up. If three PAL's occur within 30 minutes, the last of them becomes a major PAL.

From the above it will be clear that the incidence of PAL serves as a certain measure of the quality of the exchange (programme).

During the first six months of operation there was roughly one PAL every day. During the first part of 1969 the PAL rate fell first to one per week and later to rather more than one per month. After a somewhat inferior period during the summer and autumn of 1969, when, among other things, international traffic was introduced, the PAL rate has fallen to about two per month. The PAL rate is shown in fig. 4.

During the period of operation several major additions to the load of exchange programmes have been made, including the introduction of new subscriber services, automatic international traffic, and a data link to the Maintenance Centre in Stockholm. A clear relation is demonstrable between these loads and the PAL rate. After final adjustment of the programmes the PAL rate fell. It may be presumed that PAL will disappear after a certain running-in period.

It should be noted that the new programmes were introduced during operation without any disturbance of the traffic.

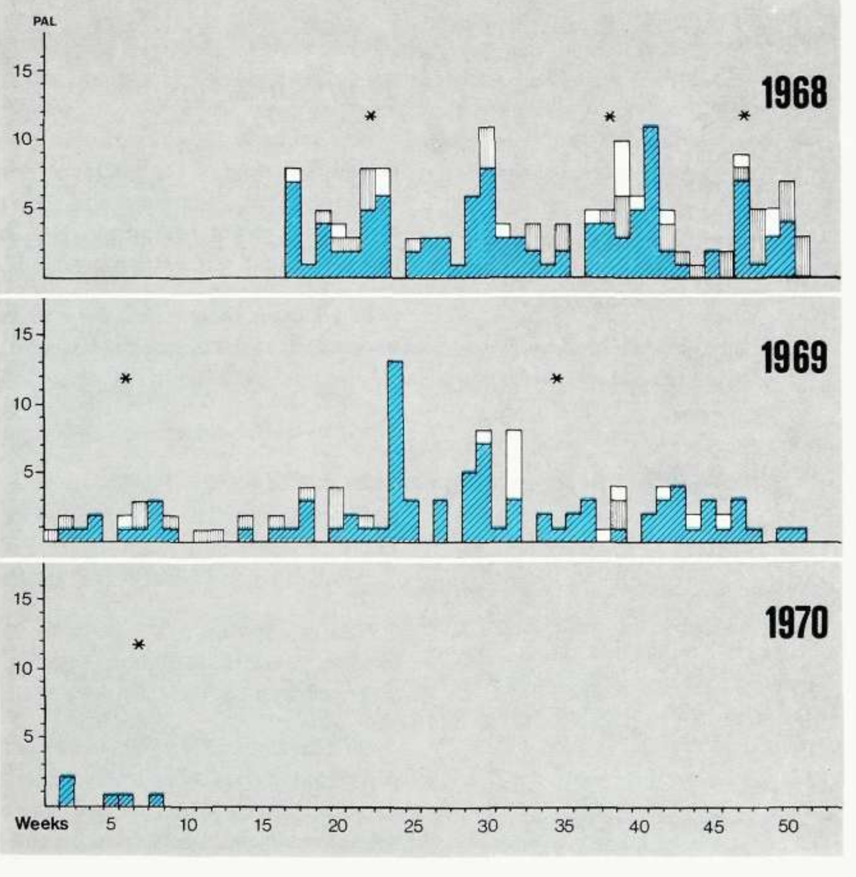
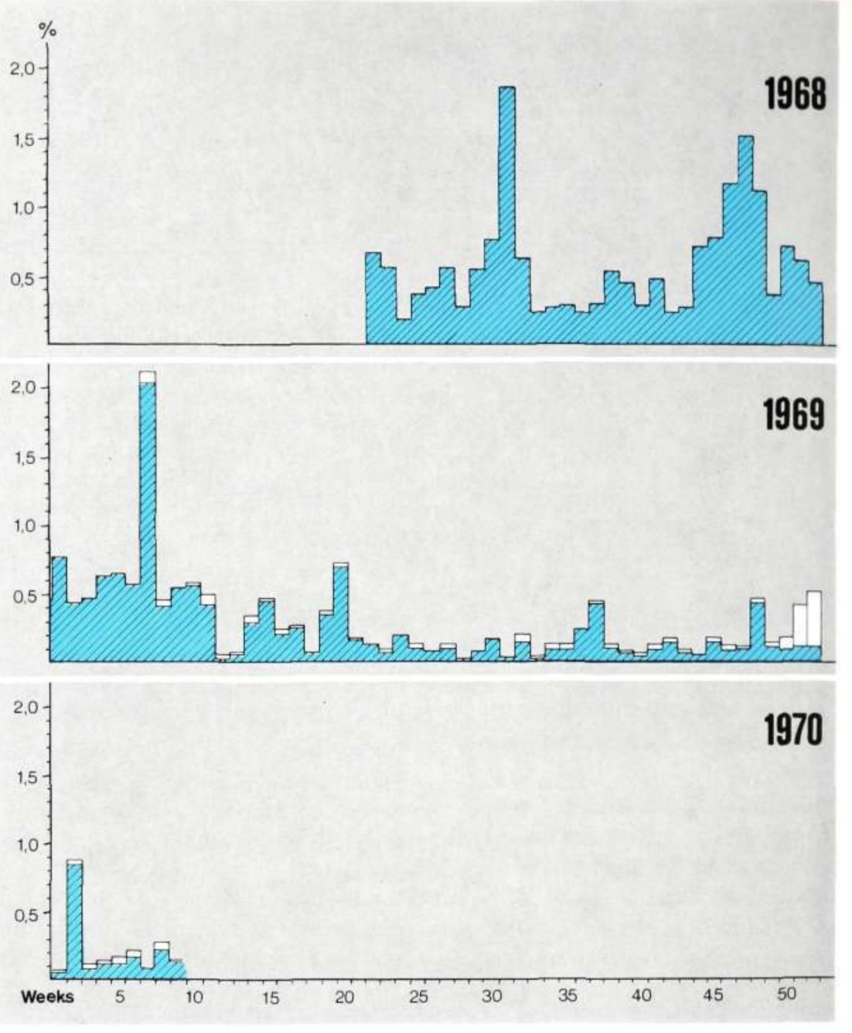


Fig. 4
Programme-handling alarm for AKE 120, Tumba

- Automatic PAL
- Clear PAL
- Test PAL
- * New edition of exchange programme introduced

Fig. 5
TVP statistics for local traffic

Technical faults
Congestion



Traffic Interruptions

Five faults at the start of operation were of such a magnitude that entire or partial reloading of the exchange programmes was necessary. The fault period varied between 30 minutes and 6 hours, the fault distribution being as follows: one in the power equipment, two in processor memories, one in the central processing unit, and one programme fault.

In all cases the reasons for the faults could be traced and measures taken to ensure that the same faults are not repeated.

Since October 17, 1968, there has been no manual reloading of memories owing to traffic-disturbing faults (up to February 1970).

On November 21, 1968, there was a major cable fault in the secondary network within the Tumba area. About 600 subscriber lines were short-circuited. The exchange continued to operate without being disturbed by the peak traffic occasioned by the fault, except in the form of congestion of code receivers.

A later addition to the programme ensures that, on a cable fault in the secondary network, the normal traffic handling capacity of the exchange is not diminished and a distinct report of the fault condition is received.

On November 25, 1969, there was a traffic stoppage owing to an accident. A printed circuit board was damaged. The exchange programme, however, remained intact. When an operator arrived and the board had been replaced, the exchange could be started up and the traffic continued.

Grade of Service

During the entire period of operation the routes both for internal and external traffic have been checked with a traffic route tester (TVP).

Of special interest in this case is the internal traffic, as it provides a measure of the grade of service of the *AKE* exchange without the influence of external factors.

It may be mentioned that the loss for this traffic during the first period varied around 0.5 %, becoming stabilized around 0.2 % at the beginning of 1969. The marke dlowering of the loss was due to adjustment of a couple of code receivers (fig. 5).

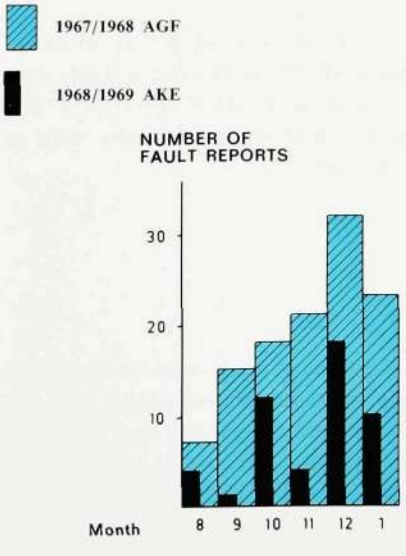
By way of comparison it may be mentioned that a conventional zone centre is considered satisfactory if it has a value below 1 % for corresponding traffic.

Subscriber Reaction

One of the main requirements before cut-over of the new exchange was that, from the subscribers' aspect, it should function at least as satisfactorily as the old *AGF* exchange. Although it is difficult to make a fair assessment of this point, one may nevertheless say with some justification that the condition has been fulfilled. This assertion is based on the fact

- that the number of fault reports referable to the switching equipment fell by more than 50 %, compared with the corresponding period in the preceding year when the exchange had *AGF* equipment (fig. 6),
- that the number of written subscribers' complaints referable to the switching equipment shows a downward tendency compared with the preceding year,
- that the large subscribers (among others Alfa Laval) were less critical of the service than before the opening of the *AKE* exchange. Alfa Laval were also able to test the possibility of automatic international calls in practical operation.

Fig. 6
Fault reports due to switching equipment



In the comparison between the two years it should be noted that the number of subscribers was greatly increasing within the area. The increase is 12—15 % per annum.

It may also be mentioned that the reactions of the five hundred interviewed subscribers were largely positive.

An important assumption for subscriber confidence in the new technique is that the subscriber metering functions perfectly. In this respect the new system involves both a new technique and new routine. Special attention was paid to the follow-up of the subscriber-metering functions. Complete check printouts were made every week and also when faulty conditions arose which might give suspicion of unauthorized interference.

The checks show that there is reason to suppose that the new technique of subscriber metering will be very much more reliable than the old.

Summary of Operational Standards

Apart from the disturbances which occurred in the first six months the exchange has functioned satisfactorily. These initial disturbances appear to be referable largely to the software side and to lack of experience in handling the new equipment.

From the experience gained it should be possible to keep the exchange at its present reliable level in the future as wll. Both the number of disturbances and the time taken to repair faults will be greatly reduced when new *AKE* exchanges are put into service.

Organization of Maintenance

Tumba is the zone centre within the Tumba zone area, belonging to the Huddinge Maintenance Area. Within this maintenance area there are some 25,000 subscribers connected to 17 exchanges. Other types of exchanges are *AGF*, *A 204* and *St 41*. The maintenance personnel are divided into groups, switching and line repairmen. The current maintenance of the Tumba exchange will be done by a group of repairmen experienced in conventional telephone systems.

In the initial stage, of course, assistance had to be provided by a central group of engineers, but the aim is that the SPC exchanges shall as soon as possible be incorporated in the normal exchange maintenance within the area.

Attendance

A guiding principle in the design of the system has been that the technique shall be so reliable and perfected that the exchange functions without special attendance. With the aid of automatic fault diagnosis, full information concerning faults and disturbances will be sent to the Maintenance Centre, where the nature and urgency of the faults will be assessed. The Maintenance Centre then gives orders for the work to be done in the exchange.

Personnel Categories

All normal fault tracing and repair work will be done by personnel of repairman category. In the case of faults which affect the automatic fault tracing, however, it is necessary to bring in experts from a central specialist group, the personnel of which have received more comprehensive training both in electronics and in system knowledge and programming.

Operational and Maintenance Routines

The introduction of the new technique necessitates supervision of all operational and maintenance routines. It permits increased centralization. This has great advantages from the supervisory point of view. It is important, therefore, that the trials with remote supervision, remote control and central storage of external programmes are completed as soon as possible. Only when these trials have been completed can the final routines be surveyed.

An essential point in the design of the future operational and maintenance routines is documentation. For natural reasons the documentation for the new system must be very comprehensive. This applies both tho hardware and software documentation. How great a proportion shall exist at the exchange, and how it should be suitably kept, mus tbe decided when sufficient experience has been gained.

It seems natural to place the entire documentation in a central computer and pick it out when required by a time sharing procedure. In this way it will be possible to have a common documentation bank for several exchanges. Only a small number of documents would in such case need to be kept at the respective exchanges.

Conclusions

The Tumba exchange may be considered to be a successful field trial. The technique has come to stay. The fault rate on the hardware side is well below the predicted level.

The experience gained on the software and operational side should lead to even more reliable operation in future.

Future work will now be directed to

- Tests comprising
  - Remote control
  - Transmission of programmes and data via data channel and telephone network
  - Storage of programmes and data in different types of external memories
- Organization of operational and maintenance routines
- Supplementation of documentation
- Training of operational and maintenance personnel
- Follow-up of operational standard and subscriber services

Construction Practice for Electronics Equipment in Stored-Programme-Controlled Telephone Exchanges

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Ericsson Review No. 3, 1968, contained an account of the build-up of the system for the stored-programme-controlled telephone exchange of type AKE 12 at Tumba. The present article describes the mechanical construction practice for the electronics units for AKE 12 in the rather modified form employed in subsequent exchanges of type AKE 13. The electronics units in these exchanges consist principally of discrete components mounted on printed circuit boards.

General Survey

The construction practice is characterized to a great extent by the low signal levels and short cycle times which occur in the system, and the high reliability required. The main features of the construction are summarized below.

- Having regard to manufacture and rational maintenance, all active units — printed board assemblies, memory units, power units etc. — have been made of plug and jack type.
- The units are plugged into jacks mounted on plates on the rear of the racks, in the sequel called the neutral planes, as they are wired to the neutral conductors of the power supply.
- In view of the low signal levels the contact surfaces of the connectors have been gold-plated and given a special shape.
- Measures have been taken to prevent faulty plugging-in of printed board assemblies etc.
- The form of the rack was chosen so as to obtain fully adequate natural cooling of temperature-sensitive electronic components, high reliability and long life, and to permit associated printed board assemblies to be placed close together — of advantage for maintenance and cabling.
- The internal rack wiring is taken the shortest way between two tags without cable forming — so called direct wiring — which, together with the neutral planes, ensures non-hazardous signal interference and delay distortion.
- The electronics racks are interconnected by means of well screened busses.
- Both racks and printed board assemblies have been built up on a consistent modular system so that the same mechanical structures can be used for widely different system applications.
- For service supervision and maintenance there is abundant supervisory equipment.

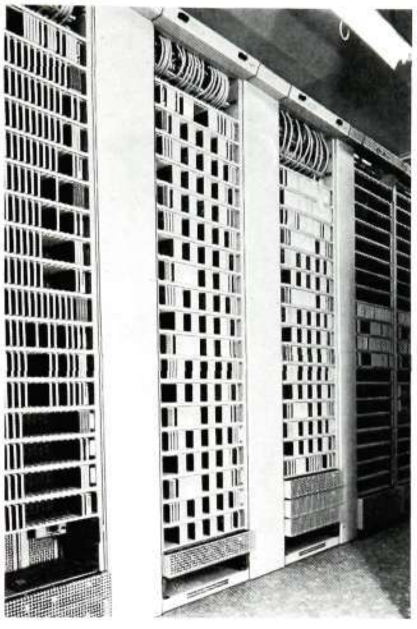


Fig. 1
Rack BDE 501

The mechanical units and the principles of the method of construction are described in greater detail in the sequel.

Rack BDE 501

The rack is 2900 mm high and 363 or 413 mm deep including power unit. The rack spacing is 670, 720, 770, 870 or 960 mm depending on the required cable compartment and cable runway. Fig. 1 shows part of a suite.

The rack is made up of a frame, a rear panel carrying jack units, a number of shelf planes, casing and doors. The rack is supplied wired and tested to the installation site. Equipment units and printed board assemblies are supplied separately.

The rack frame is a rigid welded steel structure. The verticals contain cooling air channels and are holed for sixty-nine 40 mm modules. The rack thus accommodates 23 horizontal 3-module shelves for equipment units and printed board assemblies.

The rear panel consists of mounting plates for the jack units. It is insulated from the rack frame and connected to the neutral point of the power unit. It is therefore called the neutral plane. It functions as return conductor for signal currents and voltage feed and also has a certain screening effect in the wiring field. The mounting plates have fastenings for the jacks and holes for the soldering tags. They are made for 3, 6, 9 or 12 height modules depending on the space requirements for the electrical units. The mounting unit and jacks constitute a wiring unit.

A shelf plane is composed of two steel plates which form a cooling air channel and constitute the upper and lower planes for adjacent shelves. The shelves are thus not formed until the shelf planes are mounted in the rack frame. The shelf planes can be mounted so as to obtain 3-module shelves or 6-module shelves at option. Guide strips of nylon for the printed board assemblies hook into the shelf planes and are so shaped that the printed board assemblies cannot be turned the wrong way round. Guide strips can be placed on any 6 2/3 mm section of the shelf but not closer together than 13 1/3 mm. Fig. 2 shows the parts of the shelf. One shelf accommodates a maximum of 40 printed board assemblies.

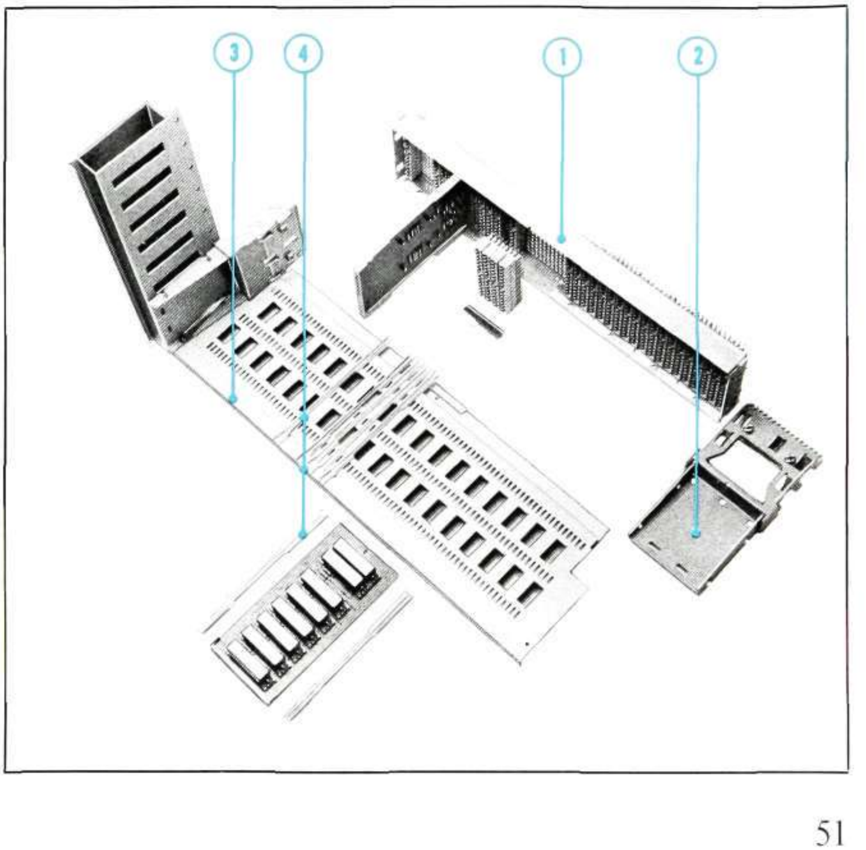


Fig. 2
Parts of shelf
① Wiring unit
② Bracket
③ Shelf plane
④ Guide strips

Fig. 3
Printed board assembly for 3-module shelf

Fig. 4
Printed board assembly with push-buttons in front frame

The *casing* covers the ends of the suite, the cable compartment between racks, and the rear of the rack. The rear casing is a folding door which protects the wiring field against damage. The front is entirely open for convenience of service and inspection of the equipment (fig. 1).

Apart from the aforementioned parts, the rack is equipped with cable runways and wire guides for external and internal wiring and with copper strips for low voltage distribution within the rack.

Printed Board Assembly ROE

Apart from memory and power units, the electronics of the exchange is made up principally on special printed board assemblies with the components mounted on printed wiring boards.

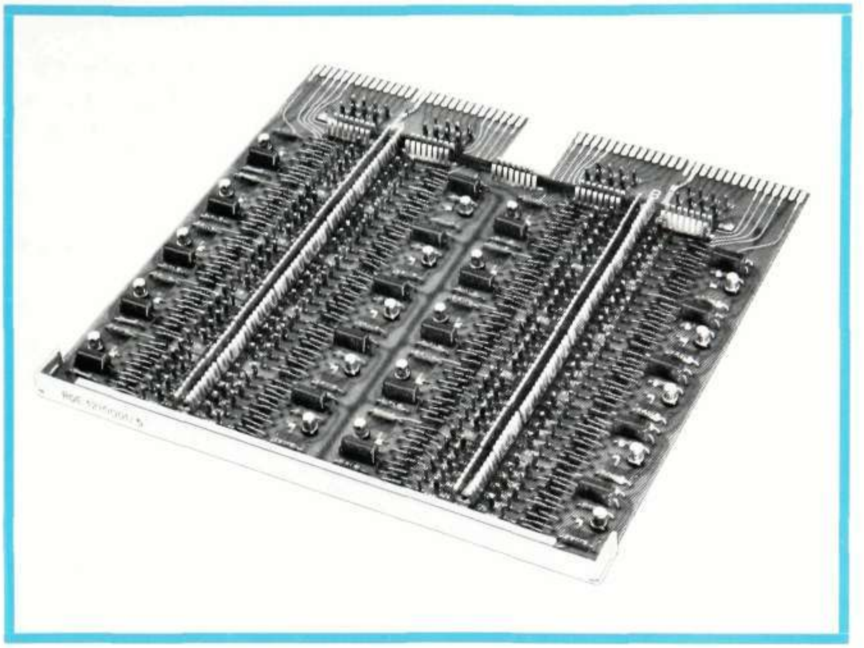
Figs. 3 and 4 show the printed board assembly for the 3-module shelf, which is the most used type. Its dimensions are 98.5×208 mm and it is made up of 1.6 mm one-sided copper-clad printed boards of flame-resistant paper phenolic laminate. Both material and design comply with international standards (IEC 52 CO 24 and CO 43).

The printed board assembly for the 6-module shelf is shown in fig. 5. Its dimensions are 218.5×208 mm. For extra stability this larger printed board assembly is made up on printed boards of 1.6 mm glass epoxy laminate. This type of board has ordinary wiring run in special wire guides which snap into the printed board, in addition to etched wiring.

The edge of the printed board assembly is furnished with 28 contacts etched out of the copper foil and a centrally placed slot which positions the board in relation to the connectors on the rack. The contacts are electrolytically nickel-plated and then gold-plated with 4 μm hard gold. The thickness, quality and density of the gold coating ensure very good resistance to abrasion.

The nickel coating effectively prevents copper diffusion through the gold coating and gives the contact surface the necessary bearing capacity for the contact pressures required for reliable contact function.

Fig. 5
Printed board assembly for 6-module shelf



To facilitate plugging in and out, the printed board assembly has handles. The handle is made of light-grey polycarbonate resin, has a labelling field, and is so shaped that, in combination with the guide strip on the shelf, the board cannot be plugged in wrongly.

The bus cables are connected by special plug-in boards which are shortened to provide space for the cables on the shelves. The boards have handles with a catch which engages with the guide strips on the shelf and prevents unintentional plugging out of the board. A bus cable with plug-in board is shown in fig. 6.

Connectors

The *ROE* boards plug into connectors *RNV-20102*. A connector consists of a body of light-grey Noryl plastic for 28 contact springs and an extra position no. 15 with a central guide which steers the printed board assembly into the connector. Around the soldering ends of the terminals pillars extend from the

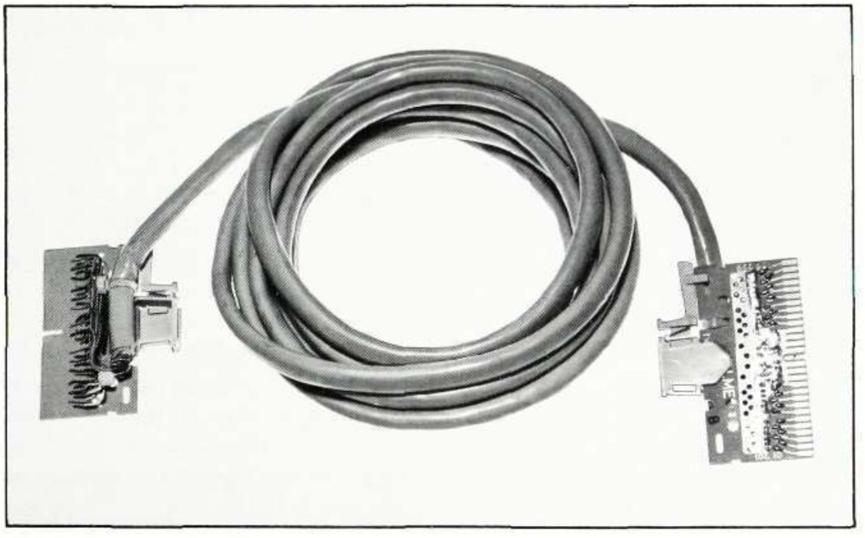


Fig. 6
Bus cable with plug-in board

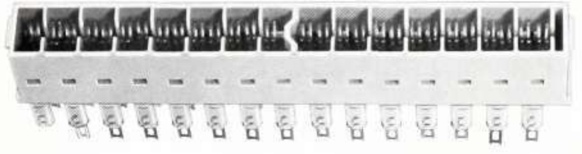


Fig. 7

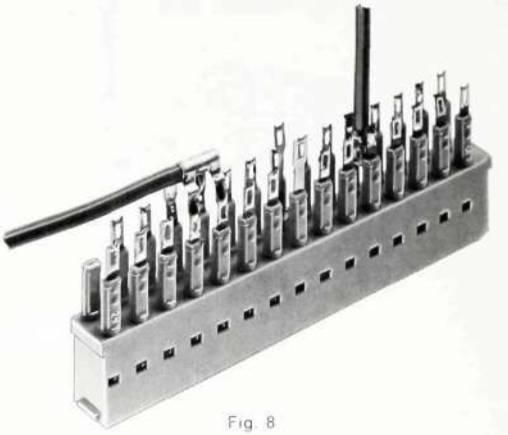


Fig. 8

Fig. 7
Connector RNV 20102

Fig. 8
Connector RNV 20102 with clamp and connected cables

connector body which prevent cutting of the wire insulation. The soldering tags of the contact springs are arranged in two rows with 6 2/3 mm spacing between the rows and between tags in the rows, hich facilitates wiring and provides ample space for connection and soldering of the wires.

On the ends of the connector there is a lug for attachment of the connector and a lug which fits into a slot in the guide strip for the printed board assembly. Thus the connector and guide strip together position the printed board assembly accurately irrespective of deviations in the dimensions of the shelf in other respects. Figs. 7 and 8 show the connector viewed from the plugging-in and from the wiring side.

The contact spring is made of 0.4 mm nickel brass strip. The spring is U-shaped and surrounds the sides of the printed board assembly. The contact forces are thus enclosed in the contact spring and do not load the connector body. The shanks of the U-shaped contact springs are cut up, thus providing two contact points on each side of the printed board assembly. The material in the spring contact points is a rolled-on inlay of gold, 5 μm, on a junction of likewise rolled-on inlay of nickel. The rolled-on inlay provides an extremely dense gold coating and, in combination with the gold contacts of the printed board assembly, ensures a very low and stable contact resistance, which well complies with the requirements for low level circuits.

The contact spring snaps into the connector body and, if necessary, can easily be removed or replaced.

For connection of the printed board assembly to the neutral plane of the rack there is a special tag which connects contact no. 16 of the connector to the mounting plate, at the same time forming a soldering tag on contact position no. 15. Two kinds of clamps permit connection of 5 mm^2 cable to the connector via four or two contact springs. A connector with cables connected is shown in fig. 8.

Memory Unit ROM 126 001 in AKE 13

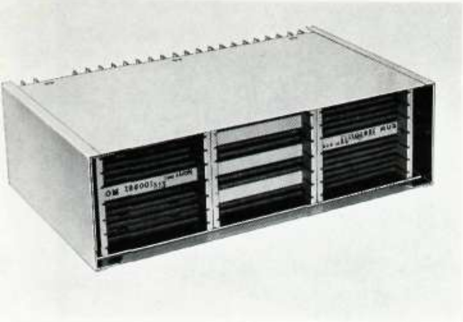


Fig. 9
Memory unit ROM 126001

The memory unit forms part of a core store with a cycle time of 2.4 μs. Its capacity is 8192 words with 17 bits per word. The seventeenth bit is used for parity check. The memory unit (fig. 9) is connected to a similar memory unit by its printed board plugs via connectors in the neutral plane of the rack, and the two units with associated printed board assemblies together form a complete module with 16,384 words.

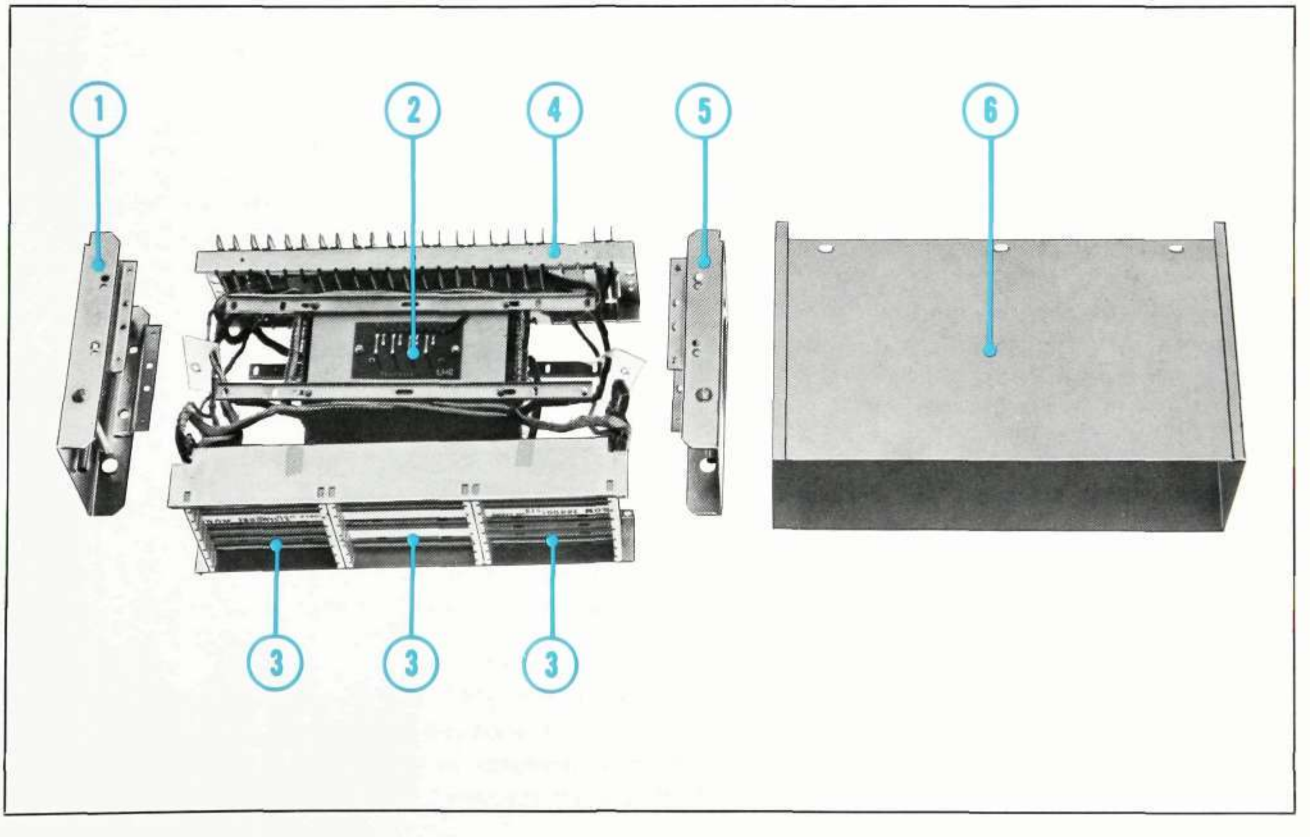
The dimensions of the memory unit are: height 99.5 mm, depth 213 mm and width 346 mm. It thus occupies 26 board positions with 13 1/3 mm spacing in a shelf. It is attached by two screws to rods in the neutral plane. During screwing-in of the unit the plug-in boards of the memory unit are inserted in the jacks. The screws are accessible from the front through tubes in each end-piece. The screws should be tightened alternately, one turn at a time, so that no damage is done to the plug-in boards. Wrong placing is prevented by mechanical coding, which consists of two pins in the memory unit and corresponding holes in the rods.

The memory unit consists of a frame surrounding the core stack. On the rear are plug-in boards for input and output signals and for attachment to the other memory unit. Printed board assemblies with diodes for selection of word in the memory plug into jacks on the front. The memory unit is enclosed under a cover and its parts are shown in fig. 10.

Fig. 10
Parts of the memory unit

① Frame end-piece
② Core stack
③ Frame front with connectors
④ Frame with plug-in boards
⑤ Frame end-piece
⑥ Cover

The core stack is screwed to four bars in the frame. The stack consists from bottom to top of base plate, connecting plate, nine double-sided core planes,



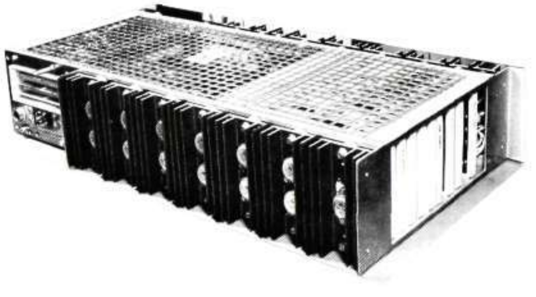


Fig. 11

Fig. 12

Fig. 11
Power pack BMN 261, rear view

Fig. 12
Power pack BMN 262, front view

connecting plate and top plate. The parts are held together by bolts to form a stable unit. Top and base plates serve for protection. The connecting plates have soldering tags shaped for connection both internally within the stack and externally via cables to plug-in boards and connectors.

A core plane consists of a frame with soldering tags and contains four layers, each consisting of 64×64 ferrite cores. The cores are sized 30 mils (0.03 inch) corresponding to about 0.8 mm outside diameter, 0.5 mm inside diameter and 0.2 mm height. Wiring and core orientation are arranged on the 3 D coincidence current principle with four wires through each core. The wire is of copper and is insulated with urethane, which is protected against damage by a coating of nylon. The outside diameter is 0.1 mm. Internally, core place and connecting plates are connected by soldering together of the tags one above the other. Above the core stack there is a printed board assembly with four thermistors which sense the temperature in the stack.

Power Unit — Power Packs BMN 261 and 262

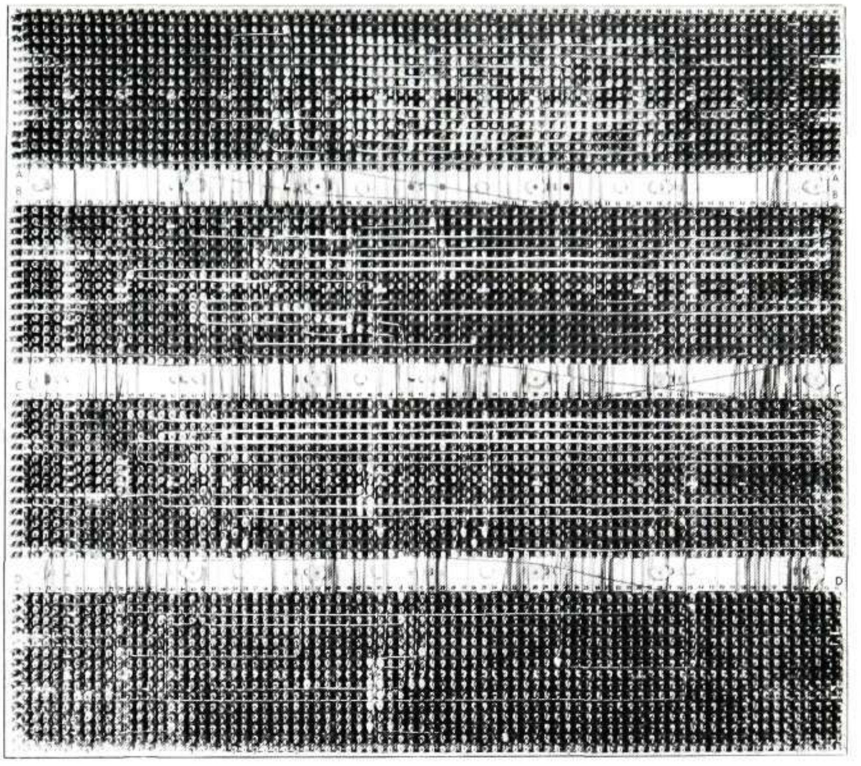
The power supply in each electronics rack is centralized to special power units. The units are fed from central inverters with 380/220 V, 3-phase, 50 Hz, AC voltage and deliver an accurately regulated DC voltage. For protection against interruption of service the units are shortcircuitproof and duplicated.

There are power units both for 3 and 6 module shelves, as shown in figs. 11 and 12.

The power unit rests in the rack on two brackets, one of which has semi-protected connectors for feed and signal voltages. The power units have corresponding connectors and a screw to assist in plugging in and out. This prevents unintentional plugging out and damage to the connectors.

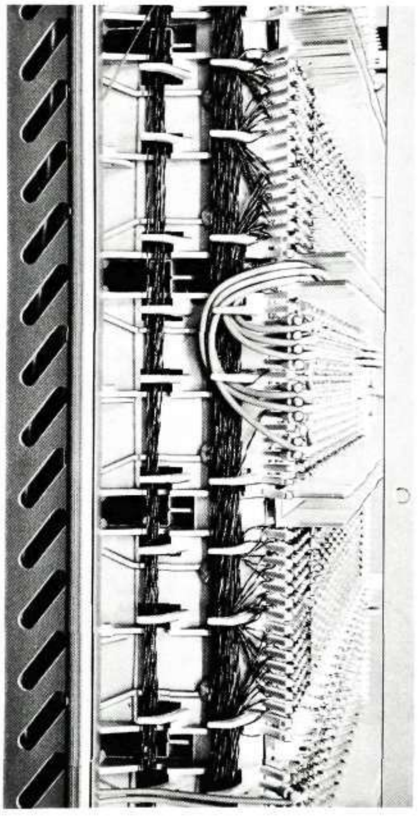
To prevent wrong placing, the power unit is mechanically coded. The coding consists of three pins in the bracket and corresponding holes in the power unit. There are ten alternative positions, so that a large number of code combinations can be obtained.

Fig. 13
Wiring unit



The power pack consists of frame carrying plug-in units, control panel, heat sinks with components, transformers, contactor, connectors, printed board assemblies and cabling. On the upper and lower sides there are perforated safety covers with warning signs.

Fig. 14
Rack wiring



Wiring Principles

Rack Wiring

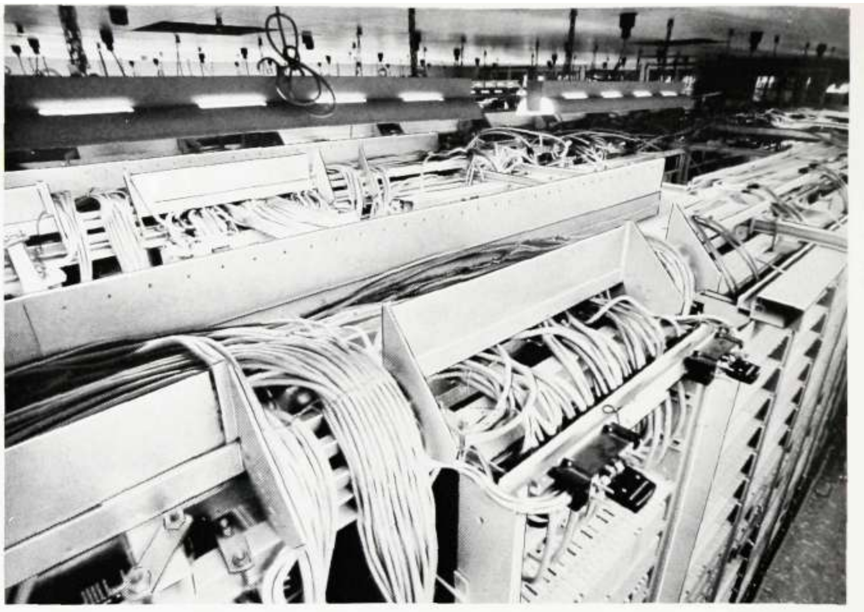
The sensitivity of the electronic circuits to interference excludes wiring with conventionally formed cables. Instead the direct wiring method is used, which implies that the wires are taken the shortest route between the soldering tags in specific runs as close to the neutral plane as possible.

The wiring consists of 0.4 and 0.6 mm nylon-insulated wire. For soldering of the wire to the terminal the nylon insulation is melted at the same time as the solder is applied. A wire guide and wire fastener are used as aids in wiring, and the wire is placed in runs formed by plastic pillars in the connector drawn around the soldering tags. At the same time as the pillars constitute wire guides, they protect against cutting through the insulation of the wire.

In order to be able to work as far as possible with easily handled units, the rack wiring is done in stages. In the first stage all internal wiring is done within each wiring unit (fig. 13). The wiring unit is then mounted on the rack. In the second stage the remaining rack wiring is done (fig. 14). The neutral planes of the separate wiring units are also connected to the common neutral busbar of the rack.

Other steel and metal parts in the rack are connected to a common earth wire within the exchange (protective earth).

Fig. 15
Cable runways and upper part of the rack



Wiring on Installation Site

The cabling to the rack runs in runways on the top of the rack. An extra runway can be placed under the main runway and used for bus cables. Incoming power cables to the rack are connected at the bottom of the rack, where terminal blocks for max. five cables can be placed. Fig. 15 shows a part of the cabling. The principle of the cabling to the rack will be seen in fig. 16.

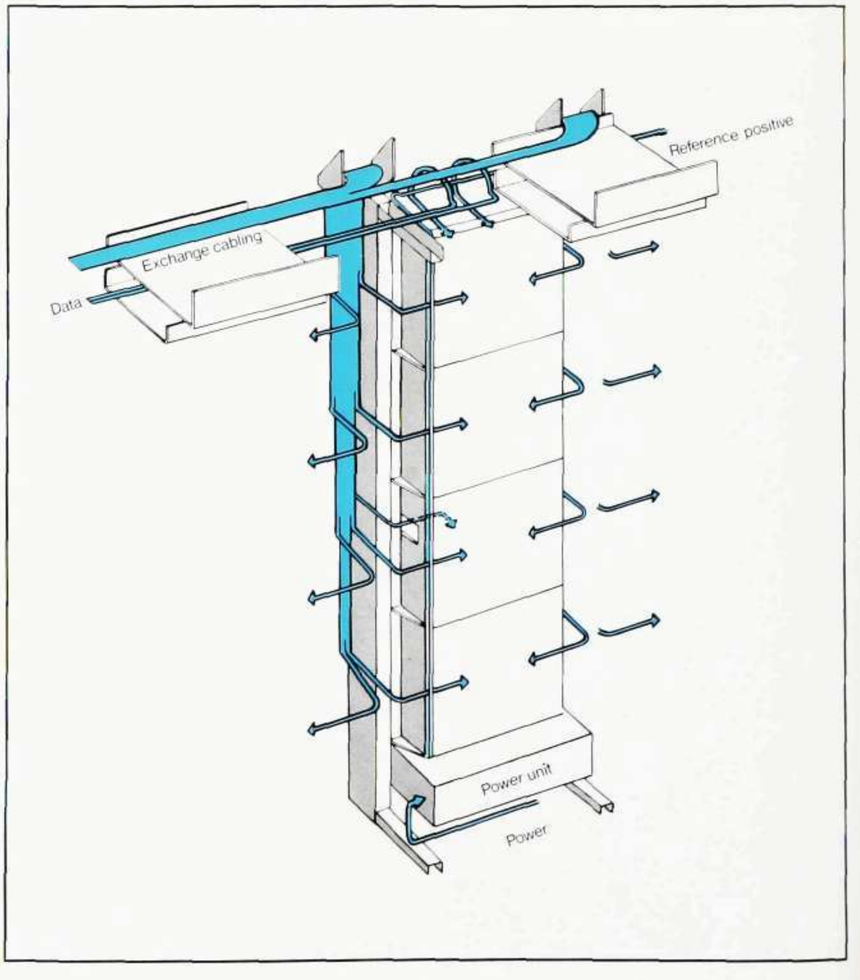
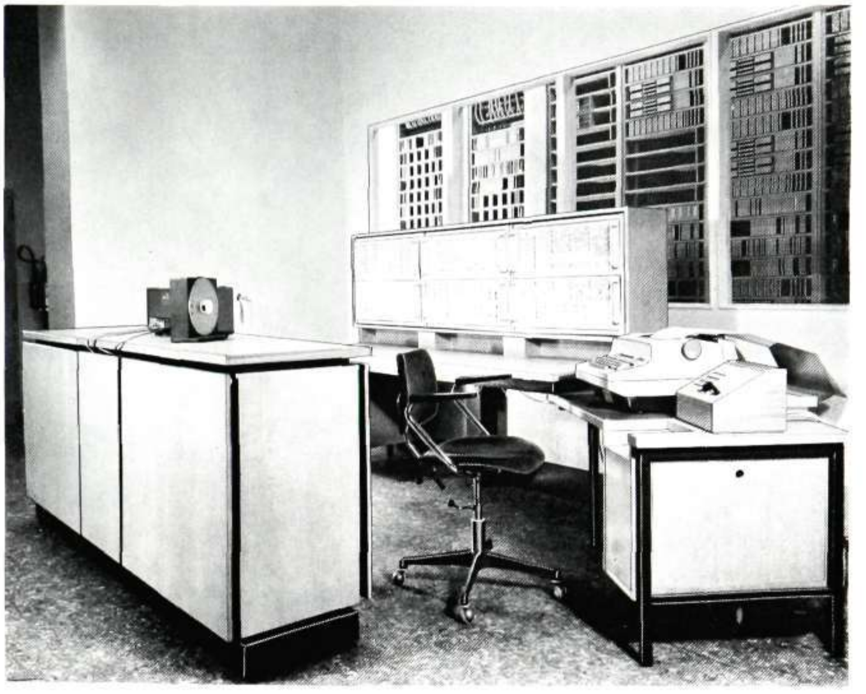


Fig. 16
Principle for connection of cables to the rack

Fig. 17

Control room with operator's desk and cabinet for electronic equipment. On the operator's desk are a programme switch, typewriter and control panel. On the cabinet is seen a reeling unit for perforated tapes and a tape punch.



Control Room

The central equipment for continuous supervision of the telephone exchange and for tests and reprogramming (extensively described in Ericsson Review No. 3, 1968) is, in the larger *AKE* exchanges, placed in a separate control room (fig. 17). A high standard of office furnishing has been arranged. The cables, for example, to the equipment units are concealed in the floor. To facilitate future changes, the floor consists of removable hatches. The furnishing is in light-coloured oak. Electronic equipment and control panels are built into low oak-panelled racks of type *BDE 501*. The units are so designed that the equipment can be easily adapted to different requirements.

New Aerial Cable System for Greater Reliability of Power Distribution

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UDC 621.315.176
LME 78
762
702
7047

Overhead lines have on economic grounds been used hitherto for power distribution in rural districts and small communities. In recent years regularly recurring storms and snowfalls have caused extensive damage to these distribution systems. In some areas thousands of trees have fallen across the lines within the course of a few hours. The repairs required are so extensive that lengthy and, for some subscriber groups, catastrophic interruptions of power supply are unavoidable, which a modern society cannot tolerate without serious complications.

In this situation it was considered necessary to develop new distribution systems, in the first place for low voltage, which ensure a greater reliability of supply at low construction and maintenance costs. The Technical Development Institution of the Swedish Power Supply Authority, the State Power Board and cable manufacturers in cooperation with the Board of Trade have developed a new aerial cable system which well complies with the requirements placed on it. A considerable part of this development work, which has now been concluded, was done by Sieverts Kabelverk. The result is the new aerial cable system ALUS which, with its suspension, branching and jointing devices developed by Sieverts, is presented below.

System Structure

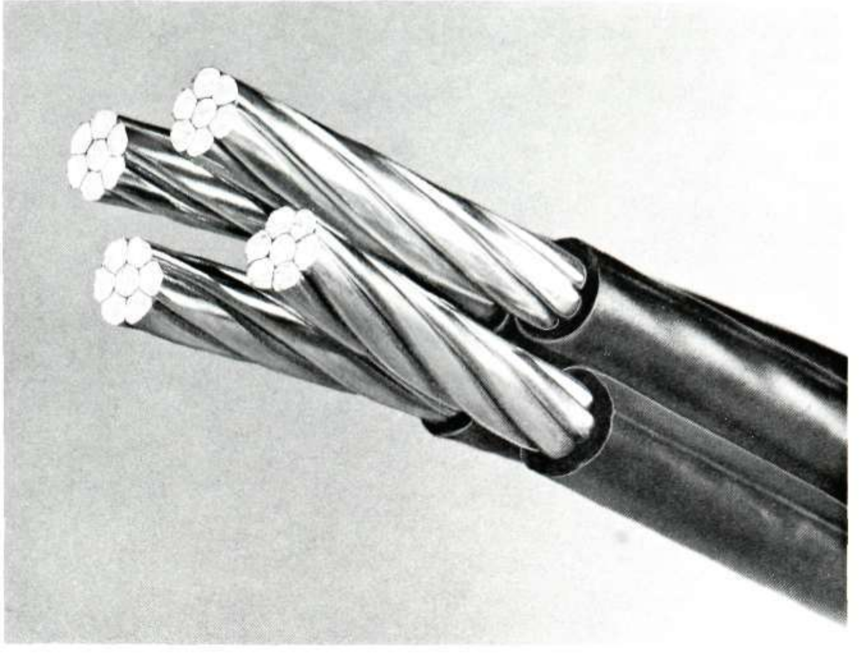
In order to reduce the construction costs a simple type of self-supporting cable was chosen. High reliability of power distribution is achieved through the fact that the cable is suspended in mechanically graded suspenders which, if a tree falls across the line or if the line is subjected to other exceptional mechanical strains, release and allow the cable to fall to the ground undamaged before the strains become so great that there is a risk of damage to conductor or insulation.

In such case the power supply can continue uninterruptedly, since the cable remains on the ground under voltage until a repair gang arrives and hangs it up on the poles again. At branch poles or at a crossing with a road or other lines, where the cable must not be allowed to fall down, suspenders without mechanical grading are used.

Cable Make-Up

The cable is made up of four conductors of hard-drawn pure aluminium wire with symmetrical lay, insulated with polythene of weatherproof quality. Polythene has a high ability to resist point pressure and abrasion and also has a temperature stability which enables it to be handled down to very low temperatures without risk of cracking.

Fig. 1
Aerial cable type ALUS with helical lay



Tests have shown that low voltage cables of this type can support puncturing of the insulation at atmospheric overvoltages without effect on the reliability. Fire tests made in summertime out-of-doors on horizontally mounted cable show that fire in the cable dies out after a few minutes. In order to be able to distinguish the cable cores even in the dark, the outside of the insulation has longitudinal triangular ridges.

The Suspenders

For use on straight-line poles and on angle poles on bends up to 90° Sieverts Kabelverk has developed a mechanically graded suspender of glass-fibre-reinforced polyester with four wedge-shaped self-locking grooves for the cable cores (fig. 2). The mechanical grading is obtained by tapering (turning down) the fore end of the stainless steel suspension bolt. As the taper is situated on the part of the bolt which is protected in the suspender, strains are avoided in the grading zone, which provides a release load with relatively small dispersion. Being placed on the thread of the suspension bolt, the grading can be simply eliminated by screwing the nut past the tapered part of the thread, whereupon the suspender functions without mechanical grading.

Fig. 2
Mechanically graded suspender for straight-line and angle poles

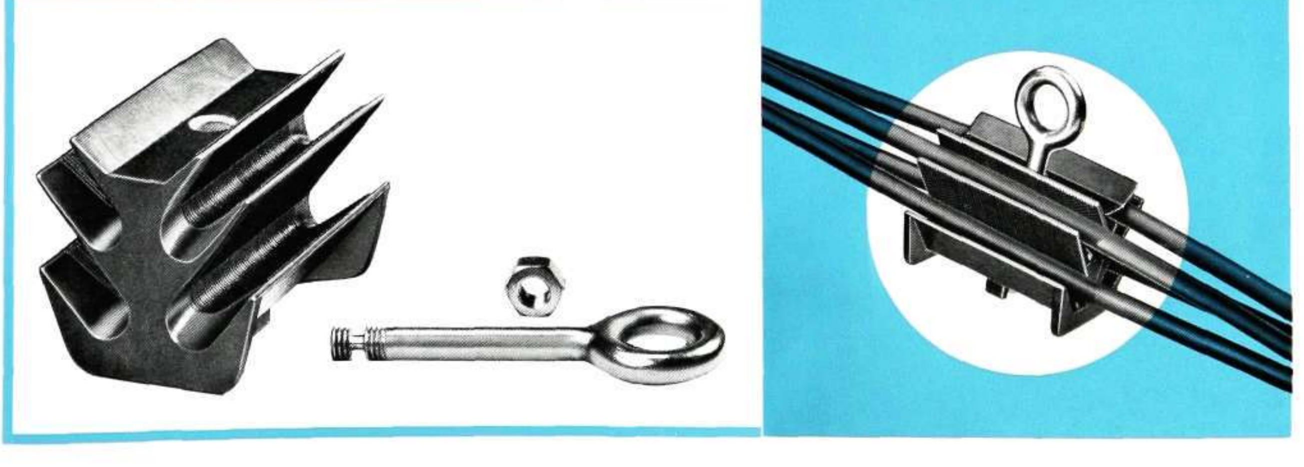
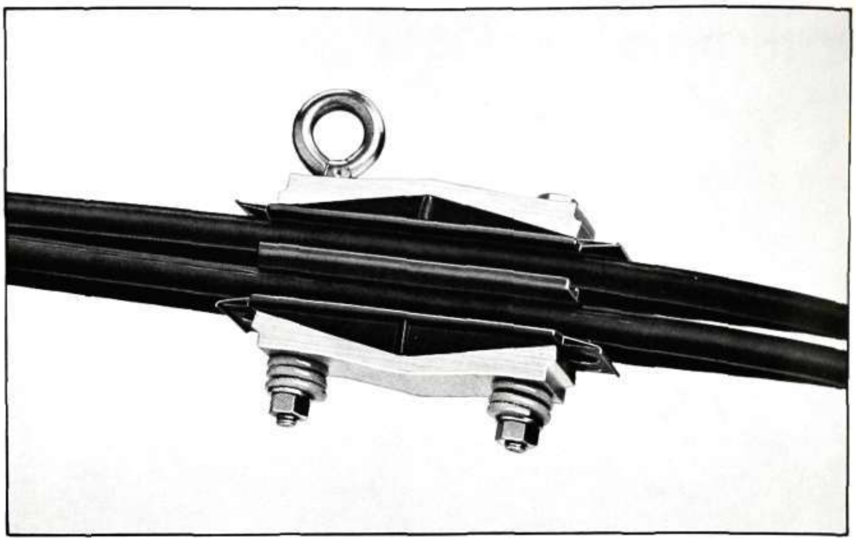


Fig. 3
Non-sliding straight-line suspender for crossing span



As the cable has a helical lay, effective self-locking of the suspender is obtained, which prevents it from sliding at the mechanical strains which may occur. This simplifies the resuspension of a fallen cable span, as no adjustment of the tension of the cable is required. The prevention of slides is also of great significance since, in ungraded state, the suspender is used in combination with branching or drop-wires, in which case the branching point must not be exposed to mechanical strains. The suspender is placed on the cable without other tool than a couple of simple wooden wedges which are used to separate the cable cores so that the suspender can be inserted between them.

At crossover spans a special type of ungraded suspender is used with improved non-sliding properties, having wedges of glass-fibre-reinforced polyester and grooves for the cable cores (fig. 3). The wedges are so shaped that they lock in both directions. The bolts which hold together this device are spring-loaded so that a constant frictional pressure is obtained even on variation of the temperature of the cable.

This device is also used for relieving the strain on the cable at terminal poles and service line terminals, but in such case is supplemented by a sectional fork of galvanized steel (fig. 4).

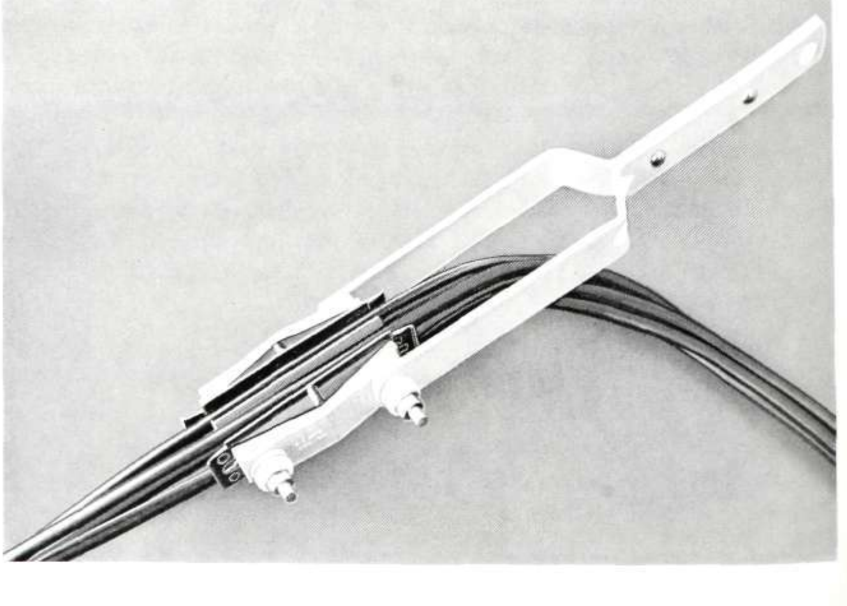
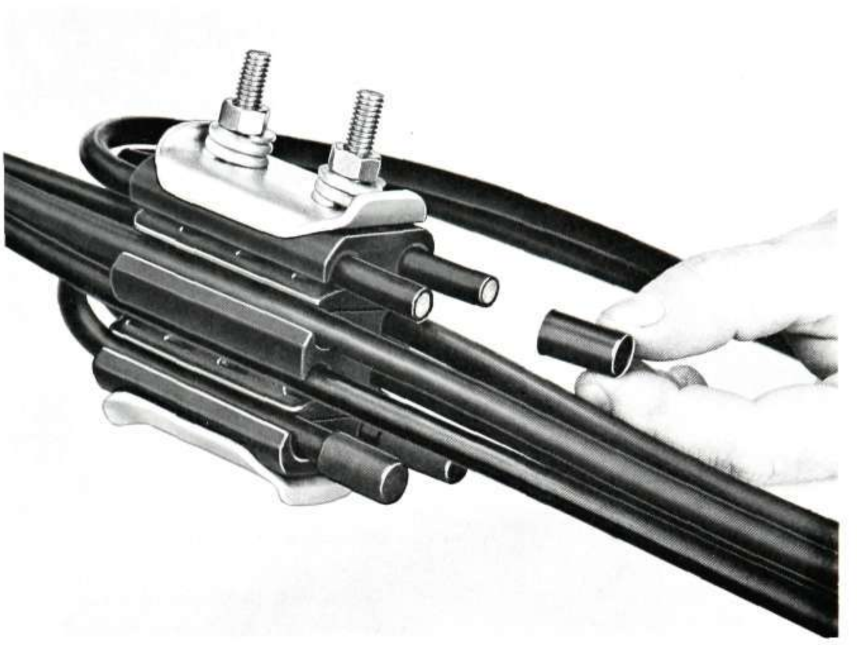


Fig. 4
Strain relieving device

Fig. 5
Branching device with contact pins



Electrical branching is done with a branching device specially developed by Siverts Kabelverk, with contact pins of tempered aluminium (fig. 5). The device is applied direct to the main cable without removal of the insulation. The cores of the branch cable are then inserted in the device, these too without removal of their insulation, and the bolts, which are spring-loaded, are fully tightened, whereupon the contact pins pierce through the insulation and establish electrical contact. No tape insulation is required, as the device is entirely insulated and the insulation is not removed from either cable core during installation. Installation of this device can be done under voltage. The time taken for its installation is about one-tenth of that required for a normal compression-jointed branch with tape insulation.

Long-time stability tests in a tropical chamber under cyclic load and extensive field tests have shown that this branching device is reliable even under severe conditions. The damage caused by the contact pins to the insulation of the cable cores is slight. A simple tape wrapping around each core is the only measure required to restore the cable to proper condition if the device has to be dismantled.

Operational Experience

The described distribution system has been tried out on a large scale in distribution networks in different parts of the country since the autumn of 1968. These distribution networks have withstood a number of storms and the system has functioned admirably. Altogether some 40 km of line of this type have been built hitherto at an average cost which is between 10 and 15 % less than that for a corresponding overhead system.

Transmission of Sound Programmes on Carrier Systems for Telephony

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UDC 621.376.2
621.395.49
LME 84291
7544

This article describes a new modulating equipment for programme channels in carrier systems, based on the double-sideband principle. An account is given of the quality requirements for programme channels and a comparison is made between different methods for programme tranmission.

Even with high circuit occupation, as the number of radio and TV broadcast transmitters increases and broadcasting times are prolonged, a rapid growth is required of the distribution network for collection of programme material, distribution of edited programme to broadcast transmitters and sound channels of television transmitters, and for central programme control and supervision.

The raising of the technical quality, which comprises both reliability and performance, and which in recent years has been introduced for production and transmitter equipment and for receivers, entails high quality requirements also for the distribution network. The transmission of stereophonic programmes involves additional requirements which in some cases may result in the fact that existing transmission networks intended for monophonic programmes become unusable.

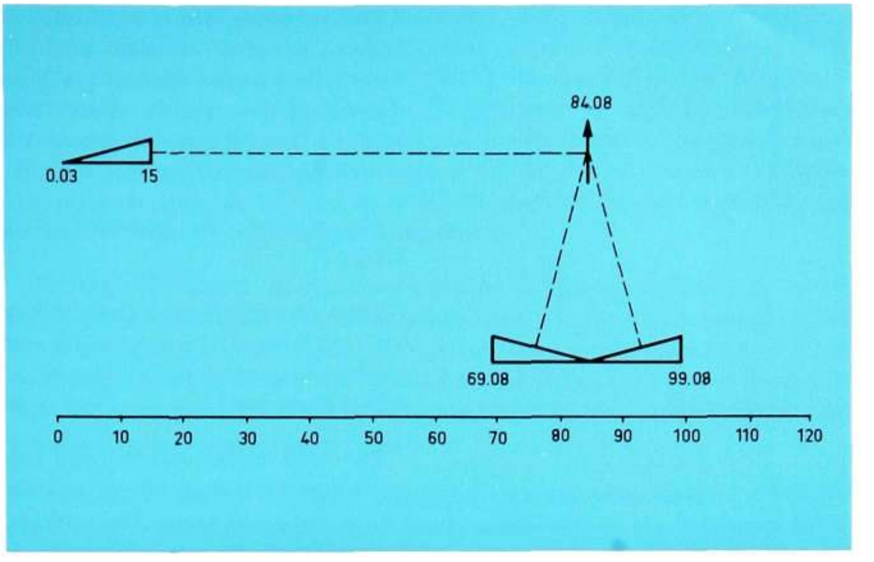
Of the variable programme traffic, the distribution to transmitters constitutes a minor fraction compared with the traffic for programme collection and programme control. For very short circuits, and also for long distance circuits of older types, physical transmission is generally adopted on specially screened programme pairs built into telephone cables.

An increase of the quality requirements for monochannels, especially in respect of bandwidth, entails heavy costs for loading and equalization of loss for physical long distance transmission on cable. Long distance transmission of setereoprogrammes with *A* and *B* signals on separate loaded pairs, equipped with manually settable attenuation equalizers, also results in a very unstable phase condition between the *A* and *B* signal.

The modern carrier system, designed for telephony in accordance with CCITT recommendations, provides the means of achieving high quality programme circuits using the bandwidth of a number of telephone channels for programme transmission. This applies both to mono- and stereotransmission. As a telephone channel has a bandwidth of 4 kHz, a programme channel with the frequency band of 0.4—15 kHz corresponds to four telephone channels. The requirements of through-connection, signal-to-noise ratio and favourable cost distribution between programme terminal and carrier equipment make it necessary to use the bandwidth of even more telephone channels for one programme channel.

As regards the quality of the transmission network, CCITT in recommendation J21 has hitherto indicated values for monochannels. A higher quality, however, is to be standardized by CMTT, which is also considering recom-

Fig. 1
Modulation scheme for programme channel terminal ZAB 1-2



mendations for two-channel stereotransmission. From the draft standard in CMTT/1041 it appears that a high quality programme circuit should be able to transmit the frequency band 0.04—15 kHz. The noise level must not be above —60 dBm0p. For stereoprogrammes it is suggested that these should be transmitted optionally in the form of A and B or M and S signals. Apart from the quality requirements for monotransmission, stereocircuits are also subject to requirements in respect of the permissible level and phase deviation between A and B signals.

Principles for Development of the System

The basic groups of the carrier system, with 48 kHz bandwidth in the frequency range 60—108 kHz, constitute a suitable terminal point for the programme traffic.

The terminal equipment of the programme channel converts the programme band in its basic position, 0.04—15 kHz, to the frequency range of the basic group. The conversion comprises level and impedance as well as frequency band.

The traffic capacity of the group is limited only by the frequency band but also by its load capacity, and this applies in respect both of mean power and maximal power. As the various modulation stages of the carrier system have accurately defined overload limits, these must be respected also by programme signals.

The specified noise level of the carrier system, even at a load of one programme channel in the group, means that the peak level of the programme signal must approach the overload limit of the group in order to maintain the signal-to-noise ratio recommended for the programme channel. The load which would result from two programme channels within the same group (although possible from the frequency aspect) must therefore be accompanied by a lowering of the level for each programme band, due to the probability of simultaneous peak level in both programme bands. This lowering of level implies that the signal-to-noise requirement could not be met in this case without the introduction of compandors.

For the same reason the programme channel must be equipped with a compandor when the group is used for simultaneous programme and telephone traffic.

The transmission of telephone and programme traffic within the same group also entails special problems in the routing of traffic.

The use of the group bandwidth for transmission of two programme bands leads to a system of single sideband type, *SSB*, or vestigial sideband, *VSB*. With a programme channel per group a double sideband system, *DSB*, may also be used, a type of system which was chosen for programme channel *ZAB 1-2*. For all types of system the loading conditions only allow a reduced transmitted carrier frequency level.

Fig. 1 shows the frequency allocation for programme channel terminal *ZAB 1-2*.

Since one programme alone can exploit the overload limit of a group, the test tone level of the programme channel, which is 9 dB below the peak level of the programme signal, can be +2 dBm0 for the *DSB* system compared with the telephony test tone level in the group.

This level implies that the load limit of the group is not exceeded either for mean power or peak power, and that the signal-to-noise requirement is met with a margin to spare. The table below shows a calculation of the signal-to-noise ratio of the programme channel on the basis of the noise level on the telephone chanel.

The level margin between the peak value of the programme signal, +17 dBm0, and the overload limit of the group, +19 dBm0, is intended both for level tolerances of the group and as level range for amplitude limitation.

Calculation of signal-to-noise ratio for AM double sideband programme channel. The calculation relates to the 2500 km hypothetical reference circuit with a load of one programme channel per group. The mean noise per telephone channel is assumed to be 2 pW/km.

Noise level of carrier system	
Weighted noise in 4 kHz band	–51.8 dBm0p
Unweighted noise in 4 kHz band	–48.2 dBm0
Unweighted noise in 16 kHz band	–42.2 dBm0
Level of programme channel in the basic group	
Test tone level per sideband	+ 2 dBm0
Max. level of programme signal per sideband	+11 dBm0
Total max. level of programme signal	+17 dBm0
Level margin to overload limit of the basic group	+ 2 dB
Signal-to-noise ratio of the programme channel	
Unweighted before demodulation	53.2 dB
Unweighted after demodulation	56.2 dB
Weighted after demodulation	52.5 dB
Weighted after demodulation and de-emphasis	60.2 dB

The raising of the signal-to-noise requirement for telephone channels, which is at present being dealt with by CCITT, to values which carrier systems already normally comply with, corresponds for the *DSB* system to a signal-to-noise ratio which is ≧ 60 dB and applies to the 2500 km reference circuit.

The 84.08 kHz carrier frequency is transmitted at a level corresponding to that applying for the group pilot in telephone operation. In that way the ordinary supervision and regulating equipment of the basic group can be used also for programme traffic.

Tests with *SSB* and *VSB* systems snow that they require complicated filters both for suppression of the unwanted sideband and for through-connection of the programme band on branching from the carrier system. The effect of the flank of the filter curve on phase deviation between frequencies close to the carrier frequency also entails complicated phase equalization for stereotransmission. As the *A* and *B* signals are transmitted via different modulation equipment, the frequency error of the carrier system between transmitter and receiver causes a different frequency error for the *A* and *B* signals. To maintain phase coincidence between these signals, therefore, special measures must be taken in respect of this frequency difference.

For the *DSB* system the filter requirements are greatly simplified. A double sideband signal also contains information about the carrier frequency, which has been exploited by equipping the receiver with carrier regeneration. In this way the programme band is not affected by the frequency error of the carrier system, which is of great significance for monochannels and, especially, for phase coincidence in the stereochannels.

On transmission of *A* and *B* signals on adjacent basic groups within the same supergroup a phase deviation nearly constant with the frequency is obtained, which may amount to about 60°. A correction of this phase error implies a parallel displacement of the phase for one *DSB* signal. This can be done with a relatively simple and continuously adjustable phase network. The absence of a compandor implies, apart from simplified equipment, that the percentage of overloading time for a supergroup, caused by the fact that several groups within the same supergroup transmit the same programme, can be limited with greater assurance. Nor is there any special requirement in respect of amplitude/amplitude response, distortion of which may affect the stereophonic quality among other factors.

Circuit Description

Fig. 2 shows a block schematic of the terminal equipment of the monoprogramme channel.

The relative levels given for the low frequency sides of the transmitter and the receiver correspond to those recommended by CCITT for an international programme connection.

The sound programme is fed from the transformer to the modulating unit, which has a pad on its input for level adjustment to the following low-pass filter, pre-emphasis network, amplitude limiter and modulator.

The main task of the low-pass filter is to suppress noise within the 69.08—99.08 kHz frequency range. Otherwise, this would pass as a direct leak through the modulator and reappear in the programme band on the receive side. The pre- and de-emphasis networks follow CCITT recommendations. Both of these units can be replaced by pads corresponding to the loss produced by the pre-emphasis network at a frequency of 800 Hz or 1000 Hz. Since the networks are designed with such great precision that they produce practically no frequency distortion, they should generally be left in circuit in order to improve the signal-to-noise ratio.

To prevent overloading of the carrier system, the input has been equipped with an amplitude limiter. This enters into operation at levels of +9 dB referred to test tone level. For input levels from +9 to +20 dB referred to test tone level the output level rises by max. 1.5 dB.

The 84.08 kHz frequency is injected both into the modulator as a carrier frequency and into the group band for transmission to the receiver equipment of the other station. The level of the carrier frequency in a group corresponds to the −20 dBm0 pilot level used in telephone transmission.

Before the 84.08 kHz carrier frequency is injected into the sending modula-

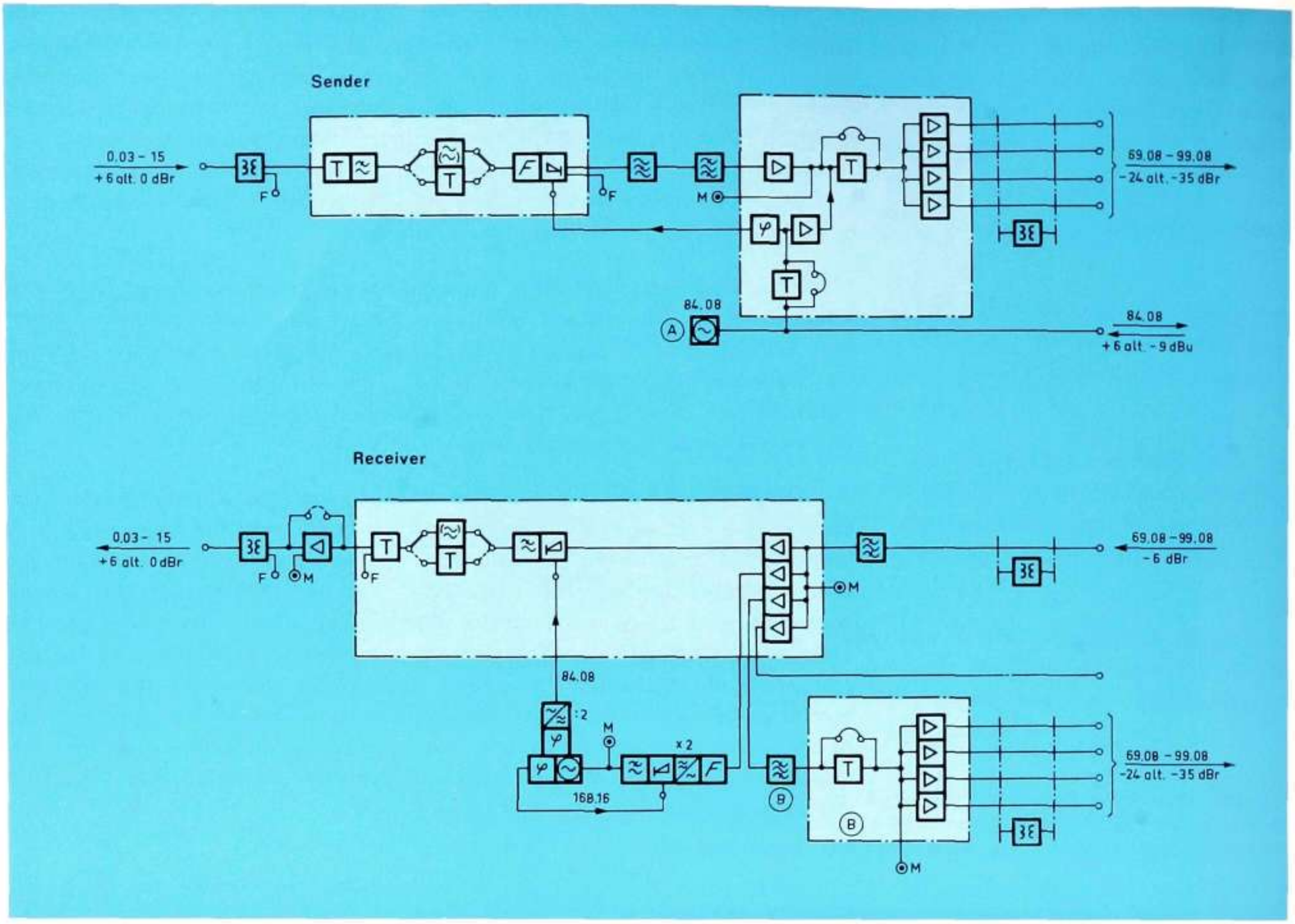


Fig. 2

Block schematic for programme channel ZAB 1-2

A Equipment for internal generation of carrier frequency
B Additional equipment for through-connection
M Maintenance test point
F Fault test point
Frequencies in kHz

tor, it is passed through a phase adjusting network. This network is so adjusted that the carrier, which in the receive equipment at the distant station is recovered by demodulation from sideband signals at a sufficiently high signal level, is in phase with the pilot frequency which is directly extracted from the transmitted line frequency band.

This phase coincidence is necessary to prevent a phase shift in the regenerated carrier frequency as the signal level varies.

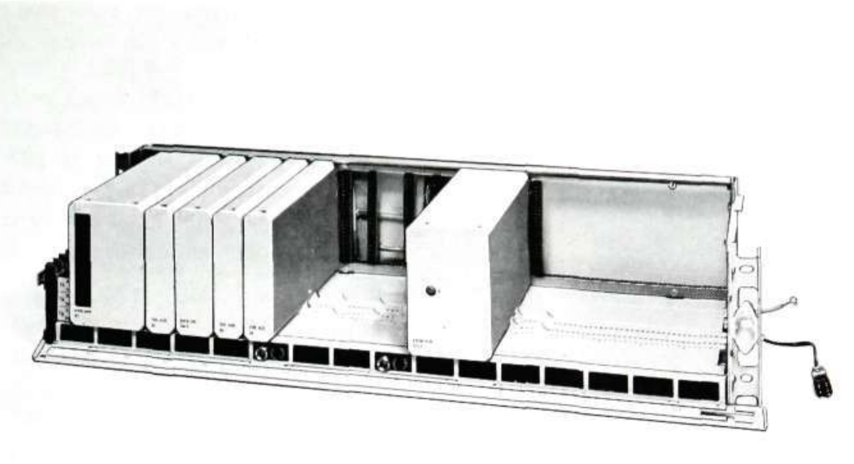
An 84.08 kHz stop filter comes after the modulator and prevents carrier leaks from affecting the subsequently injected 84.08 kHz pilot frequency. The stop filter is followed by a 68—101 kHz band-pass filter, which in addition to limiting the modulated programme band also suppresses noise outside the 60—108 kHz basic group band.

From a distributor with four parallel outputs the modulated programme band is connected to the group transmitter of the carrier system.

For generation of the 84.08 kHz frequency the transmitter equipment can be provided with an oscillator with frequency stability 1×10^{-5} and output level +6 dBu. This oscillator can supply up to two transmitting equipments.

If there is already equipment in the station for central generation of the 84.08 kHz pilot frequency, the transmitting equipment can be supplied from it. The input impedance is 75 Ω and the input level in this case +6 dBu or −9 dBu. On the receive side the modulated programme band, 69.08—99.08 kHz, first passes through a band-pass filter. After being filtered the frequency band is taken to the demodulator, which is built integrally with distributor, low-pass filter, de-emphasis network and a pad for level adjustment to an output amplifier if required. If there is a carrier leak from the carrier system, a stop filter is connected between distributor and demodulator.

Fig. 3
Programme channel shelf
Transmitter shelf with apparatus for one mono-channel and 84.08 kHz carrier frequency generator



From the distribution section of the demodulator the modulated programme band can be taken out over separate outlets to external pilot monitoring equipment, via a band-pass filter to a four-outlet distributor for through-connection and distribution, as well as to arrangements for carrier regeneration. The modulated programme band can be distributed from the through-connection distributor to four group senders.

The two band-pass filters in the through-connection equipment provide sufficient attenuation for telephone signals outside the 60—108 kHz band.

The carrier frequency regeneration is effected by a phase discriminator which converts the *DSB* signal to a signal for frequency control of the *LC* oscillator which generates the 84.08 kHz carrier frequency.

At a 90° phase shift between these signals the d.c. voltage component from the phase discriminator has a value of 0 volts. Via a low-pass filter, which serves to suppress the a.c. voltage component, the signal is applied to a capacitance diode in the tuning circuit of the *LC* oscillator. A phase variation between the signals, caused for example by the tendency to frequency deviation of the *LC* oscillator, results in a change in the d.c. voltage component which corrects the *LC* oscillator to the original phase.

Conversion of the *DSB* signal to a control signal for the phase discriminator is effected both by symmetrical amplitude limitation in two stages and by full-wave rectification. The voltage peaks from the zero passage of the *DSB* signal after rectification contain the frequency 2×84.08 kHz. This rectified signal is reversed in phase and applied to a limiting circuit for subsequent conversion to a square wave, which is applied to one input of the phase discriminator.

The procedure implies that the control signal is unaffected by the modulation envelope of the *DSB* signal, with the exception of the range corresponding to the zero passage of the modulation envelope. In this range the control signal may disappear for a very short time. By suitable design of the low-pass filter after the phase discriminator the effect of this on the *LC* oscillator is suppressed.

As the *LC* oscillator must provide the same frequency as the control signal, 168.16 kHz, the output of the oscillator to the demodulator has been equipped with a frequency divider. The output has also been equipped with a phase adjusting network for adjustment of the maximal signal in the demodulator.

Mechanical Construction

The programme-channel terminal equipment is entirely engineered according to L M Ericsson's *M4* construction practice for transmission equipment. *M4*, and the design of the system in other respects, result in a very great saving of space compared with earlier models and offer great flexibility in the planning and construction of transmission facilities. The principles of the *M4* construction practice are given in Ericsson Review No. 3, 1966.

The units are assembled on printed-wiring boards, which are enclosed in aluminium cases for screening and dust-protection purposes. The units are plugged side by side into the shelves, which have connectors for the units, cabling for inter-unit connections, and connections to the station and bay cabling, power supply, etc.

The shelf is designed for fitting to a bay frame of L M Ericsson's standard design. The shelf cabling is in this case connected to the station cabling by jacks and multiway plugs.

A shelf measuring 597×236×120 mm corresponds to the space requirement for all apparatus associated with two transmitters for monochannels. A shelf of the same size can be equipped with two receivers for monochannels. The shelves are designed for connection to the central power supply equipment of the bay. Figs. 3 and 4 show transmitter and receiver shelves equipped with apparatus for one monochannel.

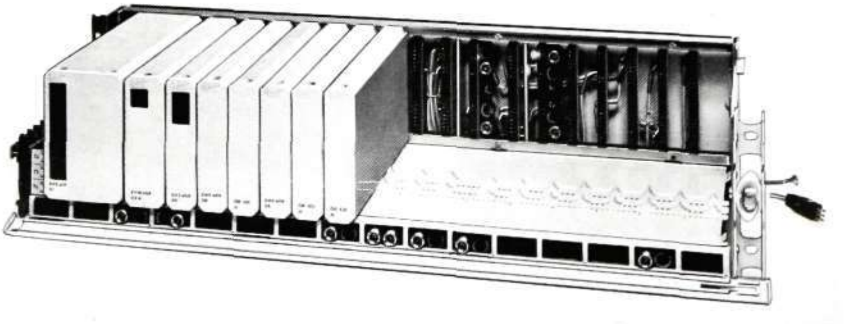


Fig. 4
Programme channel shelf
Receiver shelf with apparatus for one monochannel

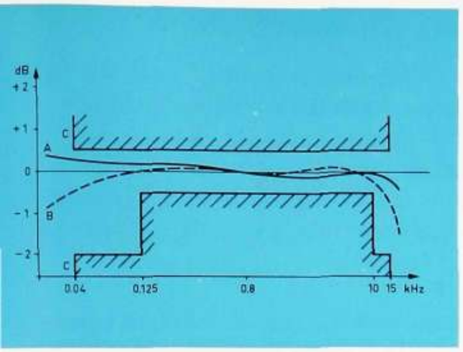


Fig. 5
Attenuation curves

- A Typical attenuation curve for looped programme channel terminal type ZAB 1-2
- B Typical attenuation curve for programme channel type ZAB 1-2 for transmission over 2500 km on carrier system
- C Maximal level deviation relative to 800 or 1000 Hz for the 2500 km hypothetical reference circuit according to Doc. CMTT/1041

Technical Data

Frequency ranges	
Low frequency programme band	40—15,000 Hz
Programme band, basic group side	69.08—99.08 kHz
Carrier and pilot frequency	84.08 kHz
Nominal level for test tone, carrier frequency and pilot	
Low frequency side, transmitter and receiver	+ 6 or 0 dBr
Basic group side, transmitter, per sideband	−24 or −35 dBr
Basic group side, receiver, per sideband	− 6 dBr
Carrier frequency, transmitter	− 6 or −9 dBu
Pilot 84.08 kHz, basic group side	−20 dBm0
Nominal impedance	
Low frequency side, transmitter	600 Ω bal. or unbal.
Low frequency side, receiver	600 or 0.3 Ω bal. or unbal.
Basic group side, transmitter and receiver	75 or 150 Ω bal. or unbal.
Carrier frequency input, transmitter	75 Ω unbal.
Return loss, basic group side, transmitter and receiver	> 20 dB
Attenuation distortion	
Looped terminal equipment as in fig. 5, curve A	
Typical attenuation curve for 2500 km. Transmission as in fig. 5, curve B	
Level stability	
Long-term stability for transmitted frequency band operating within temperature and supply voltage range for *M4* transmission equipment	< ± 0.3 dB
Noise	
Looped terminal equipment, weigthed and unweighted, at +6 dBr point	< 1 mV
Typical value for CCITT 2500 km hypothetical reference circuit, weighted or unweighted, at +6 dBr point	< 4 mV
Harmonic distortion AK_2, AK_3	
Typical values for CCITT 2500 km hypothetical reference circuit, with low-frequency signal level +15 dBm	> 45 dB
Group delay distortion	
Looped terminal equipment	
t30-tmin	< 12 ms
t100-tmin	< 6.5 ms
t15,000-tmin	< 5 ms
Power consumption	
Supply voltage	21 V
Transmitter shelf, per transmitter	2 W
Oscillator 84.08 kHz	0.5 W
Receiver shelf, per receiver	4.2 W

Costs For Different Programme Channel Systems

Apart from physical transmission on cables and programme channels in carrier systems, use is also made of radio link systems for frequency-modulated transmission of programme channels. The radio link system used for distribution of TV signals can also transmit a number of programme channels in addition to the sound channel belonging to the TV signal. These programme channels, the number of which is limited, are normally used only for part of the requirement for the regular distribution network.

The radio link system forming part of the cost comparison in fig. 6 corresponds to the system for transmission of six programme channels dealt with in Report 190 CCIR Vol. IV. As frequency modulation of the programme bands is adopted in this case, six programme channels require the same bandwidth as 300 telephone channels. This implies high h.f. line costs and accordingly high construction costs also for relatively short transmission sections, which applies likewise to physical transmission on cables.

For programme channels on carrier systems, a comparison shows that the *DSB* system has higher h.f. line costs than the *SSB* system owing to the need for larger bandwidth in the *DSB* system. For the terminal cost the reverse applies. In the *SSB* system the cost of programme channel terminals is twice as high as in the *DSB* system owing to differences in the requirement of compandors, filters, carrier frequencies and space.

A termination with simultaneous through-connection of the programme band in basic group position implies for the *DSB* system a cost which insignificantly exceeds the terminal cost. For the *SSB* system this increase of cost may be considerable and, for certain operating conditions, may be the same as for basic group through-connection filters for telephony.

Apart from the terminal cost for the programme channel, the relative costs shown in fig. 6 include the cost for the carrier system terminal. They also include the h.f. line cost, which for all cases is the marginal cost per programme channel.

For coaxial systems this implies that the calculation is based on the cost per new channel-kilometre for conversion of the system from, for example, 4 MHz to 12 MHz. As regards radio link systems the costs for aerials, masts, power equipment etc. are not included. For coaxial systems this marginal cost will be practically independent of the system capacity, and twice as high for small-diameter as for normal-diameter coaxial cable.

For radio link systems this cost diminishes with the system capacity, but is of the same order of magnitude as for coaxial systems.

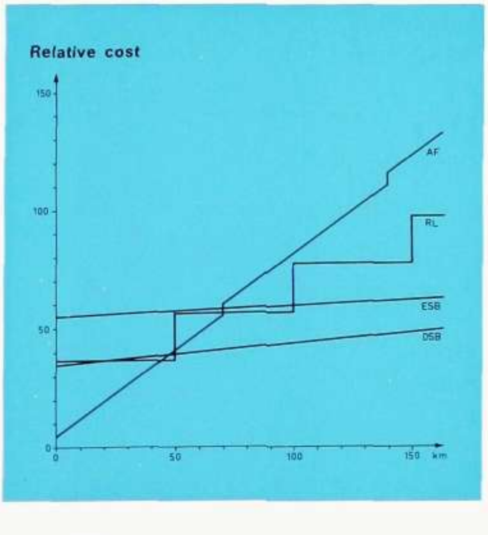
Fig. 6 shows that the *DSB* system yields the lowest installed costs for transmission sections down to about 50 km. This implies that from the economic aspect, a carrier system can be utilized for high quality programme transmission even over relatively short distances.

With this method of calculation for the h.f. line cost the installed cost of the *SSB* and *DSB* systems will be equivalent for about 500 km transmission on small-diameter coaxial systems. For normal-diameter coaxial and wideband radio link systems, and when branching with through-connection of the programme band occurs, equality of cost occurs only at considerably longer transmission distances.

Fig. 6

Relative construction costs for two-way sound channels

- AF Physical transmission, screened pairs, 0.7 mm. Two-way on same pair (simplex)
- RL FM/FM transmission, radio relay link system
- ESB Transmission with single sideband, small-diameter coaxial system
- DSB Transmission with double sideband, small-diameter coaxial system



ERICSSON News

from All Quarters of the World

Swedish Telecommunications Administration and LM Ericsson Form Development Company and Establish Collaboration in Production Questions

The Swedish Telecommunications Administration (televerket) and Telefonaktiebolaget L M Ericsson have concluded an agreement to form a *jointly owned development company* for the purpose of pursuing advanced development work with the main emphasis on electronic applications within telecommunications. The formation of this jointly owned development company is a natural extension of many years of collaboration in development work. It is suggested that the company shall be called ELLEMTEL Utvecklings Aktiebolag (Development Company).

The agreement was signed on April 24 by the Director General of televerket Mr *Bertil Bjurel*, and by the Chairman of the Board of L M Ericsson, Dr Marcus Wallenberg, and its President, Mr Björn Lundvall.

The plans will soon be submitted to Parliament and to the Board of L M Ericsson. If their approval is obtained during the spring, it is calculated that the new company will start its activities by August 1 this year.

The company will have a share capital of 10 million kronor owned *equally by televerket and* L M Ericsson. It will be located in the Stockholm area, but the actual site has not yet been decided on. Staff will be recruited primarily from televerket and L M Ericsson. Within two years it is calculated that the number of employees will be 400, and within five years 600.

Televerket and L M Ericsson intend to propose as president of the company Mr Erik Eriksen, who is at present technical head of L M Ericsson's Long Distance Division.

Joint Effort for Intensified Development

The development company will conduct development and design within the fields of automatic switching and digital transmission systems for telecommunications, with associated subscriber equipment. The company will not conduct manufacture but the products designed by the company will be manufactured by the two partners.

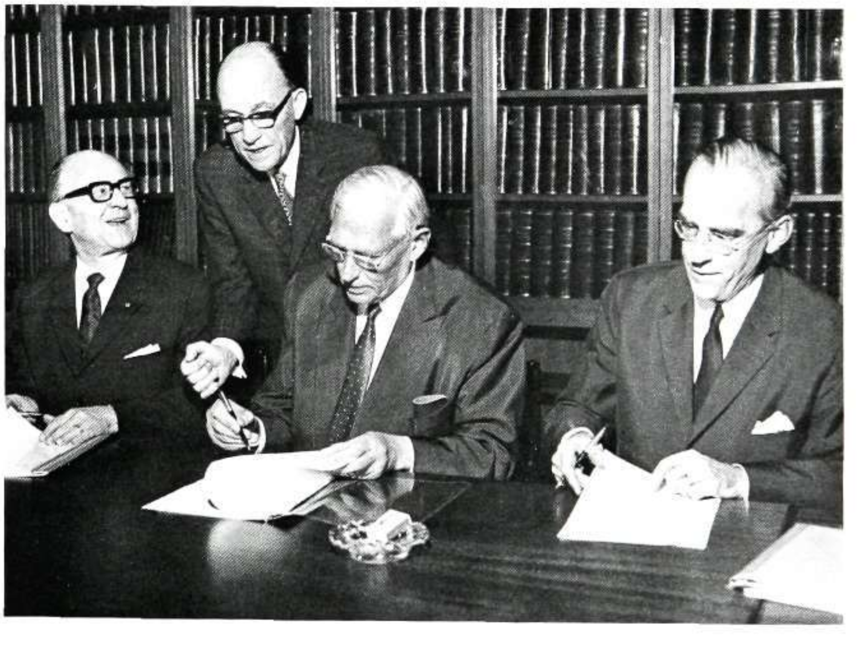
The activities will be directed to the use of new technique for the development of systems adapted to meet future requirements within the telecommunications field. The work of the company will consist principally of development projects commissioned by the partners. Certain *independent development work, however*, may also be done within limits specified by the partners.

For development projects which lie outside the field of activities of the new company, and for assignments not suited for joint projects, televerket and L M Ericsson vill retain their own development departments.

Collaboration within the Production Field

Through the joint product development resulting from the activities of the development company, advantageous cooperation can take place in respect also of the production of telecommunications equipment.

Televerket and L M Ericsson have therefore decided to enter into collaboration in the production field in order to provide better prospects of profitable expansion of the industrial activities of each party. The aim of this collaboration is that both parties shall participate in the manufacture of technically advanced products of interest from the marketing aspect. The collaboration will result in a structural rationalization which is of vital significance for achieving a



From the signing of the agreement between televerket and L M Ericsson. (From left, sitting) Director General Bertil Bjurel, televerket, Chairman of the Board of L M Ericsson, Dr Marcus Wallenberg, and its President, Björn Lundvall. (Standing) Olof Hult, L M Ericsson.

manufacturing process which meets the high requirements of efficiency and effectiveness characteristic of the modern telecommunications industry.

L M Ericsson, through its marketing facilities throughout the world, has greatly expanded its Swedish factories. The televerket factories have hitherto concentrated principally on supplying the needs of televerket. This joint drive for intensified development in conjunction with collaboration in production will enable the televerket factories to assign parts of their production to other parts of the world through L M Ericsson's marketing organization. In this way, and through televerket's direct sales on the Swedish market, it is envisaged under the agreement that the production of televerket and L M Ericsson within the joint product field in Sweden will in future develop at the same pace.

The expansion which collaboration in development and production will make possible for the parties is of importance in respect both of employment opportunities and of conditions for effective production.

Rational use of the National Resources

The main part of televerket's activities is the operation of the Swedish telephone network and to furnish the best possible service at a reasonable cost. The various services offered must be of a high standard and on a level with those offered in other advanced telecommunication countries. As the Swedish telecommunications network is an integral part of the international network, televerket must also ensure that international traffic can be handled quickly and reliably and in accordance with international standards. Televerket has for a long time manufactured telecommunication equipments and its production today covers about two-thirds of its needs in respect of switching and subscriber equipments.

L M Ericsson must be able successfully and profitably to compete with other leading telecommunications manufacturers in the world. Sales and marketing must be conducted throughout the world and be supported by a highly developed technique and effective production. L M Ericsson has today 130 telephone administrations or telephone operating companies as its customers, all with their special demands and desires. Manufacture in its own factories and under licences is at present carried out by 26 companies abroad.

Wide-ranging Cooperation Extending over Many Years

Televerket and L M Ericsson have cooperated in research and development over a long period and in many fields. Examples are the development of modern telephone exchanges based on crossbar switches in which televerket has made pioneering contributions and Sweden today occupies a leading position in the world. The development of computer-controlled telephone exchanges, the design of the Dialog telephone, the development of the coaxial cable system for increasingly large transmission capacities, and theoretical and practical studies in the field of telephone traffic, are other examples of fields in which televerket and L M Ericsson have conducted far-sighted and fruitful cooperation.

Joint development has many advantages. Televerket will obtain access to the great technical resources and extensive international experience of the Ericsson Group. Through the more permanent cooperation with so advanced a telecommunications administration as televerket, L M Ericsson will obtain an increased access to the Administration's extensive operating experience, which can be put to use in product development. L M Ericsson can thereby increase its competitive power on the international market. The development of products within the telecommunications field will require other and far more expensive efforts in the future than hitherto. The joint development activities of the new company will therefore bring to both parties essential technical and economic advantages.

Televerket and L M Ericsson supplement one another to a large extent. There is therefore a natural basis for success in the closer collaboration now initiated through the formation of the new company.

The joint development work will be accompanied by collaboration in the production field. With the form that this collaboration has been given there are good prospects that its aims will be fully realized. Both parties hope for a satisfactory rate of expansion within the joint product field and for a structural rationalization and increase of efficiency which will provide satisfactory employment opportunities and a high level of profitability.

The essential feature in the new expanded collaboration is a joint will to coordinate development and production so that Sweden's scarce resources can be put to the best possible use.

L M Ericsson's new factory at Thalnepantla, a suburb of Mexico City, is now under erection. The first stage, comprising about 31,000 m², is expected to be completed by the beginning of 1971. The second stage will be completed by 1975. The plant will then comprise a total of 67,000 m² and provide work for 2500 employees.

Deutsche Ericsson GmbH, L M Ericsson subsidiary in Dusseldorf, has moved into its new building on Adlerstrasse. Apart from office accommodation there is also a spacious staff dining-room and a more than 80 m² exhibition room in which visitors and customers can be given a survey of the Group's activities and manufactures.

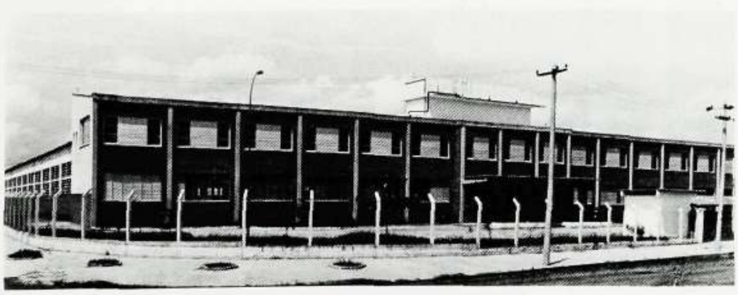
In April this year the Hungarian Foreign Minister, János Péters, visited L M Ericsson's main factory at Midsommarkransen. Here he is seen with Fred Sundkvist, LME (right).

During his visit to Brazil at the month end Feb./March 1970 the L M Ericsson President, Björn Lundvall, visited, among others, the President of Brazil, Emilio Garrastazu Médici, seen in the centre. (Left) Mr Geraldo Nóbrega, Ericsson do Brasil and (right) Mr Lundvall.

During the same journey Mr Lundvall met the Brazilian Minister of Communications, Col. Hygino Corsetti (left).

Crown Prince Carl Gustaf during a visit to L M Ericsson's Östersund factory. He is speaking to Miss Eva Solem and in the background (from left) are the Provincial Governor H. Gustafsson, Chairman of the Town Council N. Uddgård, and Factory Manager J. Frenning.

At the beginning of March L M Ericsson was visited by the Russian Vice Foreign Minister, who made a tour of several of the company's factories among other places. (From left) the Russian Ambassador to Sweden, V. Maltsev, Vice Foreign Minister Andrei Smirnov, Councellor to the Embassy L. Popov, and Chr. Jacobæus, Technical Director of L M Ericsson.



The new factory of Fios e Cabos Plásticos do Brasil S.A. (FICAP), an associated company of L M Ericsson, inaugurated on March 13, 1970.

(From left) W. Wessel Hansen, Chief Engineer, K. Gulstad, P. E. N. Skov, Director General, DSB, and F. Loell and A. Wiuff, DSI, sign the contract for delivery of equipment for automatization of the Copenhagen local railway traffic.

Danish State Railways Purchase Signalling Equipment for 45 Million Kronor

Between the Danish State Railways (DSB) and Dansk Signal Industri A/S (DSI) a contract has been signed for the delivery of equipment for automatization of the signalling plants on the Copenhagen local lines.

The contract relates to the delivery of equipment for an electronic remote control and train describer system, including three computers of L M Ericsson make, and equipment for automatic station operation for the entire local line system that is planned. The contract also includes equipment for interlockings and automatic line block for the Køgebugt line.

The signing of the contract implies that DSB is now starting to realize the plans for complete modernization of the signalling plants on local lines.

With the new remote control equipment the fully extended local lines, with about 80 stations, can be remote-controlled from a centre at Copenhagen H. The plant also controls the platform signboards at the stations.

When the plant has been put into service, the traffic handling will take place entirely automatically and all train movements will be followed on a track diagram. The operating staff can therefore concentrate solely on supervision of train running. Only if delays occur must manual operation be adopted.

Apart from purely traffic assignments the remote control equipment will also deal with the switching of calls on the internal DSB signal telephone network, which comprises both stations and telephone posts along the line. The computers have a special supervisory equipment which, via typewriters, records certain changes of state and function and faults in the plants.

The electronic remote control system was developed by L M Ericsson, Stockholm, while the equipments for interlocking and line blocks were developed in intimate cooperation between DSB and DSI.

The fully extended plant for the local lines comprises equipment for 45 million Swedish kronor.

New Appointments

I. Horelli

Y. Ollus

Mr Ingmar Horelli retired on pension on April 30, 1970, from the presidentship of the Finnish subsidiary O/Y L M Ericsson A/B, Helsinki. Mr Horelli has been appointed chairman of the board of the company in succession to Mr Runar Hernberg, who remains a member of the board.

Mr Yngve Ollus, Executive Vice President of the company, has been appointed President as from May 1, 1970.

The L M Ericsson Group has acquired all shares in the earlier partly owned cable works Fábricas Colombianas de Materiales Eléctricos Facomec S.A., Cali, Colombia.

Mr Olof Irgens, at present head of Private Market Sales at Ericsson de Colombia S.A., Bogota, has been appointed head of the cable works, and Mr Fredrik Croneborg, of Sieverts Kabelverk AB, Stockholm, its Production Manager.

Mr Ragnar Stålemark, head of the Ericsson Corporation, USA, retired from his post on February 28, 1970, after attaining pensionable age.

Mr Carl Olof Lennmalm, who has worked in the company during a number of years, has been appointed his successor.

N. Kallerman

C.-H. Ström

Mr Nils Kallerman retired on pension on April 30, 1970.

Mr Carl-Henrik Ström har been appointed his successor as head of the marketing area covering Europe excluding Spain, the USA and Canada within the Management Staff Department for Sales Questions.

The Ericsson Group

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Centrum Electronics Ltd. *Morden, Surrey*, Crown House, London Road, tel: (01) 542 2222, tgm: celefon, telex: 935979 "SWEDERIC LDN"

Centrum Rentals Ltd. *Morden, Surrey*, Crown House, London Road, tel: (01) 542 1001, tgm: celefon, telex 935979 "SWEDERIC LDN"

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SETEMER, Soc. per Az. *1-00198 Roma*, Via G. Paisiello 43, tel: (06) 86 8854, tgm: setemer

SIELTE, Soc. per Az. *I-00100 Roma*, C.P. 5100, tel: (06) 577 8041, tgm: sielte, telex: 61225, "61225 SIELTE"

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A/S Industrikontroll *Oslo 6*, Grenseveien 86/88, 3. etg., tel: (02) 68 7200, tgm: indtroll

A/S Norsk Kabelfabrik *Drammen*, P.O.B. 369, tel: (02) 83 7650, tgm: kabel, telex: 18149, "KABEL N".

A/S Telesystemer *Oslo 6*, Tvetenveien 32, Bryn, tel: (02) 68 7200, tgm: telesystemer, telex: 16900, "ALARM N"

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AB Rifa, *S-161 30 Bromma 11*, tel: (08) 26 2600, tgm: elrifa, telex: 10308, "ELRIFA STH"

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L M Ericsson Data AB, *S-171 88 Solna*, tel: (08) 83 0700, tgm, ericdata, telex: 10793 "ERICDATA STH"

L M Ericsson Telemateriel AB, *S-135 01 Stockholm-Tyresö 1*, Fack, tel: (08) 712 0000 tgm: ellem, telex: 1275, "1275 TELERGA S"

Sieverts Kabelverk AB, *S-172 87 Sundbyberg*, tel: (08) 28 2860, tgm: sievertsfabrik, telex: 1676, "SIEVKAB STH"

Svenska Radioaktiebolaget, *S-102 20 Stockholm 12*, tel: (08) 22 31 40, tgm: svenskradio, telex: 10094, "SVENSKRADIO STH"

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Centrum Electronic G.m.b.H. *3 Hannover*, Postfach 1247, tel: (0511) 63 1018, tgm: centronic, telex: 0922913, "CELEC D"

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Cont. on next page

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On cover: Rio de Janeiro — View of Guanabara Bay

Development of the LD Network in Brazil

M. F. MELCOP, EMBRATEL, RIO DE JANEIRO & A. M. FERRARI, ERICSSON DO BRASIL, SÃO PAULO

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Brazil is an enormous and largely inaccessible country. It has an area of 8.5 million square kilometres, which is more than 75 % of the area of Europe, and a population of more than 88 million. For a country of this character a well developed LD network with high-standard transit exchanges is of the greatest significance. A few years ago a nationwide extension of the LD network started, and the aim of this article is to give an idea of the now quickly advancing work on this project.

Introduction

Up to the mid-1960's Brazil had not yet found the way to integration of its 800 local telephone companies through an efficient long distance system. At that time there were already some routes equipped with radio links, coaxial cables and carrier on open wire lines, although operating on an *OTD* (operator toll dialling) or *RD* (ring-down) basis. A few routes, especially between some satellite cities of São Paulo and also of Rio de Janeiro, had *DDD* (direct distant dialling) circuits to both big cities.

The most important routes equipped with a reasonable number of good quality circuits late in 1965 were the following:

Rio de Janeiro–São Paulo	Radio link**
Petrópolis–Rio de Janeiro	Coaxial cable
Santos–São Paulo	Coaxial cable*
Nova Friburgo–Rio de Janeiro	Radio link*
Rio de Janeiro–Belo Horizonte	Radio link**

* Fully delivered by L M Ericsson.
** Multiplex equipment partly deliverad by L M Ericsson.

Besides these routes, two others should be mentioned, in view both of the distances involved and of the short time available for the installation, two basic factors which have recurred in the subsequent installations. The first of these two routes, Rio de Janeiro–Belo Horizonte–Brasília–Goiânia, a distance of over 1,450 kilometres and with an installation time of 10 months for all the 26 repeater stations, was built in order to permit the transfer of the capital of Brazil in April 1960. The associated radio equipment was supplied by RCA, while the multiplex equipment was supplied by L M Ericsson and installed by Ericsson do Brasil.

Circuits were extended thereafter up to Corumbá, close to the Bolivian border. The installation of this route was a true Odyssey. Ericsson do Brasil installers lived for several months in a railway wagon towed along the route. Meanwhile the linemen were engaged on changing or straightening pole cross-arms, altering the transposition, and introducing by-pass filters at every railway station so as to allow the simultaneous use of existing selective calling systems.

Both of these routes pass through sparsely inhabited regions covered by tropical forest where no public mains are available. Diesel engines (with 100 % stand-by capacity) run day and night to supply the repeater stations. Helicopters were often used on the Belo Horizonte—Brasília section to deliver fuel and food to the repeater sites.

Another large venture in the Brazilian telecommunication history has been the installation of a carrier system composed of 8 circuits on open wire line more than 2000 km long, joining São Paulo and Campo Grande (capital of the State of Mato Grosso).

Before 1960 there was no Federal Communication Commission to control the operating companies. In the mid-60's telecommunication services in Brazil were placed under the "*Ministério das Comunicações*". Until that time any operating company could purchase any type of equipment without regard for its technical or economic features. All projects must now be previously approved by federal communication authorities, which prevents poor quality switching and transmission equipments from being installed.

CCITT standards and recommendations are followed and national regulations have been put into force to cover aspects which are left to the discretion of the individual country. In the past the concessions for telecommunication systems were granted by local authorities: the Municipality for local service; the State for services between towns within the boundaries of one state; the Federal authorities for *LD* circuits crossing state boundaries. According to the later regulations only the Federal authority is allowed to grant a concession for telecommunication services of any kind.

EMBRATEL, a fully government-owned company, was formed in 1965 mainly to operate the basic telecommunication networks, a high capacity system for *LD* between states as well as the international service. This company, whose full name is Emprêsa Brasileira de Telecomunicações (EMBRATEL), operates only the backbone network.

The regional and local private or government-owned companies operate the lower level networks serving particular regions, which may comprise one or a group of states, part of a state or merely a single town.

To give a general idea of the development of this backbone network, the Brazilian telephone network, is the main goal of this article.

Numbering

Uniform numbering has been adopted for the Brazilian network, so that a national number will always contain 9 digits in accordance with CCITT recommendations (Blue Book, part VI, Q 11). For the trunk prefix the digit *0* has been assigned, and *00* for the international prefix on international *DDD* calls. The length of the trunk code varies according to the length of the subscriber number: the longer the subscriber number within a numbering area, the shorter its trunk code (Table 1).

Fig. 1
National numbering regions

Table 1. National numbering scheme

Theoretical capacity of numbering area (lines)	National number	
	Trunk code	Subscriber number
8,000,000	$A_1\ B_1$	Y N N N N N N
800,000	$A_1\ B_2\ C_2$	Y N N N N N
80,000	$A_1\ B_3\ C_3\ D_3$	Y N N N N
8,000	$A_1\ B_4\ C_4\ D_4\ E_4$	Y N N N

$$A_1 \neq 0 \quad B_1 \neq B_2, B_3, B_4 \quad C_2 \neq C_3, C_4 \quad D_3 \neq D_4 \quad Y, C_2, D_3, E_4 \begin{cases} \neq 0 \\ \neq 1 \end{cases}$$

Some exceptions, however, are certain to occur in local networks where "step-by-step" exchanges prevent an economical solution for obtaining information concerning the subscriber number length. In these cases step-by-step subscriber numbers are one digit shorter than those of subscribers connected to register-controlled exchanges.

The country is divided into nine regions (see fig. 1). Some trunk codes have been assigned to regions in neighbouring countries so as to allow future traffic with these countries based upon bilateral agreements.

Special Service Codes

Special services have 3 digits, always starting with digit *1*. They have the general configuration *1 RS*, where *R* usually indicates the class of special service, whether barred to the public or not, chargeable or free, emergency service, or restricted for telephone administration use. *S* indicates the subdivision within the class or – in cases of *LD* special services – the different centres within a large metropolitan network where non-centralized special services are attended to.

Public Local Special Services (R=0)

CODE	*SPECIAL SERVICE*
100	Assistance operator
101	Record line – *OTD* and *RD* routes to other states
102	Local information
103	Complaints
104	*LD* information at the origin
105	Local operating company
106	Record line – Rural service
107	Record line – *OTD* and *RD* within the State
108	Information on *LD* charging
109	Ringback circuit

Chargeable Information Services (R=3)

130	Time announcement (speaking clock)
132	Weather forecast
133	News
134	Wake-up service
135	Phonograms

Emergency Services (R=9)

190	Police
192	Ambulance
193	Fire brigade

Maintenance of Local Network (R=1)

110	Installers
112–116	Line test desk
117–118	Splicers
119	Automatic tester *(APR)*

Radio Services (R=5)

151	Record line – International
152	Information on charging of international calls
153	Record line – HF and VF national circuits

Long Distance Special Codes

Are dialled after trunk prefix and trunk code of the numbering area where they are located.

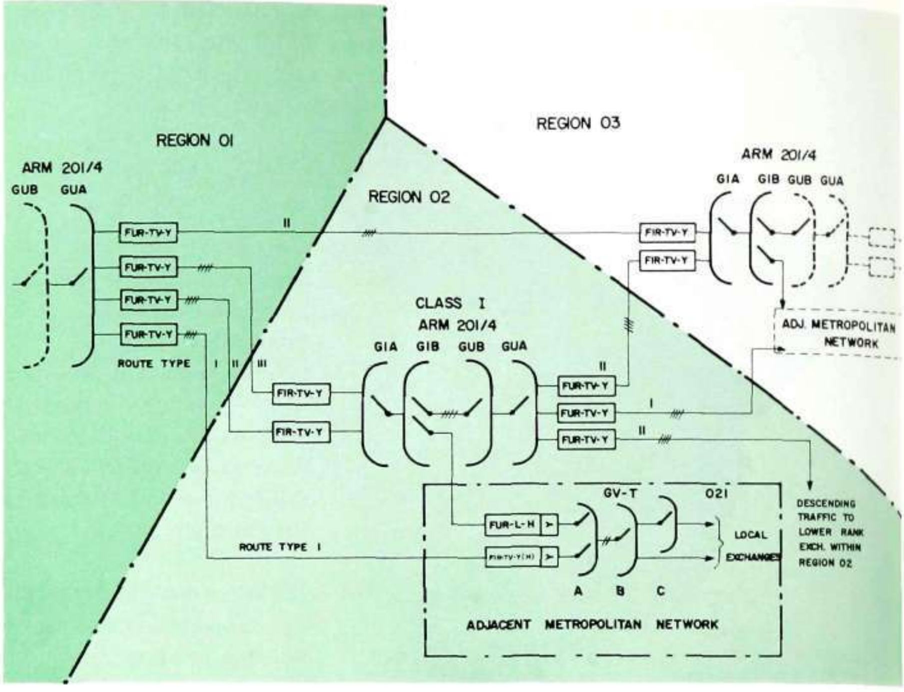
171	Operator to extend calls to areas not yet converted to *DDD*
121	*LD* information at the destination
181	Line measuring desk
185	*ATME* (automatic transmission measuring equipment)

Switching

The Brazilian *LD* network is being built with high standard switching equipment. As early as 1966 the Federal authorities stipulated as a minimum requirement that crossbar switching on register control principles should be adopted at all local exchanges to be connected to the *OTD/DDD* network.

Besides these requirements, EMBRATEL and regional administrations stipulate that transit exchanges shall have common control, 4-wire switching,

Fig. 2
Trunking diagram



4-wire pad switching, etc. The installation of step-by-step, motor-driven and other kinds of sliding contact equipments has not been allowed since 1966 in places which are to have *OTD/DDD* services.

Alternative routing is another feature required by administrations in charge of *LD* services, not only improve the *LD* circuit utilization but also to provide automatic rerouting in case of congestion, partial failure of multiplex equipment, etc.

The Switching Plan foresees five levels in the *LD* network structure: Terminal exchange (Local Exchange) Class *IV* (Group Centre), Class *III* (Zone Centre), Class *II* (District Centre) and Class *I* (Regional Centre).

All Class *I* exchanges will be directly interconnected in the future. Due to the traffic distribution now prevailing, which shows that some regions do not show a noticeable community of interest with others, the decision has been made provisionally to route the traffic between those regions via a third intermediate Class *I* exchange.

The large metropolitan networks in the most developed and larger States influence the traffic to a very great extent. A considerable part of the traffic terminates in the metropolitan networks.

In order to save switching equipment and to avoid distrubance of terminating traffic by transit traffic peaks, EMBRATEL adopted the route splitting principle to main metropolitan networks, as shown in fig. 2.

Route *I* is intended for terminal traffic in a metropolitan network close to the transit exchange. Route *II* is the first-choice route for terminating traffic within the area belonging to the transit exchange. This route also constitutes the first alternative for Route *I*. Route *III* is the first-choice route for transit traffic to a third region. It is, simultaneously, the first alternative route for Route *II* and the second alternative for Route *I*.

All Class *I* exchanges and some Class *II*, which are obviously 4-wire type (Table 2) lie along the basic structure. Furthermore EMBRATEL are installing several 2-wire incoming distribution stages in some local networks, which will start operation with full automatic *LD* terminating traffic, whereas during the initial period the originating stage will be maintained on an *OTD* basis. These tandem stages are not included in the table. As mentioned above, most of Class *II* and all lower class exchanges do not form part of the basic structure for the high capacity *LD* routes. This means that from EMBRATEL transit exchanges there spread out regional or state systems, wich are not dealt with in this article but follow the general requirements of the national network planning under its various aspects.

Table 2. Transit exchanges in the backbone network

Four-wire transit exchanges					
Exchange	Class	Initial capacity (trunks)	Charging	Operation starting in	Remarks
São Paulo	I	6,106	TT	1970	*
Rio de Janeiro	I	5,257	TT	1970	*
B. Horizonte	I	1,548	TT	1970	*
Curitiba	I	1,466	TT	1970	*
Pôrto Alegre	I	965	TT	1969	*
Brasília	I	803	TT	1970	
Salvador	I	588	TT	1970	*
Recife	I	706	TT	1970	*
Belém	I	479	TT	1971	*
Gov. Valadares	II	195	MM	1970	
Uberlandia	II	316	MM	1970	
Blumenau	II	161	MM	1970	**
Fortaleza	II	331	TT	1970	*
Baurú	II	837	TT and MM	1971	
Sorocaba	II	514	MM	1971	
Rib. Preto	II	658	TT	1971	
Vitória	II	469	TT	1970	*
Campos	II	342	MM	1970	*

* ARM 201/4 equipment supplied by Ericsson do Brasil
** ARM 503/2 equipment supplied by Ericsson do Brasil

TT centralized Toll Ticketing
MM centralized Multimetering

Register Signalling

The compelled multifrequency system (*MFC*) is the one used for the standard register signalling in Brazil. All *LD* switching equipment and all city exchange installations since 1968 have complied with the principles of the *MFC* register signalling system approved in Mexico City as standard register signalling for *RIT* (Interamerican Telecommunication Network). The Brazilian *MFC* signalling scheme includes the fifth backward frequency, but the additional signals containing this frequency will not be used until the 4-backward-frequency system introduced before 1968 is altered to match the 5-backward-frequency system.

Some very slight differences of signal meanings have been introduced in the *MFC* scheme in order to keep the cost of alterations in the 4-backward-frequency system within reasonable limits.

Line Signalling

Standard line signalling in the Brazilian long distance network is of the pulsed type. Two signal elements are used: short element (150 ± 30 ms) and long element (600 ± 120 ms). See table 3.

Line signalling on transmission equipments is of out-of-band tone-off-idle (high level) type.

Table 3. Line signalling scheme

Line signalling	
Designation	Signal
Seizure	--- 150 →
Answer	← 150 ---
Charging	← 150 ---
Clear forward	← 600 ---
Clear back	-- 600 →
Forced release	← 600 ---
Release guard	← 600 ---
Trunk offering*	--- 150 →
Re-ring*	--- 150 →
Blocking	← Continuously --

* not used

Audible Signalling

Information tones follow CCITT recommendation Q.35, with local additions for special and reference tones.

Charging

Every Class *I* transit exchange is equipped with automatic toll-ticketing facilities (*TT*). Some class *II* exchanges in more automatized regions also have *TT* facilities. The *TT* equipment functions on a centralized basis, i.e. it charges calls originating from directly connected local networks as well as calls from distant transit exchanges which have multimetering (*MM*) facilities only. Analysis at *MM*-equipped transit exchanges based upon originating and terminating area information decides whether the call shall be charged at a certain multimetering rate or be toll-ticketed at the superior exchange.

The tariffs as functions of the distance between originating and terminating charging area are shown in the table below.

Distance (km)	Relative tariff	US$ per minute of conversation
≤ 50	0.15	0.07
51– 100	0.20	0.09
101– 200	0.25	0.11
201– 300	0.32	0.14
301– 400	0.40	0.18
401– 500	0.50	0.23
501– 700	0.62	0.28
701–1000	0.70	0.32
1001–1500	0.80	0.36
> 1500	1.00	0.45

Charging (telephone to telephone) in April 1969 (1 US $ = NCR $ 4.00)

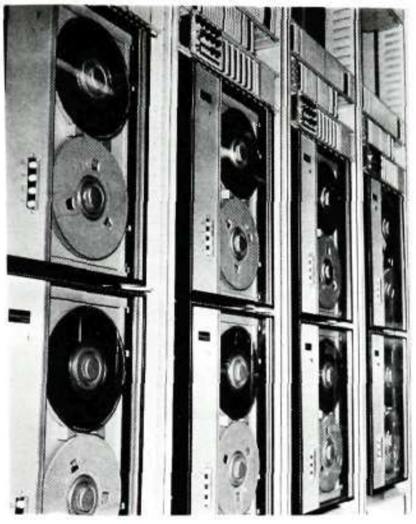


Fig. 3
Toll-ticketing equipment at ARM exchange, São Paulo

Regional and state networks usually operate on a multimetering basis, but some large regional networks have *TT* equipment at their Class *II* exchanges. Charging in these exchanges is very complex as, when seizing a particular junction repeater, one does not know which kind of charging is to be applied by the exchange in question. This can be decided only after analysis of the calling and called subscribers' charging areas.

TT data are recorded on magnetic tape. Special subscribers who need an immediate accounting service have the data for each call additionally recorded on a punched card or in plain language in a teleprinter.

Experience gained with the first *ARM 201/4* equipped with *TT*, also delivered by Ericsson do Brasil, shows the suitability of the *TT* equipment as an aid during final testing, as it supplies quite a lot of information regarding traffic conditions in the distant terminating networks, the operation of the home *ARM* exchange, and the possibility of checking the reliability of the *A*-identification procedure. For this purpose the magnetic tape is processed and the computer prepares a listing which is carefully checked by a switching engineer, abnormal cases being noted. As the condition of the called subscriber's line is also recorded in *TT*, the computer can be programmed to provide statistical data regarding busy subscriber, no answer, idle subscriber and congestion level in terminating local networks.

Transmission

The Transmission Plan for the Brazilian network complies with CCITT G.121. It is planned that the maximum number of sections to the international exchange will be five. Three of them will be four-wire. The task of the Plan is to keep 95 % of calls within the maximum limit for the reference equivalents of the national system (T = 20.8 dB, R = 12.2 dB).

Four-wire pad switching is used to the full extent. A 3.0 dB pad insertion is controlled by digit information stored in the transit exchange register.

The operational conditions of the *LD* circuits are continuously checked by the Automatic Transmission Measuring Equipment (*ATME*). For this purpose transit exchanges have also the facility of individual circuit selection. Testing of any *LD* circuit forming part of the *DDD* network is done under remote control from a centralized *ATME* parent unit. Data of the location of individual *LD* circuits within the network as well as test programme are recorded on punched cards. A feeding unit reads card after card corresponding to the circuits to be tested. A circuit presenting transmission characteristics outside the present limits results in a card being punched at the output unit with the transmission data for that circuit.

LD Circuits

Development of new *LD* routes to connect remote regions to the backbone of the national system is being hastened on.

High capacity radio links are replacing old *HF* equipments, existing radio links are being extended or established on completely new routes. Microwave equipments (4 or 6 GHz) are being installed in the southern, eastern and north-eastern regions. Owing to reasons of traffic economy and topography, troposcattering systems are being installed in the northern and western regions (figure 4 and table 4).

Fig. 4
Trunk network

Microwave

Tropo-scattering

VH

In operation (10.4.70)

Table 4. Complementary data to Fig. 4

Route See map	Band GHz	Total length km	Repeater stations		Radio EQ. capacity		Facilities for TV			Provisional operation starting date
			Total	With demo-dulat.	Initial	Final	Stand-by	Addi-tional	Simult.	
1	6	972.3	22	1	1TF+1	2×(3+1)	yes	no	–	20.12.68
2	6	413.5	9	–	1TF / 2TF }+1	3+1	yes	yes	yes	24.04.69
3	6	413.5	9	4	1+1	3+1	yes	no	–	24.04.69
4	4	1,440.7	30	5	1TF / 1TV }+1	3+1	yes	yes	yes	6.05.69
5	6	1,906.2	54	4	1TF+1	2×(3+1)	yes	no	–	15.12.69
6	4	1,052.2	22	5	1TF+1	3+1	yes	no	–	9.07.70
7	6	857.1	20	2	1TF+1	2×(3+1)	yes	no	–	20.02.70
8	6	945.3	26	3	1TF+1	2×(3+1)	yes	no	–	30.10.71
9	6	2,005.2	45	12	1TF+1	3+1	yes	no	–	30.12.70
10	6	327.8	13	1	1TF+1	2×(3+1)	yes	no	–	20.12.69
11	6	295.3	8	2	1TF+1	2×(3+1)	yes	no	–	27.08.69
12	7	462.2	14	2	1TF+1	120 ch	yes	no	–	15.05.70
13	0,9	2,752.0	13	3	1TF (120 ch)	120 ch	no	no	–	27.06.71
14	2/6	263/150	5	–	1TF (120 ch)	120 ch	no	no	–	30.05.71
15	2	1,481.6	9	3	1TF (120 ch)	120 ch	no	no	–	30.11.70
16	2	784.4	4	2	1TF (120 ch)	120 ch	no	no	–	30.09.71
17	HF	660.0	–	2	4 ch	4 ch	–	–	–	Feb. 1970

Fig. 5
Brazilian earth station with antenna in background

International Circuits

Most of the international circuits are operated via a satellite (INTELSAT III). The Brazilian earth station was completed shortly before the first moon landing, which allowed Brazilians to watch the event.

The Tangua earth station near Rio de Janeiro has a Cassegrain antenna with a 30 m diameter reflector and is also prepared to track non-synchronous satellites (fig. 5). The antenna structure rotates from $+270°$ to $-270°$ horizontally and can be elevated from 2° below to 92° above the horizon.

Interconnection between the international exchange and the earth station is performed by a 7 GHz microwave system, 960 channels final capacity. Multiplexing equipment at both ends is of *M4* type manufactured by L M Ericsson. The system is equipped, for the time being, with 120 + 12 circuits.

The international exchange routes the terminating traffic in Rio de Janeiro and São Paulo directly to corresponding local networks. Traffic to other points of Brazil is routed via Rio de Janeiro Class *I* transit exchange from which it is switched by the national system in a similar way to national traffic.

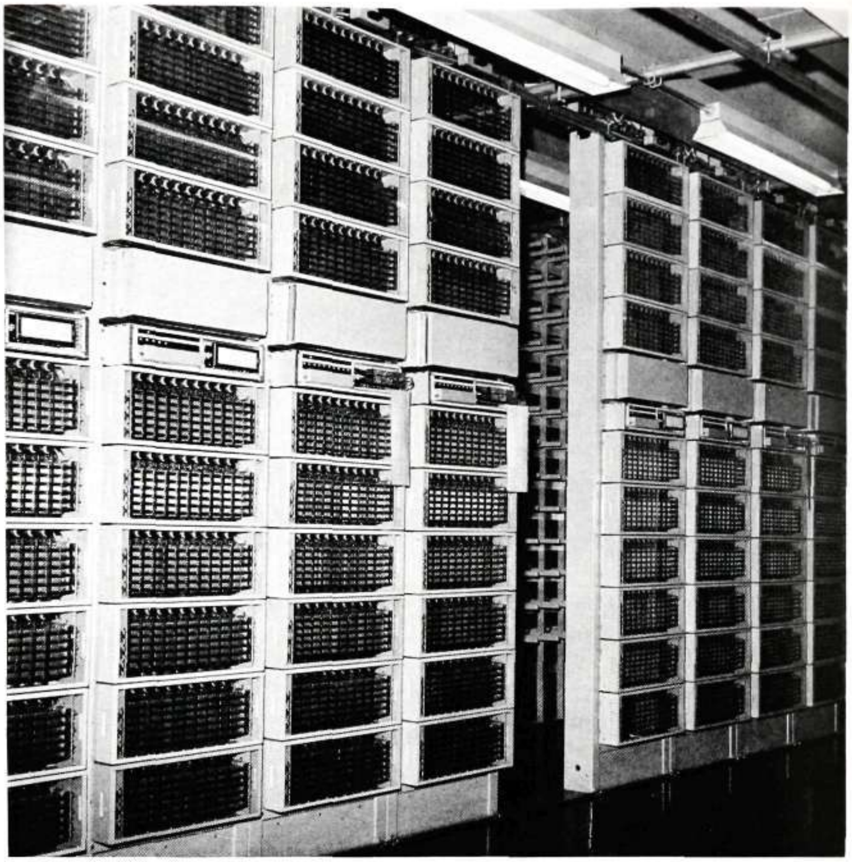
International satellite circuits exist to several European and American countries as per the table below (circuits in operation as per 1.1.70 within brackets).

Argentine	12 (6)	Italy	5 (3)	UK	5 (2)
Canada	4 (1)	Mexico	3 (1)	Uruguay	6
Chile	3 (1)	Peru	3 (1)	USA	27 (14)
Colombia	2	Portugal	5	Venezuela	3
France	6 (2)	Spain	3 (2)		
Germany	5 (2)	Switzerland	4 (1)		

Conclusion

This ambitious telecommunication development project being undertaken by EMBRATEL requires the parallel support of correlated fields, such as local and foreign telecommunication industries and agreements with technical and engineering schools for the supply of manpower. Local contractors were assigned special tasks all over Brazil for surveying the new routes, opening up

Fig. 6
Group selector racks at ARM exchange at Pôrto Alegre



most of the roads to the new antenna sites, erecting the buildings to house hundreds of repeater stations, most of them deep in unexplored equatorial jungle, and multistorey buildings in the heart of the major cities for 23 four-wire transit exchanges, totalling 22,490 trunks on Feb. 1, 1970.

Ericsson do Brasil's experience of the local manufacture of crossbar systems since 1957 played an important role when tendering for switching equipment, as contracts for most of the largest switching centres were granted to this company.

Effective cooperation between the technical staff of both companies permitted good solutions to the various problems involved in interconnecting the existing equipments of different operating principles and makes.

The results of such common efforts are now appearing. In December 1969 the Pôrto Alegre *ARM* exchange was put into service. During 1970 two *ARM* exchanges with a capacity of more than 5000 circuits each will be cut-over among others. These two exchanges located in Rio de Janeiro and São Paulo rank high among the highest capacity exchanges in the world.

Telephone Traffic Research in Sweden

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This article is based upon a lecture presented in Tokyo in November 1969 to telephone engineers at the Laboratory of the Nippon Telegraph and Telephone Public Corporation NTT. The lecture was held within the framework of the Swedish Technical Mission to Japan arranged by the Swedish Academy of Engineering Sciences.

The prominent position occupied in the world by the Swedish telephone industry and telephone service is a well known fact even in non-professional circles. The Swedish telephone industry — mainly L M Ericsson of course — has the entire world as its field and stands in the first rank within many spheres. The Swedish Telecommunications Administration can boast of a telephone density which is the second highest in the world. In the course of the years Sweden has also introduced a number of new features within the field of telephony. The crossbar switch systems were introduced on the world market by L M Ericsson around 1950 and gave our company a very strong position in the field of automatic telephony; the plastic telephone set, new carrier systems for coaxial cables etc. have been developed in Sweden. Sweden probably devotes a greater part of its resources to work wihtin the telecommunication field than any other country.

It is perhaps difficult to analyse in detail the reasons for this state of affairs — here it may be said merely that an early interest on the part of industry created a tradition which has since been built upon. Naturally the prerequisites existed in the form of suitably trained manpower, venture capital and a market response, primarily in Sweden but later also to an increasing extent on the export market.

CONNY PALM

This article will be concerned with a field of significance for telephony, namely *telephone traffic research*. The role of telephone traffic research is naturally known — its aim is to provide a basis for the quantitative dimensioning principally of telephone plant. It thereby assumes a significance both for industry and for telephone operating enterprises. Industry acquires guiding lines as to how its systems should be built up and administrations can judge the quantity of investment needed and how investments should be distributed.

The first person in Sweden to engage in studies of telephone traffic problems was *Conny Palm*. During a 15-year period up to his death in 1951 he achieved a great deal within this field and gave Swedish telephone traffic research a place of international rank. The chief contribution made by Conny Palm was his doctor's thesis, "Intensitätsschwankungen im Fernsprechverkehr" (Ref. 13), in which he dealt with "inert variations" with an impressive expert knowledge and used a very advanced mathematical apparatus. He departed

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from Erlang's assumption of statistical equilibrium and achieved results of a general applicability relating to variations in call intensity which lie outside the strict Poisson process.

Palm's work manifestly concerns the foundation for nearly all telephone traffic research, namely the mathematical model by which telephone traffic can be described. The practical significance of his work has perhaps not been so great — telephone traffic researchers in the past years have been concerned more with applications to plants and systems. But in the future a greater interest will inevitably be devoted to the nature of telephone traffic. Palm's work will then be a very essential point of departure. A sign of its continued interest is that his thesis will shortly be published in English.

Conny Palm also dealt with most "classical" problems within traffic research (Ref. 4, 8, 11, 15, 18, 19, 27). He was one of the first to establish exact expressions for the congestion in certain gradings (Ref. 2). He made use of the method of general equations of state for this purpose. He also studied delay problems (Ref. 5, 7, 14, 20, 21, 22, 26).

Conny Palm was in charge of the work on the first major analogue traffic machine in the world for congestion studies. This, too, was a pioneering achievement. This machine, which was constructed before the age of the electronic computers, was electromechanical and designed chiefly for studying gradings with sequential hunting. It was used for measuring a very large number of traffic cases in the 500-selector system.

Palm's interest in the question of how human behaviour affects telephone traffic was also manifested in a study of the annoyance caused by congestion (Ref. 10, 37).

Other persons who worked at an early stage with traffic problems were *N. Rönnblom* and *K. Lundkvist* (Ref. 3, 6, 12, 28). The earliest known publication of a traffic study was that by *R. Holm* in 1919 (Ref. 1).

Palm has had a very great significance for traffic research in Sweden. Through him Sweden advanced to the foremost rank in this field. He introduced modern statistical methods and methods of operational analysis. Subsequent research in Sweden has hardly matched his original achiements but has inherited his insistence on scientific stringency and integrity.

L M Ericsson and the Swedish Telecommunications Admnistration started to take an interest in the crossbar switching systems at the end of the forties.

These systems appeared to offer many advantages from the technical aspect. A difficulty, however, was that no simple and reliable methods for the computation of link systems existed. In the years 1947—1950 the author of this paper elaborated an approximative method for the calculation of congestion in these systems (Ref. 25, 31, 34). The method was published in his thesis, "A Study on Congestion in Link Systems" (Ref. 31). Very close agreement with measured values was obtained and the method may now be said to be a standard method used throughout the world. For L M Ericsson it had a very great significance since it permitted the design of crossbar systems with very good economy. This opened the way for the advance of L M Ericsson's automatic systems on the world market during the fifties and sixties.

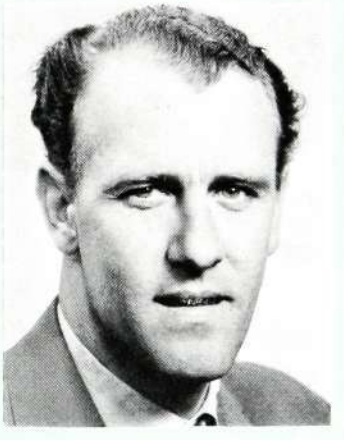
A large number of studies on different types of link systems followed. Among other things the dependence between the loadings on secondary stages and outlets was studied (*Elldin*, Ref. 50, 70). Possibilities for more accurate calculation of link systems with high congestion and overflow traffic (*Wallström*, Ref. 71, 89, 98, 112) resulted from these studies.

Apart from link systems, a large number of problems have been treated by *A. Elldin*. His doctor's thesis, "On the Congestion of Gradings with Random Hunting", dealt with a special type of grading (Ref. 41, see also 52). Elldin has also studied the use of general equations of state for a large number of different constellations of devices (Ref. 51, 53, 61, 101). Of great practical importance are his and his collaborators' studies of the capacity of the common control systems in the crossbar systems (Ref. 86).

The method of using a digital computer for traffic simulation was first demonstrated by *G. Neovius* in 1955 (Ref. 42). He dealt with certain simple gradings in this way. Neovius' method of simulation has since been developed into standard methods which are used throughout the world for traffic cases for which the theory is either too combersome or otherwise unsatisfactory (Ref. 62, 82, 91, 107, 108, 119). *K. M. Olsson*, in particular, has made valuable contributions to the development of simulation technique (Ref. 94, 99, 106).

In a long series of papers *Y. Rapp* has dealt with different problems concerning the planning of urban and trunk networks (Ref. 9, 32, 74, 77, 87, 88, 96, 111, 121, 128, see also 117). His results have been applied to a number of practical cases, with great savings as a result. Rapp has also treated with great success questions concerning the economic location of exchanges, and likewise problems relating to the most favourable stages of expansion for exchanges and cable networks. Rapp's work has met with a very great international appreciation.

Y. RAPP



K. M. OLSSON

S. Ekberg assisted Palm in the construction of the Swedish traffic machine and thereafter, during a number of years, was in charge of the measurements on the machine (Ref. 36, 44, 82, 83, 91). Ekberg has also studied gradings with the aid of derivative parameters of telephone traffic distribution functions (Ref. 45, 46, 63, 65).

Among other researchers may be mentioned *K. Lundkvist* who, in a number of theoretical studies, dealt with fundamental problems concerning the nature of telephone traffic (Ref. 29, 35, 40).

K. M. Olsson has studied, too, different problems concerning dispersion in traffic measurements (Ref. 47, 55, 85, 93, 99, 106). These types of problems were studied also by *G. Lind* (Ref. 103, 120, 127). Olsson has also developed further the theories for the full availability group and for simulations (Ref. 94, 106). He has also made simulation studies of different groupings. *I. Tånge*, apart from his work in C.C.I.T.T., has published valuable papers concerning alternative routing and gradings (Ref. 48, 54, 66, 73, 83, 92).

Measurements on systems in practical operation have early attracted a great interest among Swedish researchers. The first studies of this kind which included comprehensive measurements on systems with common control were made by *Conny Palm* (Ref. 13, 23). A new method for the investigation of the traffic conditions in crossbar systems was the so-called lamp panel method (*Elldin, Jacobæus, von Sydow*, Ref. 38). They recorded the occupation conditions in a switching system photographically at regular intervals. Important information was provided in this way concerning the distribution of states in different stages. During a number of years *Elldin* and *Tånge* have studied the traffic development on some routes from the Swedish city of Malmö (Ref. 66, 125). The studies were specially concerned with the seasonal variations and the growth of the telephone traffic. The work was mainly done as a contribution to C.C.I.T.T.'s studies for measuring and dimensioning international routes. The results from the measurements contributed to a great extent to the recommendation on this subject given by C.C.I.T.T. in 1964. Further results have been reported by *S. Westerberg* and *M. Anderberg* (Ref. 113, 124).

The studies by *Elldin* on the possibilities of taking into account traffic variations in the drawing up of congestion standards may be considered as a continuation and consequence of the above-mentioned measurements (Ref. 100).

Investigations by *H. Y. Kræpelien* concerning the influence on telephone traffic of the tariff system have provided interesting results which unfortunately, however, have not been followed up (Ref. 58, 59). *Rapp* has studied the dimensioning of telephone plant having regard to the value of the subscriber's time, by linking together congestion, service quality and transmission quality (Ref. 67, 68, 69, 72, 75). Here again further research is required for the achievement of results of practical significance.

Sweden has done much work within the field of telephone traffic theory in C.C.I.T.T. Mention may be made of the problems of dimensioning and optimization of alternative routes, general standards for the permissible level of congestion on international connections, etc.

Swedish work within the field of telephone traffic theory has been a recurrent feature at the international telephone traffic congresses. The Swedish participators have played a promiment role both as lecturers and in the discussions. The author was for that matter one of the initiators of these congresses. Many of the papers referred to above have been presented on these occasions. Other valuable contributions have been made by *G. Lind, G. Wikell, L. Håkansson, E. Szybicki, J. Gerstl Valenzuela* and others (Ref. 60, 76, 90, 92, 95, 97, 102, 107, 109, 110, 122, 123, 126).

These have been the main achievements during the last 30 years. A large number of other valuable papers and reports have been published (Ref. 16, 24,

S. EKBERG

B. WALLSTRÖM

30, 33, 39, 49, 57, 64, 116, 118). Several authors have published a large number of surveys or papers of a general nature or intended for teaching, and these have been valuable for studies in this field (Ref. 6, 56, 72, 78, 79, 80, 81, 84, 104, 105, 114, 115).

What is it that at present captures the interest of Swedish telephone traffic researchers? One may perhaps say that since solutions of many fundamental problems have been found, not many problems remain. But it is characteristic of all scientific work that solutions of one problem give rise to new ones. The same applies to telephone traffic research. The new type of computer-controlled exchanges that are now being marketed — stored-programme-controlled exchanges — have brought partially new problems concerning the call handling capacity of the computer (Ref. 110). Various optimatization problems both within the exchange and within the line plant will also require much future work. Finally there is the problem of acquiring a more profound knowlegde of the nature of telephone traffic and of subscriber reactions in different traffic situations. This field has perhaps been neglected since technique has been the dominant interest in the last 25 years.

Work within the telephone traffic field is being conducted both at L M Ericsson and at the Swedish Telecommunications Administration. Intimate cooperation has been established between these organizations, comprising discussion and allocation of assignments, joint measurement programmes, and evaluation of results. Manufacturer and Administration work hand in hand for the achievement of the best possible results.

At the institutes of technology research is also being done in this field, mostly in cooperation with L M Ericsson and the Administration. In Stockholm the work is being led by Professor *Stellan Ekberg*, earlier a member of the Administration's group of traffic researchers. At Lund the department is headed by Professor *Bengt Wallström*, formerly of L M Ericsson. Thanks to these prominent researchers, who are well versed in telephone traffic theory, students have been ensured the possibility of research and teaching under the best guidance. This provides industry and administration with an admirable basis for recruitment of researchers within the field.

The prominent position occupied by Swedish telephone traffic research is due naturally to the fact that managements within industry and administration have understood that this research is necessary for successful and internationally competitive work within telecommunications. Sweden has been able to foster a number of prominent researchers in this field, who have created a tradition — a tradition which we are anxious to maintain and develop.

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Equipment for Maintenance of ARM 20 and ARM 50 Automatic Telephone Exchanges

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LME 1548

Ericsson Review No. 2, 1966, under the heading "Centralization Trends in Exchange Maintenance", contains an account of the maintenance philosophy recommended by L M Ericsson and of how maintenance work can be rationalized through centralization.[1].

The present article contains a brief account of the standard equipment used for maintenance of ARM 20 and ARM 50 exchanges and of the automatic transmission measuring equipment used on the trunk lines.

Owing to the high requirements placed on the reliability of circuitry, crossbar switches and components, the *ARM* exchanges are highly reliable in operation. This is an ensurance of cheap maintenance, as confirmed also by many administrations.[2]

But even if the fault rate is very low, it is important that disturbances which affect the traffic should be immediately indicated and that means should exist for tracing of faults. This requirement is fulfilled with a minimum of manual labour as equipment is available which automatically supervises the functional quality and provides indications when it becomes unsatisfactory. This equipment is supplemented by supervisory circuits, built into common control devices, which indicate disturbances in the function of these devices.[3]

Maintenance Equipments

The maintenance philosophy recommended by L M Ericsson is called "controlled corrective maintenance". It is very labour-saving and presumes the use of extremely reliable maintenance equipment, the objectivity of which cannot be doubted. Such maintenance equipments are described below.

They may be divided into six groups for the following purposes:

- supervision
- indication
- fault tracing and testing of switching equipment
- repair of faults
- traffic measurements
- centralized supervision
- tests of trunk circuits

Supervisory Equipments

Fig.s 1 and 2 show how different equipments continuously supervise the function of the *ARM 20* and *ARM 50* exchanges.

The information from the built-in supervisory equipment is then analysed, in most cases entirely automatically, and the results are presented on a CENTRALOGRAPH or at the observation desk.

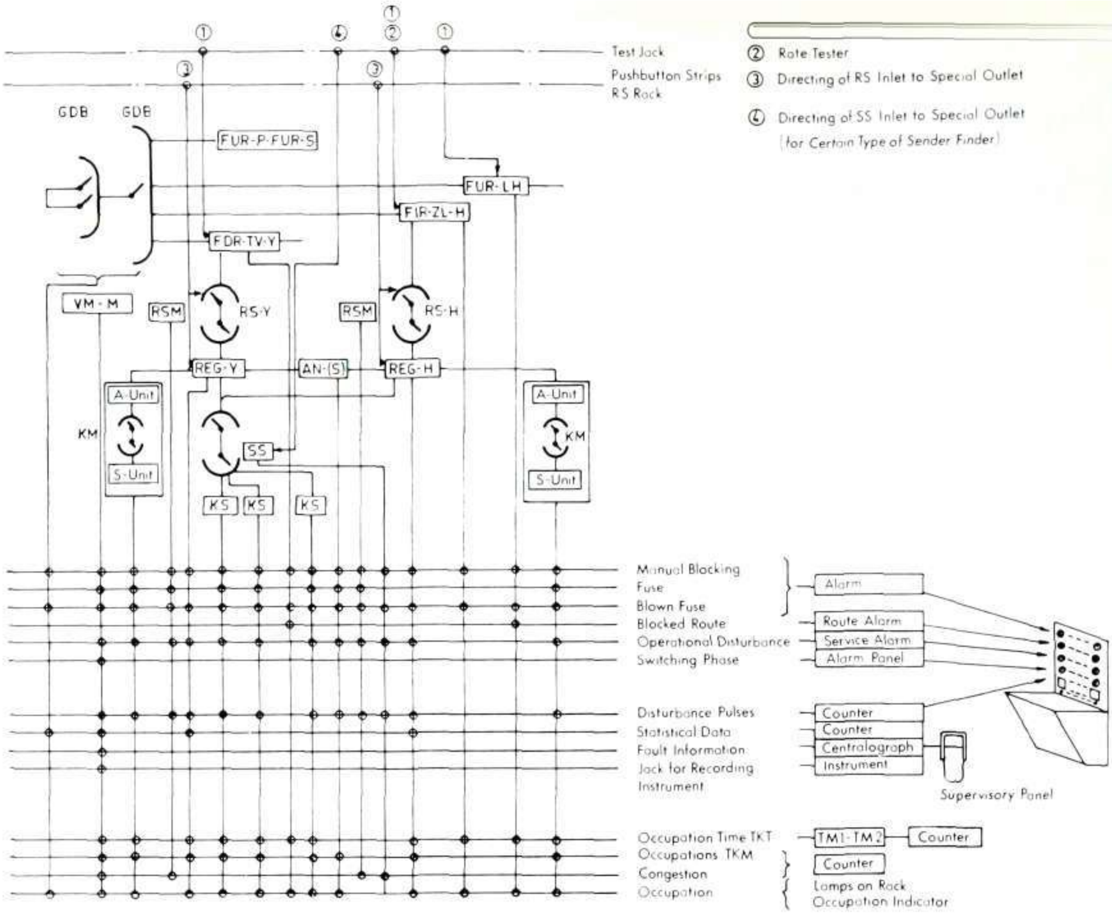
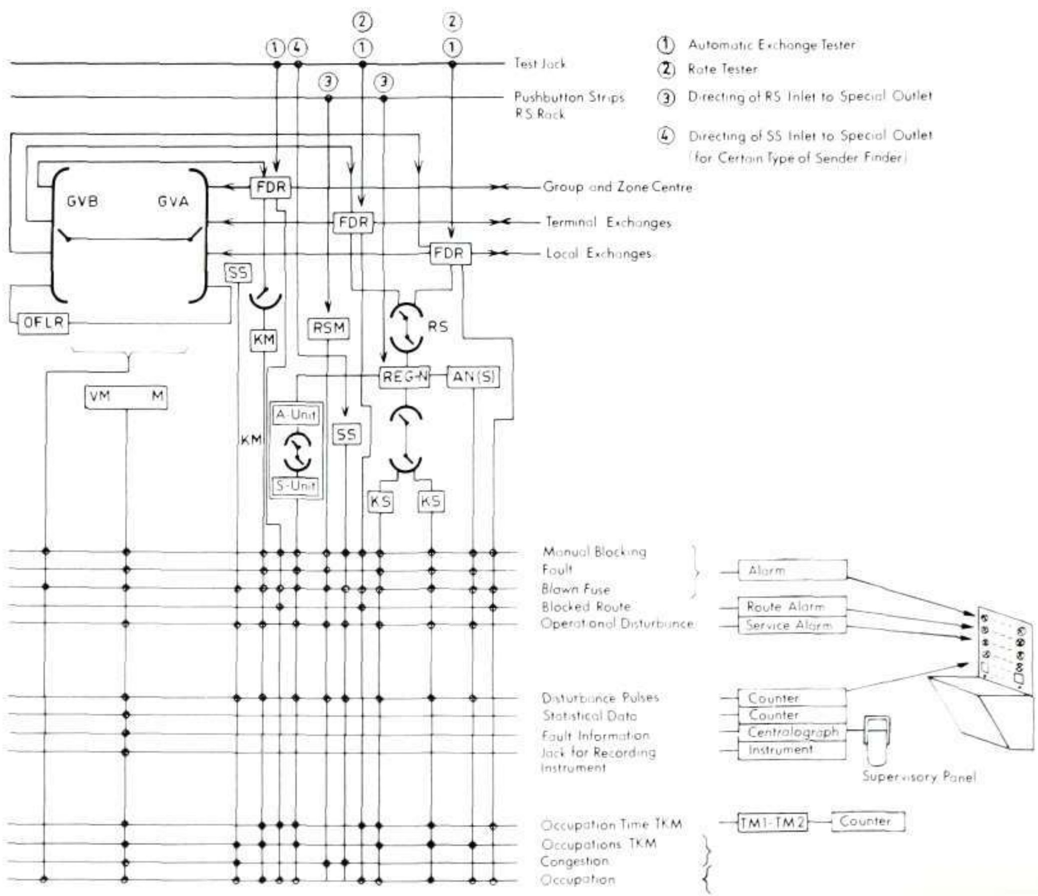


Fig. 1
Test and supervisory facilities for ARM 20

For the *ARM* exchanges the centralograph equipment is one of the chief aids for supervising the grade of service through the exchange. The equipment is standard for *ARM 20* and can also be connected to *ARM 50* exchanges, since provision for this purpose has been made in the route marker. Whether *ARM 50* should be equipped with a centralograph or not must be decided from case to case.

Fig. 2
Test and supervisory facilities for ARM 50



Normally the fault rate is low and consists of temporary faults which it does not pay to search for. If a serious fault occurs, the fault rate rises in a sudden jump. For quick information of such a condition the common control devices are equipped with an equipment for "disturbance ratio supervision". A "disturbance memory" in the form of a relay chain sums the number of disturbances. At the same time the number of occupations is summed on a counter which can be preset to a given level. When this counter records the preset number of occupations, the disturbance memory is zeroed. If the number of disturbances is too large before zeroing takes place, a "service alarm" is issued. The disturbance ratio, i.e. the number of permissible faults for a given number of occupations, is chosen at a level such as to avoid alarms resulting from temporary random faults but to ensure that an alarm is issued on a sudden increase caused by persistent faults. The disturbance ratio can be set at a very much higher level than the average fault rate.

The following devices are equipped with disturbance memories:

- route marker *(VM)*
- marker *(M)*
- register *(REG)*
- register finder *(RS)*
- sender finder *(SS)*
- code sender *(KS)*

Supervision of outgoing Routes

The junction relay sets are blocked in the event of a fault and an alarm is issued. For route supervision the blocking alarm circuit for all junction relay sets on a route is connected to a detecting relay in blocked route alarm relay set. This relay set contains circuits for 10 routes, and by means of strapping per route one can decide the number of blocked devices for which a route alarm shall be issued. When a device on a route has been blocked, its alarm lamp glows faintly but changes to a bright light when the preset number of blocked junction relay sets has been reached. Only then is an alarm issued.

When special importance is attached to the traffic carrying capacity of a given route, the congestion tendency can be supervised with a disturbance memory, a so-called route congestion alarm relay set. Automatic zeroing can be done either at specific time intervals or after a given number of occupations. If the number of congestion conditions within an interval exceeds a preset value, an alarm is issued.

Indication Equipments

Alarm System

This system is so arranged that the type of alarm — e.g. blown fuse, service alarm, blocking, locking — is indicated on lamps on the relay set or rack where the fault has occurred.

For indication on the suite supervisory equipment or on centrally placed alarm panels, a category of alarm is instead issued which indicates how quickly action must be taken.

Fault alarms are divided into the following categories:

A1 fault which must be repaired immediately, both within and outside working hours (day and night)

A2 fault for repair as soon as possible, but only in normal working hours

A3 fault which can be repaired when convenient.

Observation alarms are divided into the following categories:

01 condition which must be investigated as soon as possible, but only in normal working hours

02 condition which can be remedied when convenient.

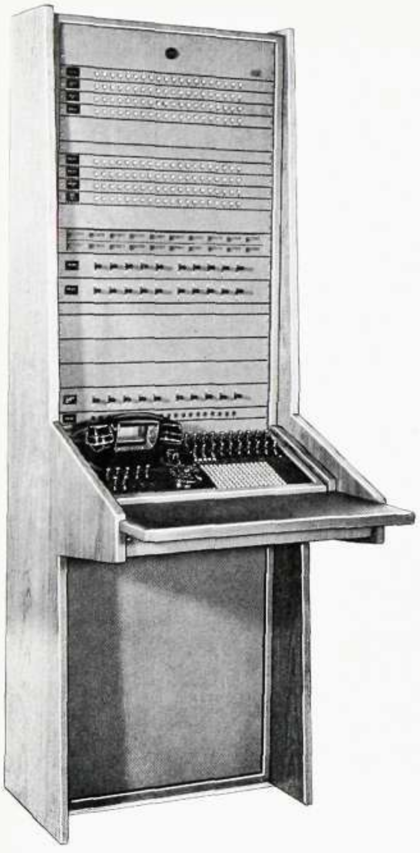


Fig. 3
Supervisory panel for ARM

Supervisory Panel

As will have been apparent from the above remarks, lamps, counters and keys are required for operation of the supervisory equipments and for indication of the results. For effective supervision, and at the same time to keep the maintenance personnel outside the switchroom as far as possible, it has been arranged that all operation and indication from the supervisory equipments take place on a supervisory panel in a room outside the switchroom. Fig. 3 shows a supervisory panel for an *ARM* exchange.

The supervisory panel contains counters used for statistics and analysis of disturbances from registers, code senders, code receivers, register finders, sender finders, route markers and markers.

Occupation Indicator

For deciding whether a condition is caused by the traffic load in the exchange or faults in the switching equipment, it is important to know whether all available switching paths in the group in which the congestion occurs are being utilized. For this purpose every crossbar switch vertical has been furnished with a supervisory circuit connected to a terminal of a 200-point jack in the rack jack box.

An occupation indicator can be connected to the jack. When a vertical is occupied, a hole is burnt in a replaceable metallized chart.

At the end of the test one can decide from the holes in the chart whether all verticals have been in operation.

Equipment for Fault Tracing and Testing of Switching Equipment

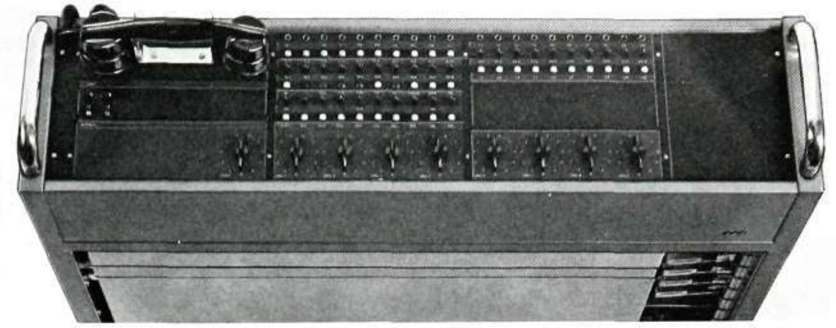
When fault indications or statistics show that fault tracing is required, special units are used for supervision and testing of individual devices.

Automatic Exchange Tester for ARM 20 and ARM 50

The automatic exchange tester connects to one of the junction relay sets *FIR*, *FUR* or *FDR*, and is thus intended chiefly for testing of these units. When connected to an *FIR* or *FDR* (incoming traffic), however, the tester can

Fig. 4
Exchange tester

Fig. 5
Rate tester



be used for testing a given register, as RS has a built-in device which enables a connection to be directed from a given inlet to a given outlet. This device is controlled from pushbutton strips on the jack box of the *RS* rack. If the exchange is equipped with a 20-pole sender finder, moreover, "control box", a unit for directing calls in code sender finders *SS*, can be connected to the sender finder. In this way the connection can be directed from a given register to a given code sender or code receiver. Means thus exist for testing of registers, code senders and code receivers with the exchange tester. The exchange tester has statistical counters and a lamp on which the switching procedure can be followed.

Rate Tester

The rate tester connects to *FIR* or *FDR* and is designed for testing of the metering circuits in these devices. Indirectly the rate determination in *VM* is also tested.

The rate tester has the same mechanical design as the exchange tester and can in most cases also be used as such. The rate tester is used when the exchange has no toll ticketing equipment.[4]

Lamp Panel for Recording of Switching Processes (DKL)

For ease of fault tracing, recording contacts have been introduced on certain relays in route marker and marker. The contacts are wired to jacks and, by connecting *DKL*, which in principle is a lamp panel with relay memory, information can be obtained as to which relays in the route marker and marker are operated when a disturbance occurs.

Multirecorder

The multirecorder is used for simultaneous recordnig of a number of functions (max. 30). As the recorder has a highimpedance inlet, it can be connected either directly to a relay winding or to the jacks referred to above, or to special measuring contacts placed on the relay armatures. From the multirecorder chart one can read how the supervised relays work in relation to one another in time (fig. 6).

Fig. 6
Multirecorder

Fig. 7
Card for reading of write-out

For larger units such as markers it is of value to have sequence diagrams for different functions. By recording a new diagram when a fault occurs, one can compare the two diagrams and obtain guidance for tracing the fault.

Counters (DKR)

To facilitate the collection of statistics, 40 zeroable counters have been assembled in a box which can be connected to the unit under test via an 80-point jack.

CENTRALOGRAPH Equipment

On time release in route marker or marker the CENTRALOGRAPH equipment is connected into circuit and automatically records switching data for the devices concerned. The equipment consists of a rack for connetion of the units of which the conditions are to be recorded, and a printing unit (the CENTRALOGRAPH itself).

In *ARM 20* the following data are recorded on time release in the devices concerned: five digits, or four digits and other data, and the switching route through the selector stages.

In *ARM 50* a record is made of the calling register, the same digital information as in *ARM 20*, and certain relay conditions in the route marker.

The write-out takes place on a paper tape. To facilitate reading of the tape, a card of the same width as the tape is used. The card is divided into columns for the various write-outs. By placing the card on the tape one can quickly interpret the writeout.

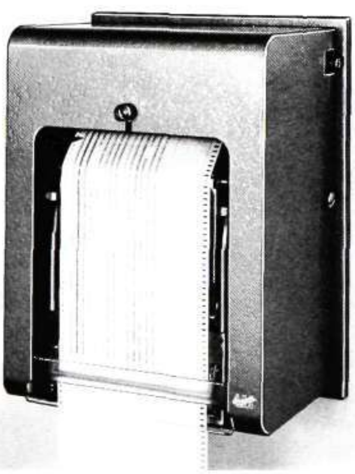
Fig. 7 shows the front of a card with data for the route marker *VM*. On the back of the card there is a corresponding layout for write-out for marker *M*. During the time spent on write-out the marker is held by the CENTRALOGRAPH equipment.

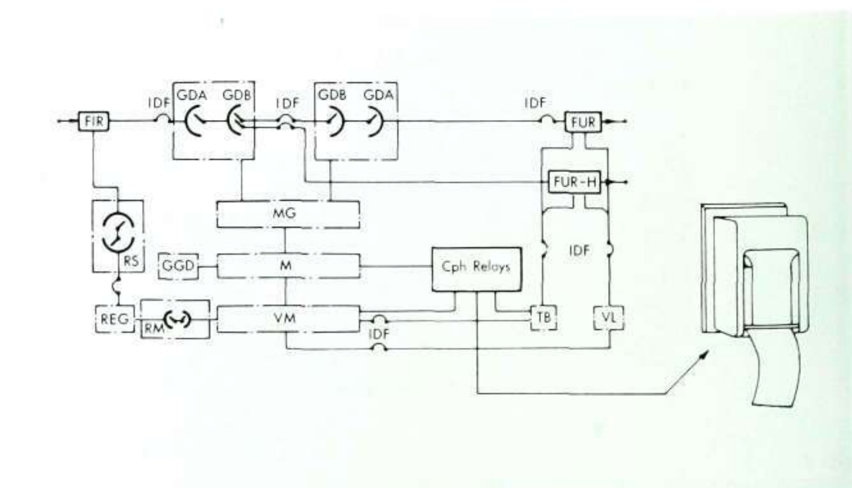
Fig. 8 shows a CENTRALOGRAPH.

Fig. 9 shows how the CENTRALOGRAPH equipment is connected to *ARM 20*.

Fig. 8
CENTRALOGRAPH (left)

Fig. 9 (right)
Plan of CENTRALOGRAPH equipment connected to ARM 20





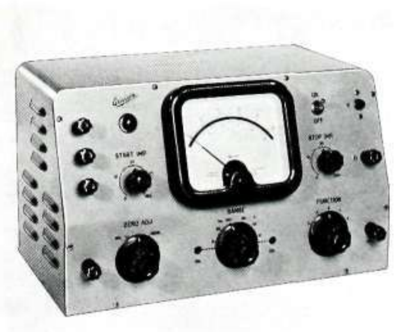


Fig. 10
Electronic time meter

Equipment for Analysis of Disturbances

In case of a service alarm from a group of devices, e.g. a register, code sender or marker, fault tracing is simplified if the group of devices or marker is connected to special analysis counters.

For devices within a group a record is obtained of individual occupations and disturbances, and one can easily see which device has the highest fault rate.

For the markers the counters are connected so that, in addition to occupations, a record is obtained of the number of disturbances in different switching phases, from which conclusions can be drawn for fault tracing.

Other Instruments

Various instruments can be used for special investigations, e.g. *MFC* tester, electronic time meter (fig. 10), pulse timers and recorders of different types.

Filing of Circuit Diagrams

If circuit diagrams are kept in a file and taken out when required, there is a risk that in due course they will become torn or dirtied. By placing often used circuit diagrams in a plastic pocket file they are readily available when required and do not become dirty or torn. Plastic pocket files are supplied in three sizes.

Equipment for Fault Repair

Even if faults in relays and switches occur very seldom, there must be special tools for adjustment or replacement of components. A tool cabinet (fig. 11) contains the necessary tools for a large crossbar exchange. At small unattended exchanges the tools need not be kept at the exchange but can be carried by the maintenance-man in a tool case (fig. 12).

Fig. 11 (left)
Tool cabinet

Fig. 12 (right)
Maintenance tool case

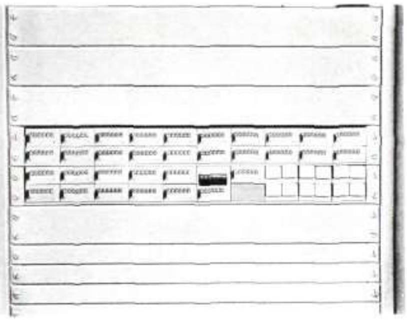


Fig. 13
Stationary traffic meter

Equipment for Traffic Measurement

The traffic intensity, *TKT*, is measured with an automatic traffic meter. Depending on the size of the exchange and the desires of the administration, this traffic meter can be either permanently installed or portable. *TKT* wires from 20 devices are interconnected into a group on the *I.D.F.* Connection to the jack of the traffic meter is thereafter done in such a way that, if possible, all devices of the same type, e.g. *FIR*, can be measured simultaneously.

The traffic meter scans the number of occupied devices in every group 100 times during an hour. On every scan the number of occupied devices in the group is recorded on individual counters. The meter can be started and stopped automatically. The number of scans can be preset on a zeroable counter.

The permanently installed traffic meter can at the same time measure the traffic intensity of 20×60 devices and consists of relays for automatic connection of the *TKT* wires, measuring equipment, and counters for the groups of devices to be measured (fig. 13).

With an auxiliary unit *TMVS* four programmes can be selected with keys, with 1200 devices in each programme.

The number of occupations, *TKM*, is measured on separate counters. For measurement of *TKM* during the same period as *TKT*, the voltage to the *TKM* counters is steered via a relay in the traffic meter.

The portable traffic meter is assembled in two portable cases, one of which contains the measuring equipment and the other the *TKT* counters. This meter can simultaneously measure the traffic on 20 devices in 45 groups, i.e. 900 devices. In one type of this traffic meter the counters have been replaced by a tape punch. A code is punched on the tape, indicating the number of occupied devices in each group at the time of measurement.

Equipment for Centralized Supervision

Traffic Route Tester (TRT)

TRT is an equipment for generation of traffic for supervisory purposes. *TRT* is connected to a local exchange having direct circuits to the *ARM* exchange. The reliability of the exchange as shown by *TRT* will thus be identical to the reliability of the traffic offered to the telephone subscribers. Lost calls are recorded by *TRT*.

The traffic to other local exchanges accessible only via transit exchanges *(ARM)* can also be supervised by *TRT*. To the test number used in the remote local exchange there is connected a code answerer which, when the call has been put through, delivers a signal back to *TRT*. Reception of the signal by *TRT* means that the attempted connection has been successful, and *TRT* releases the circuit and starts on the next test. In this way the *ARM* exchange on the switching path has also been supervised.

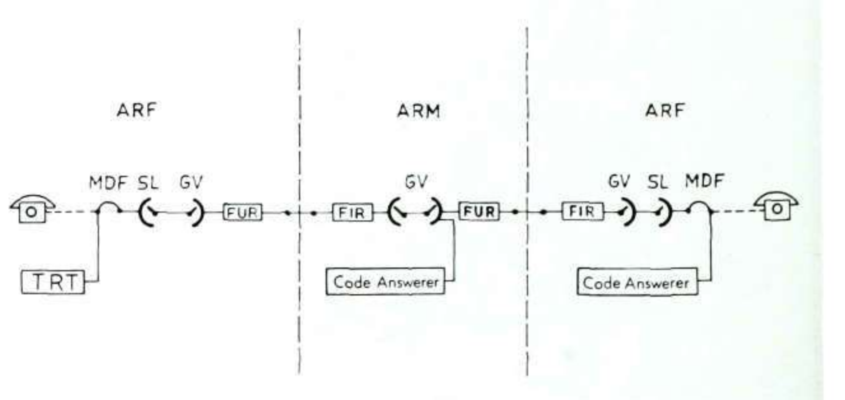


Fig. 14
Switching path TRT — ARF — ARM — ARF — CODE ANSWERER SET

ARM can also be equipped with code answerers. These are connected like a *FUR* to a given route reserved for test traffic.

TRT is a very important link in the centralized supervision, as it permits central supervision of the operational quality for different exchanges in a group. One of the practical consequences of this is that the maintenance personnel can be directed to the point where they are most needed. This contributes to the achievement of equivalent operational quality for the exchanges of the group (fig. 14).

Equipment for Measurement of Trunk Circuits

Automatic Transmission Measuring Equipment (ATME)

ATME is an equipment for automatic measurement of the transmission characteristics of circuits. Measurements are made in respect of attenuation and noise.

The equipment exists in two types, one for measurement of national networks, the other for measurement of international networks. The measurements in national networks are controlled from a central point.

Three equipments are used, equipments *A*, *B* and *C*. Equipment *A* is the controlling equipment, equipment *B* is required at exchanges of which the outgoing circuits are to be measured, and equipment *C* is required at exchanges to which measurements are to be made from an *A* or *C* equipment.

The measurements can be carried out quickly during low-traffic periods, e.g. during the nighttime.

The measurements are controlled either from punched cards, punched tape, or manually from an observation desk. The transmission of orders for measurements and results is done by *MFC* signalling. The results are presented centrally at the *A* exchange on punched cards or teleprinter. With manually programmed measurement the result is shown on lamps. For details of these equipments we refer to Reprints 1374 and 1390 from Ericsson Review.

Table of Maintenance Equipment for ARM Exchanges

The table on the following page shows the maintenance equipment which should exist in *ARM* exchanges. The quantity of equipment required has not been indicated, as this varies from case to case.

Concluding Remarks

Even if the description given in this article is breif, it should be apparent that great opportunities exist for economical provision of suitable maintenance equipment at telephone exchanges so as to obtain a high reliability at a low maintenance cost. More detailed information concerning the function and use of the equipments can be obtained from L M Ericsson representatives.

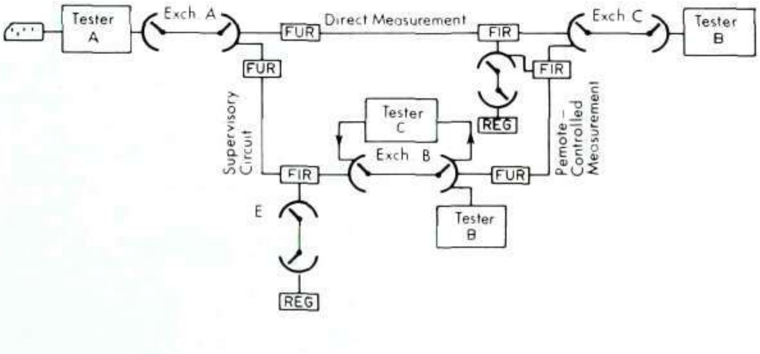


Fig. 15
Automatic transmission measuring equipment (ATME) for measurement of national networks

Maintenance equipment ARM	ARM 20	ARM 50
Service observation equipment		
Supervisory desk or supervisory frame	×	×
Blocked route alarm relay set	×	×
Route congestion alarm relay set	×	×
Supervisory desk or supervisory frame	×	
Service alarm unit, DL	×	×
General alarm unit, CL	×	×
Statistics counter	×	×
Fault counter	×	×
Connecting relay set	×	×
Zeroing relay set NR	×	×
Lamp panel VM-M	×	
Centralograph	×	(×)
Occupation indicator	×	×
Testing equipment		
Automatic exchange tester	×	×
Rate tester } When exchange not	×	
Used with FUR-P/FUR-S } equipped for toll ticketing	×	
Code answering unit FUR-SP	×	×
Fault indicator DKL	×	×
Counter box DKR	×	×
TM equipment		
TKT meter, fixed	×	
TKT meter, portable	×	×
TM plugs	×	×
TM clock	×	×
*Instruments**		
Multirecorder	×	×
Electronic time meter	×	×
Pulse recorder	×	×
Pulse timer	×	×
Pulse generator	×	×
MFC tester	×	×
Universal instrument	×	×
*Tools and miscellaneous**		
Tool cabinet	×	×
Maintenance tool case	×	×
Drawing file	×	×
Steps, 8-rung	×	×
Steps, 5-rung	×	×
Wheeled bench	×	×

*) The choice both of instruments and tools will depend on the number of exchanges within the area.

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from All Quarters of the World

Record Attendance at 1970 Maintenance Conference

L M Ericsson's 1970 Maintenance Conference—the eleventh since the start of these conferences in 1956—was held this year between May 25 and June 5. The year's conference broke a number of records. The numbers of delegates and of participating nations and administrations have never been as great as this year. Apart from 22 delegates from L M Ericsson in Sweden and four from the Swedish Telecommunications Administration, there were no less than 49 foreign delegates representing 34 administrations and 23 nations. France, Hungary, Iraq, Kuwait and Saudi Arabia were represented for the first time.

During the first week of the conference in Stockholm a series of addresses and discussions were held on various maintenance problems, while the second week was devoted to a 4-day visit to the Danish telephone administrations and to the Repeater Station and Maintenance Centre of the Swedish Telecommunications Administration in Malmö.

Centralization tendencies within maintenance were one of the main subjects of discussion. In Denmark a visit was made to the Maintenance Centre in Odense, which, like the new Swedish Maintenance Centre in Malmö, attracted a great interest. As at the last year's conference, much interest was devoted to the SPC system, both as subject of addresses and through visits to the Tumba exchange.

New L M Ericsson products and production methods were presented in addresses and at a special exhibition.

N. H. Loh from Singapore Telephone Board tries out L M Ericsson's new observation desk for automatic telephone exchanges at the Maintenance Conference Exhibition.

LM Ericsson Receives 42 Mkr Order from Lebanon

L M Ericsson has reveived an order for telephone exchange equipment to a total value of 42 Mkr. from the Lebanese Administration des Téléphones.

The contract covers telecommunications equipment for 60 automatic telephone exchanges, which will offer service to an additional 38,800 subscribers in Lebanon. Nineteen exchanges, six of which will be installed in the capital, Beirut, and 13 in other parts of the country, will be entirely new installations. Equipment has been ordered for extension and modernization of 41 exchanges already in operation.

The contract includes installation and maintenance of the equipments ordered.

All exchanges are calculated to be in operation by the autumn of 1973.

LME received its first order for telephone exchanges from the Lebanese Administration in the early fifties and has since installed exchanges which today provide service for more than 115,000 subscribers. With this last order LME has sold exchange equipment to Lebanon for nearly 200,000 subscribers.

When the contracted equipment has been installed, Lebanon's telephone density will have passed the level of 10 telephones per 100 inhabitants, the fourth highest figure in Africa and Asia together. The corresponding levels for the USA and Sweden are 54 and 52 telephones per 100 inhabitants respectively.

After having had a Technical Office in Lebanon for some 20 years, LME has now established a subsidiary company, Société Libanaise des Téléphones Ericsson (SLT). With Head Office in Beirut it will undertake installation, documentation and technical consultation assignments. It is expected to have some 150 employees by the end of this year.

Exhibition in Rotterdam

Manifestatie Communicatie '70—C '70 for short—is an event which is being held in Rotterdam between May and September this year to celebrate the liberation of the city 25 years ago. Through exhibitions and by other means it is desired to show what has happened during these 25 years and what Rotterdam has to offer as port and as industrial, cultural, athletics and festival centre.

L M Ericsson is taking part in the exhibition with a large stand in the PTT building at Coolsingel. During May alone the stand was visited by more than 15,000 persons interested in the new features shown within the telecommunications field: videophones, Electrowriter, alarm systems, telephone exchanges, general demonstration tableaux etc.

From the Rotterdam Exhibition "Manifestatie Communicatie '70". (Left) Mr E. Brandsma, President of Ericsson Telefoonmaatschappij, (right) Mr Sven-Ture Åberg, former President of LME, during a visit to the stand.

STE Delivers Telephone Equipments to Gaboon and Madagascar

Société Française des Téléphones Ericsson (STE) is to deliver telephone equipment for the new government plan for extension of the Gaboon telephone network.

Two new exchanges are to be put in operation at the end of 1971 in Libreville. A third exchange will be built later in conjunction with the planned deep-water harbour at Owendo. Three further exchanges will be built in Libreville at a later stage.

STE is also to deliver equipment for extension of the traffic facilities in other towns in Gaboon. The exchange at Port-Gentil, for example, will be extended to 2000 subscriber lines at the beginning of next year.

In Madagascar as well the P. & T. has employed the services of Ericsson's French subsidiary for the planned extension of the Madagascan telephone network; an order for 11 telephone exchanges has recently been placed with STE. Two of these exchanges are intended for transiting of the automatic telephone traffic between the capital, Tananarive, and the port of Tamatave. The expected final capacity is 1200 automatic circuits and 9000 subscriber lines.

L M Ericsson's French Subsidiary Concludes Agreement with Another French Enterprise

L M Ericsson's French subsidiary, Société Française des Téléphones Ericsson (STE), and Compagnie Industrielle des Télécommunications (CIT) have concluded an agreement for joint technical development, particularly in respect of computer-controlled telephone exchanges for the French PTT. They have also concluded an agreement concerning coordination of production in order that each party may achieve longer production series.

In conjunction with the agreements between STE and CIT, it has been agreed between L M Ericsson and the parent company of CIT, Compagnie Générale d'Electricité, that CIT shall acquire 16 % of the share capital of STE.

After completion of the transaction L M Ericsson will retain a majority holding in STE.

All agreements are subject to approval by Swedish and French authorities and by the boards of L M Ericsson and Compagnie Générale d'Electricité.

Training of Installers and Testers in Tunisia

Since the end of last year an extensive programme of training has been arranged in cooperation between the Tunisian PTT, SIDA (Swedish International Development Authority) and L M Ericsson. The goal of the programme is to train a large number of PTT technicians for installation and testing work on the telephone equipments from L M Ericsson which are at present under installation.

After a brief period of assistance from L M Ericsson personnel when a training course is started, the training will be conducted by the PTT itself. A number of engineers and technicians who have earlier been trained at L M Ericsson in Stockholm will act as instructors. The goal for the present training programme is that in the near future the PTT will be able entirely to take over the installation and testing of new exchanges.

One of the aids used on the courses is the instruction tape recorder working on the RITT method, i.e. each pupil has an individual tape recorder with the various sections of the course recorded on tape cartridges. This procedure has proved to save much time and to be an effective method, since the pupil can adapt the instruction to his own working rhythm.

Hitherto some 80 Tunisian PTT engineers and technicians have been trained in Stockholm. Another 30 are expected to undergo traning in the near future.

Tunisian installer being instructed by the RITT method.

During a recent trip to Brazil, Mr Björn Lundvall, President of L M Ericsson, visited the Governor of São Paulo, Dr Roberto Costa de Abreu Sodré. (From left) Sr Juracy M. Magelhães, Chairman of Ericsson do Brasil, Mr. Lundvall, Governor Sodré, and Mr. Hans Sund, L M Ericsson.

The Head of the National Telecommunications *Department of Brazil (DENTEL)*, General Kleber Rollin Pinheiro, and the Brazilian Ambassador to Sweden, Dr Aluzio Napoleão, during a visit to L M Ericsson in Stockholm in May 1970.

◀

An exhibition was arranged in Geneva in May in conjunction with the 100th Anniversary of the Swiss Fire Brigade Association. L M Ericsson's Swiss subsidiary, Ericsson AG, exhibited in particular fire alarm equipments, and radio communication equipments from Svenska Radio AB.

At the end of June the Malaysian Prime Minister visited the Head Factory in Stockholm. (From left) Mr Arne Mohlin, LME, Prime Minister Tunku Abdul Rahman Putra, and Mr Björn Lundvall, President of LME.

◀

L M Ericsson's subsidiary, Instruktionsteknik AB, participated in the Teaching Aids Fair, DIDACTA, in Basel at the end of May and beginning of June. The RITT, instruction unit and equipments for multiple choice methodology attracted a large number of visitors.

The Orchard Exchange and Engineering Centre, the new telephone exchange at Singapore, for which L M Ericsson supplied its crossbar system ARF 102, was cut over in May.

Ellemtel Utvecklings AB Approved by the Crown

On June 5, 1970, Parliament authorized the Crown to approve the agreement between the Swedish Telecommunications Administration and L M Ericsson for joint development work conducted by Ellemtel Utvecklings AB. The agreement had earlier been approved by the board of L M Ericsson.

It is planned that the Board of Ellemtel shall consist of the following members: from the Telecommunications Administration—Director General Bertil Bjurel, Operational Director Torsten Larsson, and Technical Director Eric Waldelius; from L M Ericsson—President Björn Lundvall, Vice President Fred Sundkvist and Dr Christian Jacobæus.

E. Eriksen

The President of Ellemtel will, as earlier mentioned, be Mr Erik Eriksen.

New Member of the Management

The Board has oppointed Mr Karl-Axel Lunell Vice President of the Company and head of the Management Staff Department for Licence Questions.

K.-A. Lunell

Mr Lunell succeeds Mr Olof Hult, who, however, after attaining pensionable age, will remain with the company for special agreement questions.

Mr Lunell entered into his new appointment on June 1, 1970.

New Appointments

Mr Sven-Olof Tonnæus has been appointed head of L M Ericsson's recently formed company in Beirut, Société Libanaise des Téléphones Ericsson. He took up this post on August 1.

S.-O. Tonnæus

M. Marcel Coutier was appointed President of LME's French subsidiary, Société Française des Téléphones Ericsson at the Annual General Meeting on June 1, 1970, in succession to M. André Duprez, who leaves the post as Head and Chairman of the Board on attaining pensionable age.

At the same time M. Marcel Cazes was appointed Chairman of the Board.

M. André Duprez will remain on the Board of the Company and has at the same time been appointed Honorary Chairman.

Ericsson Technics

Ericsson Technics Nos. 1 and 2 for 1970 contain two papers each.

The first paper in No. 1, *Digital Filters with Multiple Shift Sequences*, by T. Fjällbrant, describes how, in digital filters for sampled signals, the time between the samples can be used for signal processing since the storage time in each shift register is a submultiple of the sampling interval. The multiplication constants in the filter equipment can assime different values during the various shift sequences. With this method variable filters can be effectively realized since the desired filter characteristic can often be obtained by variation of a single parameter. Furthermore a reduction of the requirement of coefficient accuracy in filters of higher degree can be obtained.

The second paper, by T. Ericson, *An Information Theory Approach to the Source Approximation Problem*, deals with the problem of approximating a random time series from the point of view of information theory. Mc Millan's theorem and the entropy concept form the basis for the theory developed. Two classes of approximation processes are studied: finite order unifilar Markov sources and renewal processes. Both classes are shown to possess certain desirable properties for approximation purposes. The treatment is far from exhaustive and the theory as given must be regarded as preliminary.

Ericsson Technics No. 2 starts with a paper by O. Ekholm and N. O. Johannesson, *Loading Effects with Continuous Tone Signalling*. It describes a carrier system with continuous outband signalling loaded, inter alia, with sine voltages. Unless special precautions are taken, the system quality may be seriously impaired by, for example, overloading of line repeaters, unacceptably low crosstalk ratios and interference tones in programme channels. These phenomena are studied in detail and it is shown that there is a very effective remedy—random phasing. Analytical expressions are derived and the theories are compared with extensive measurements. All carrier systems with outband signalling in Sweden have now been converted to random phasing.

Finally in *A Simple Iterative Method for Evaluation of the Characteristic Function in Filter Synthesis*, H. Rapp describes how arbitrarily prescribed insertion and/or reflexion losses specified in the form of connected rectilinear sections for an arbitrary number of pass and stop bands are uniformly approximated by the characteristic function, which is evaluated by an iterative single-step method. The method consists of an equalization procedure making use of all degrees of freedom for the approximation. The computer programme is described. The computation demands have been reduced by a special transformation and by describing the approximation error in terms of physical requirements. The programme is characterized by modest demands on storage requirements.

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Cont. on next page

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On cover: L M Ericssons latest new building within the Midsommarkransen area in Stockholm

Miniaturized Main Distribution Frame

L. OLOFSSON & E. JOHANNESSON, TELEFONAKTIEBOLAGET L M ERICSSON, STOCKHOLM

UDC 621.315.3:621.316.172
621.395.722
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73754

L M Ericsson has manufactured and marketed M.D.F. equipment since the 1890's. The demand for M.D.F. equipments has remained largely unchanged up to the end of the 1960's, since when miniaturization of M.D.F. equipment has been increasingly called for.

This article presents an entirely new M.D.F. equipment which occupies very much less space. The new equipment, popularly called the Mini-M.D.F., is based on an entirely new type of frame devloped by L M Ericsson, using sleeve contact connectors.

General Considerations

The main task of the M.D.F. is to provide space for cross-connections between the telephone exchange and outside plant. The M.D.F. can also be equipped with fuses and overvoltage protectors for the switching equipment and provides a number of other facilities listed below under "Mini-M.D.F. facilities".

New types of switching equipment with high insulation resistance, and new types of outside plant in which the lines run to a large extent in underground cables, do not require overvoltage protection to the same extent as before, when the lines consisted largely of overhead cables. The need for fuses has also diminished, since in an efficient cable network the lines are well protected. If an excess current results in destruction only of the individual line equipment and is of rare occurrence, a fuse may be unjustified.

If, on the other hand, an excess current may result in blocking or non-operation of the central devices of an exchange, fuses should be used.

The basic equipment in the new Mini-M.D.F. caters solely for the main purpose of the M.D.F. as here described. If further M.D.F. facilities are required, the basic equipment can be supplemented by plugs of different kinds.

Maintenance Aspects

In the design of the Mini-M.D.F. the main emphasis has been on easy handling of the equipment from the maintenance point of view. Investigations have shown that a jumper wire is replaced after 5—9 years owing to movements of subscribers. It is therefore very important that the manual work involved in changing of wires is limited to a minimum. That this is so will be seen from the account under "Work on the M.D.F.".

High Concentration

Charactersitic of the Mini-M.D.F. is its high concentration. With a standard height of frame of 2900 mm, 2000 two-wire cross-connections can be made

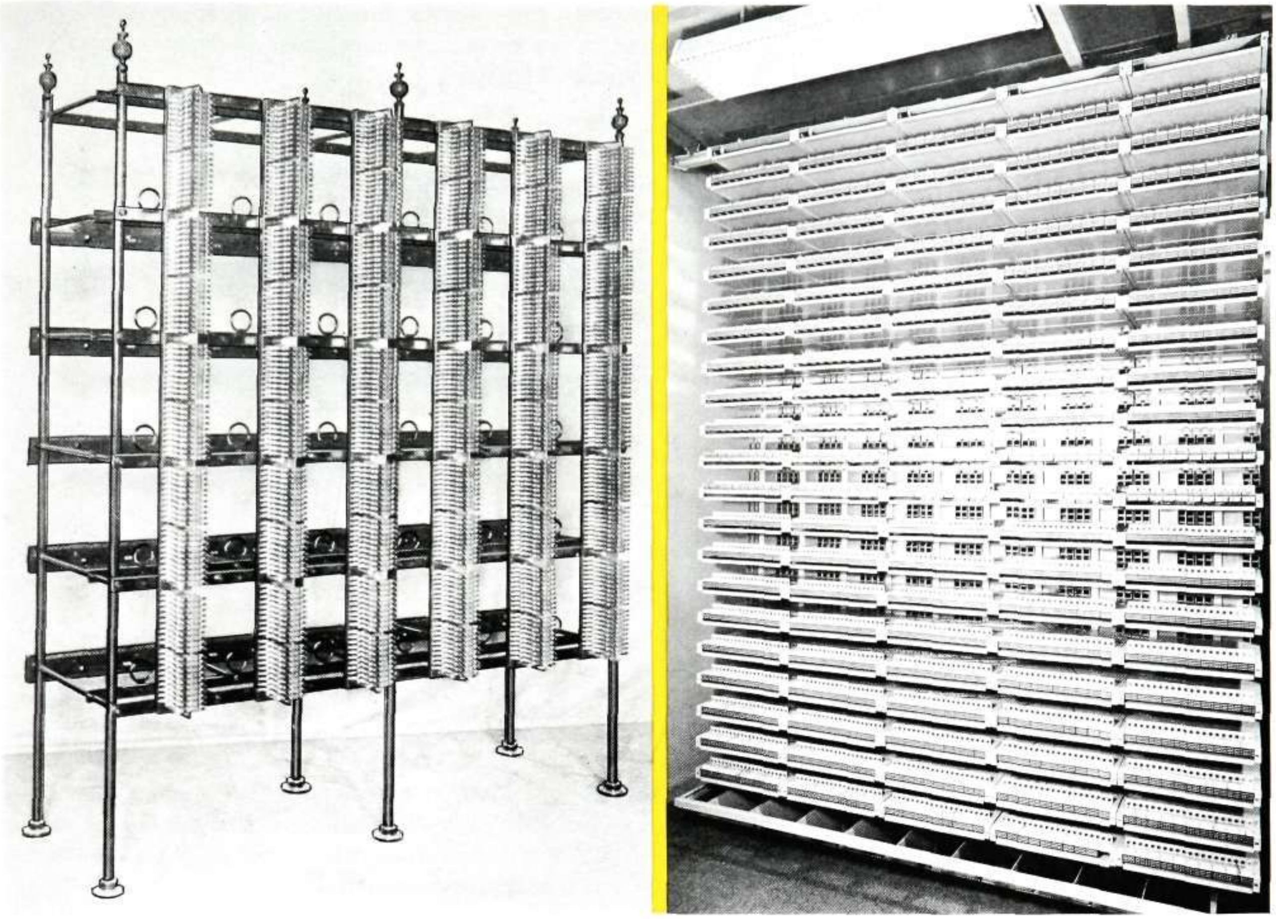


Fig. 1
M.D.F., 1897 model for 600 pairs of wires (left). Mini-M.D.F., 1970 model, for 10,000 pairs (right)

between the exchange and line sides of the M.D.F. Five such frames connected together into an M.D.F. unit occupy a floor space of 2×0.7 m and accommodate jumper wires for a 10,000-line exchange capacity.

Ease of Accessibility

The jumper wire run between the exchange and line sides of the M.D.F. unit is taken in two directions — one vertical and one horizontal (figs. 3 and 4). In order that the jumper wires shall not form thick bundles, from which it is difficult to withdraw old wires, the frame has been so designed that the wires are evenly distributed throughout the entire M.D.F. unit in a natural manner at the time of laying. This effect is obtained through the fairly large number of shelves (20) on the exchange side and through the wire guide arrangement which exists at the transition from horizontal to vertical wiring.

The wire guide arrangement divides up the bunch of wires into smaller bunches and thus prevents locking of the first laid wires. With M.D.F. units for up to 20,000-pair capacity on the exchange side the direction of wiring is changed only once, at the transition from horizontal to vertical wiring. The risk of locking of jumper wires is therefore very small. The jumper wires have a diameter, including insulation, of 1.2 mm. The conductors are tinned and are of 0.6 mm diameter.

Simple Connection

The connection of the jumper wires on the exchange and line sides is done by stripping off their insulation and plugging them into sleeve contact connectors. The force required for plugging in of a wire is so small that ordinary tinned copper wire of 0.6 mm diameter can be used to advantage. With the jumper wire plugged in, the contact pressure between the sleeve contact and the jumper wire is min. 250 g.

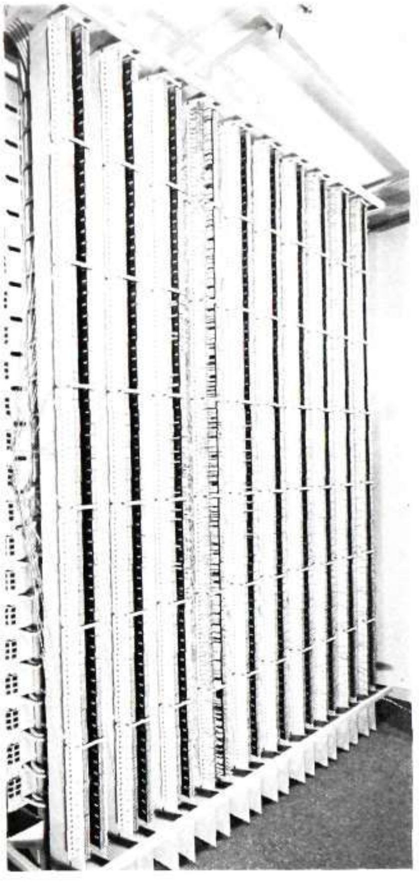


Fig. 2
Vertical side (line side) of Mini-M.D.F. for 14,000 pairs of wires

Good Electrical Properties

The short length and fairly large cross-sectional area of the jumper wire ensures satisfactory transmission properties. The length of wire, which is directly proportional to the length of the M.D.F. unit, is considerably shorter in a Mini-M.D.F. than in older types. The difference in length of wire is greater for large M.D.F. units.

The risk of crosstalk between two parallel pairs of wires is also diminished as a result of the fairly large number of horizontal shelves.

Mini-M.D.F. Facilities

The main object of the M.D.F. is to interconnect any pair of wires on the exchange side with any pair on the line side. The Mini-M.D.F. also offers the following facilities:

- ☐ Rapid connection of the lines to the exchange, approx. 1000 lines per person and hour. The number of persons working simultaneously, however, should be adapted to the size of the M.D.F. unit and the layout of the M.D.F. room. By "connection" is meant in this case the work involved, for example, in cutting over a new exchange. All preparations have been made, i.e. all cables are soldered to the connectors and the jumper wires have been plugged in. The work is done by one man who stands in front of the frame and inserts the plugs required. On large M.D.F. units a number of persons can plug simultaneously into different parts of the M.D.F. unit.
- ☐ Rapid disconnection of the lines from the exchange. The disconnection time is rather shorter than the connection time.
- ☐ Easily accessible facilities for parallel monitoring on the exchange side without risk of interruption of an established connection.
- ☐ Possibility of connection of test equipment with which tests can be made alternatively to the line or the exchange.
- ☐ Possibility of cutting off an individual line.
- ☐ Possibility of vacant subscriber connection, which implies cutting off an individual line and connection of a tone or announcement to the exchange side without producing an answer signal.
- ☐ Possibility of visual marking of a cut-off line.
- ☐ Possibility of protection of each individual line by a fuse.

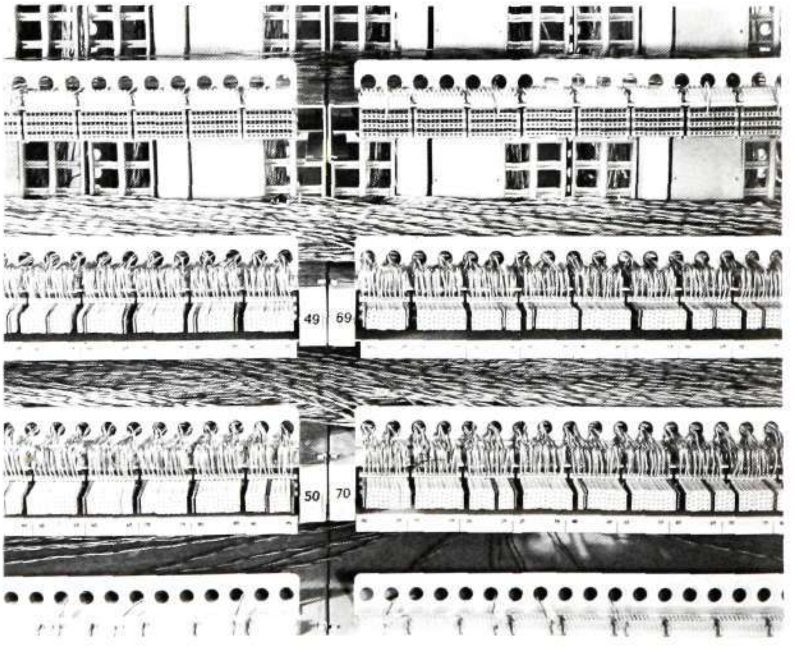


Fig. 3
The horizontal wiring of the M.D.F. is done on horizontal shelves

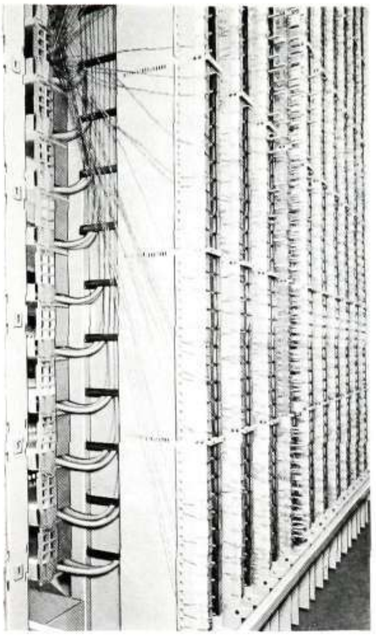


Fig. 4
The vertical wiring of the M.D.F. is done on vertical "shelves"

Mechanical Design

Frame BAB 320

The frame used in the Mini-M.D.F. is of a new type, *BAB 320*.

The frame consists of 21 horizontal shelves on one side and 4 vertical "shelves" on the other. The distance between the horizontal and vertical sides is 0.7 m, which provides adequate space for cabling. The cabling space on the horizontal side is dimensioned for 2×30 50-pair cables and on the vertical side for 2×40 50-pair cables. There is also space, of course, for jumper wires between the horizontal and vertical sides. These figures relate to a frame height of 2.9 m, which is the standard height of M.D.F. in telephone exchanges. For special requirements there are other frame heights, with capacity adapted accordingly.

Five frames can be placed in line to form an M.D.F. unit for 10,000 pairs on the horizontal (exchange) side and 14,000 pairs on the vertical (line) side. If a larger ratio between exchange and line sides is desired, this can be obtained by increasing the number of frames. The capacity on the exchange side will then not be fully utilized. For larger M.D.F. units several suites are built, with 5 frames in each suite, the suites being interconnected by means of special cabling shelves, which permits jumpering within the entire M.D.F. unit (fig. 5).

If the final capacity of the M.D.F. unit is not to exceed 10—15 frames, all frames can be placed in the same suite (fig. 6). The factor limiting the length of the suite is then the space on the horizontal shelves.

Regardless of whether the M.D.F. unit consists of a number of suites with 5 frames in each or of one suite of 10 frames, the number of wires will be greatest on the horizontal shelves of the fifth frame. With normal distribution there will be 100 pairs of wires on these shelves. In practice, of course, the number of pairs on the shelves will vary fairly considerably, and therefore the shelves have been designed to accommodate 500 pairs of wires.

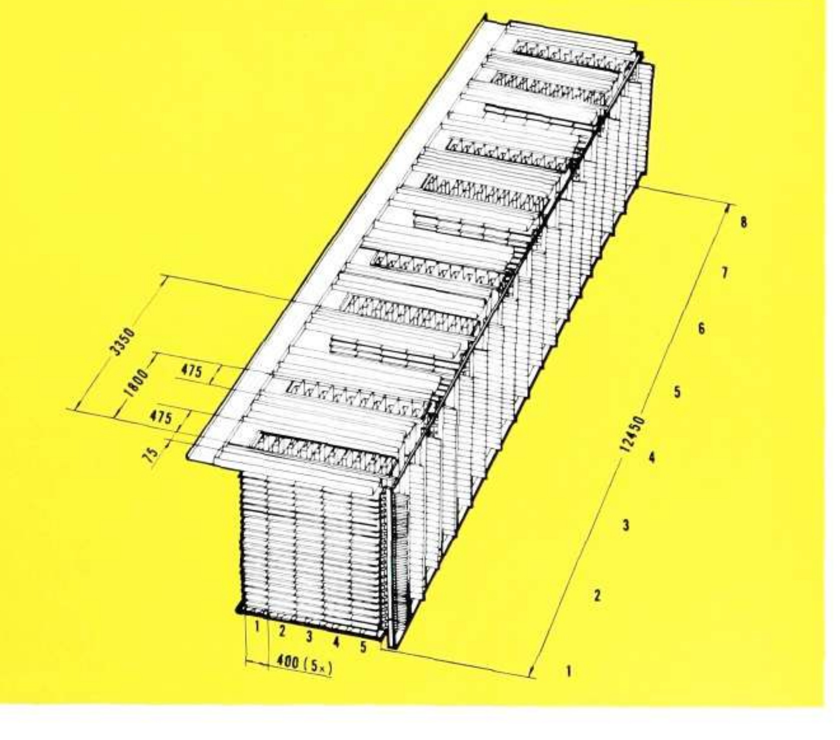
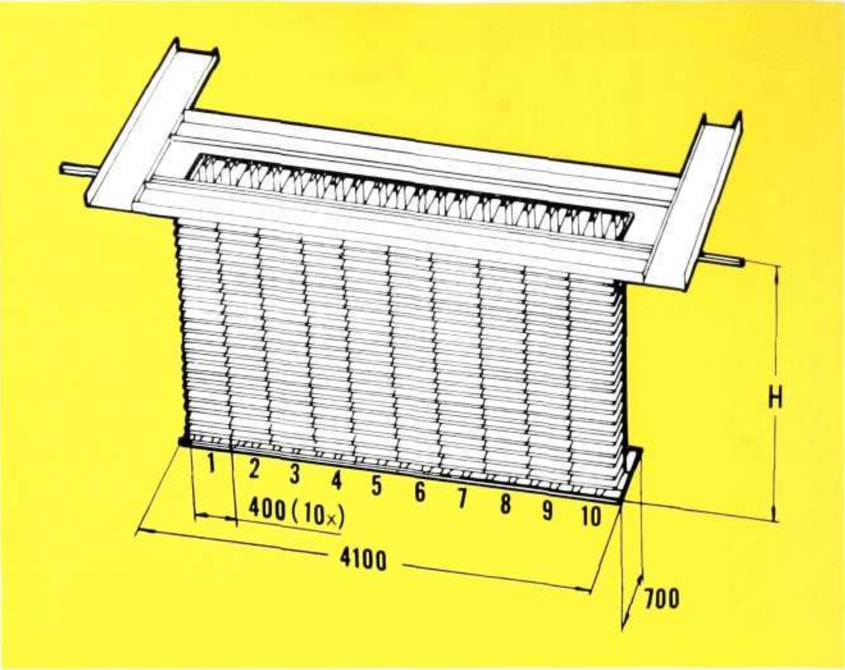


Fig. 5
M.D.F. for 80,000 pairs of wires on the exchange side and 112,000 on the line side

Fig. 6
M.D.F. for 20,000 pairs of wires on the exchange side and 28,000 on the line side



Connector Unit

On the shelves are placed connector units in which the cables are connected and the jumper wires are plugged. A connector unit (fig. 7) normally contains 6 connectors and forms a wiring unit for 10 pairs of wires. For every pair of wires, accordingly, there are 6 contacts, two of which are used for plugging in of the jumper wires and four for service plugs.

When the service plug is inserted, contacts 1, 3 and 5 are in parallel and connected to the a-wire, and contacts 2, 4 and 6 are in parallel and connected to the b-wire.

The connector units are similar on the horizontal and vertical sides but can also be cut down to 2 connectors on the vertical side and 2—6 on the horizontal side.

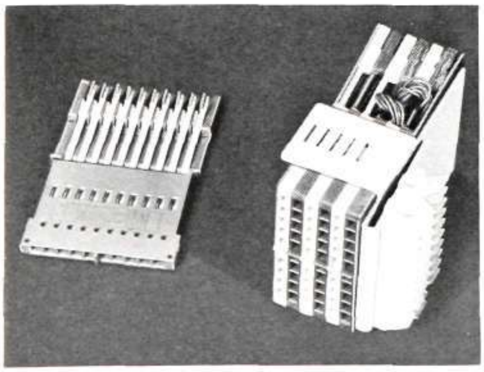
Service Plug

Service plugs are used for rapid connection or disconnection of a line.

Service Plug with Fuse

If a fuse is required, the ordinary plug is replaced by a plug with fuse wire.

Fig. 7
Connector unit for 10 pairs of wires and extra connector for vacant subscriber connection



Test Plug, 2-Pole

For parallel connection of a line a 2-pole plug with cord is inserted in the service plug. The cord can then be connected to a telephone, subscriber call recorder or the like.

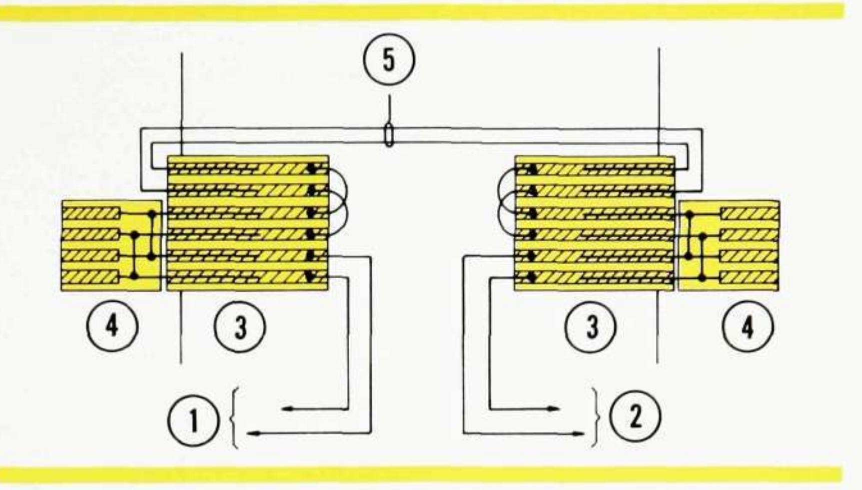
Test Plug, 4-Pole

For connection to a line test desk or the like a 4-pole test plug with 4-wire cord is used. Two wires are connected to the line side and two to the exchange side. Separate tests can then be made to the line or exchange.

Fig. 8

Circuit diagram for through-connection of a pair of wires from horizontal to vertical side of the M.D.F.

① Cable to the exchange
② Cable to the line
③ Connector unit
④ Service plug
⑤ Jumper wire



Vacant Subscriber Plug

When a subscriber's line is temporarily cut off, e.g. owing to failure to pay a bill or to removal, a special tone or a standard message from an announcing machine can be inserted on that subscriber's position. This can be done by means of a vacant subscriber plug and an extra connector in the connector unit. The vacant subscriber plug contains certain components such as resistors and rectifiers to prevent the issue of an answering signal, which would cause metering to take place.

Work on the M.D.F.

The M.D.F. occupies a number of persons who, on medium-sized and large M.D.F. units, are continuously engaged on rearrangement of the jumper wires. The reason for such rearrangement is that some subscribers move from, to or within the exchange area. Every such movement usually means that an old jumper wire must be removed and a new one inserted. Statistically every subscriber moves every 5th—9th year, which means that every jumper wire must be replaced once in 5—9 years.

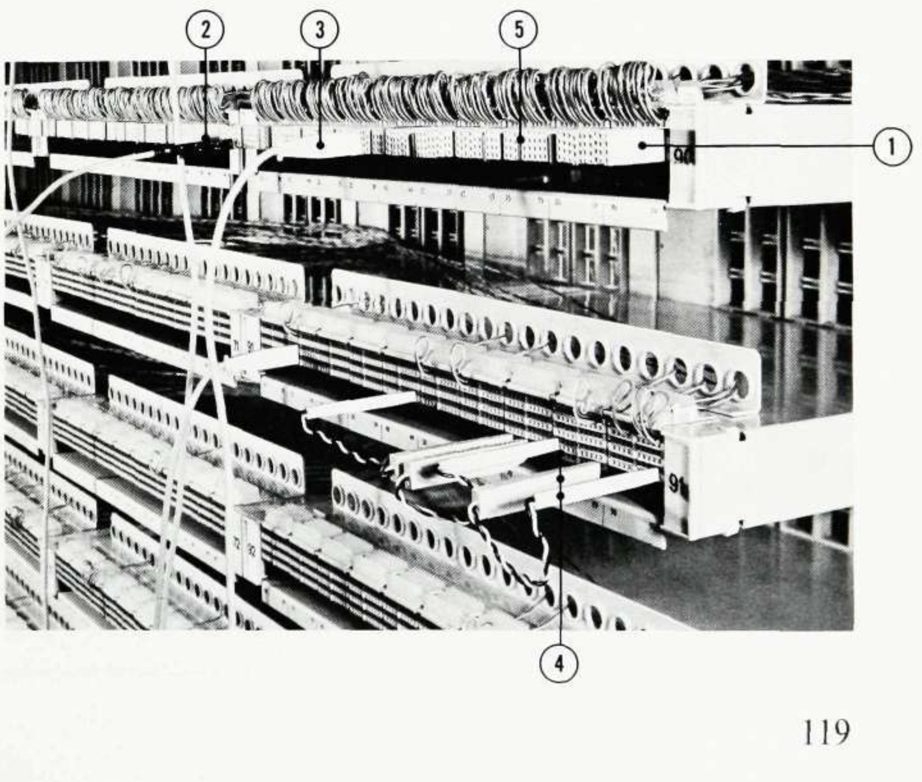


Fig. 9
M.D.F. accessories

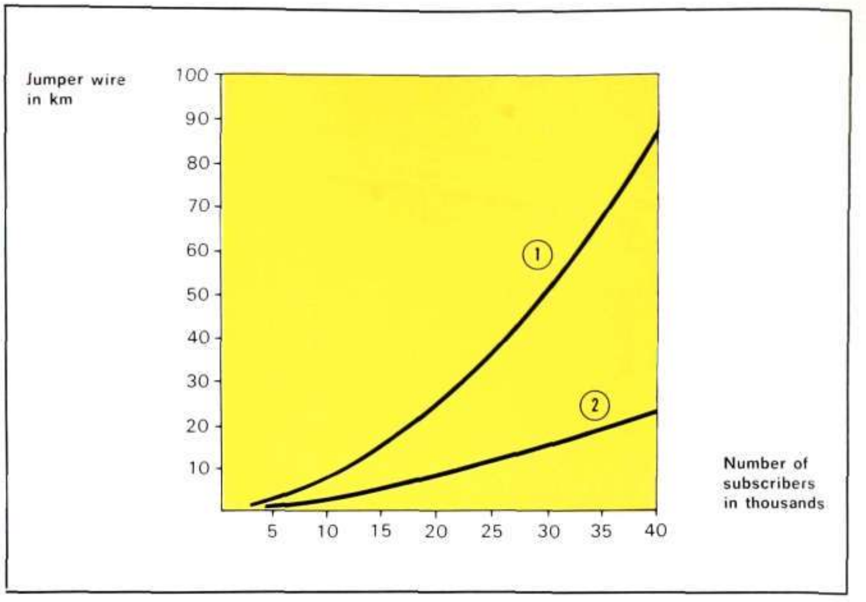
① Service plug
② Test plug, 2-pole, with cord
③ Test plug, 4-pole, with cord
④ Vacant subscriber plug with extra connector
⑤ Marking plug

Fig. 10

Annual consumption of jumper wires as function of number of subscribers

① Conventional M. D. F.
② Mini-M. D. F.

The curve is based on the assumption that 11.5 % of subscribers move every year



The cost for replacement of jumper wire consists of the cost of the wire and the labour cost for removal and reinsertion. The labour cost is proportional to the length of the jumper wire. The maintenance cost is thus proportional to the consumption of jumper wire (fig. 10). Comparing the mean length per jumper wire for Mini-M.D.F. and older types of M.D.F., it is found that the jumper wire is considerably shorter in the Mini-M.D.F. For M.D.F. units for 10,000 pairs of wires the mean length per jumper wire will be approx. 2.5 m for the Mini-M.D.F. and about 6 m for older types of M.D.F. The same comparison for M.D.F. units for 20,000 pairs of wires shows that the lengths of wire are 3.5 and 10.5 respectively. One may thus speak of a greatly reduced maintenance cost.

Space Requirement

The frame *BAB 320* occupies a floor space of $0.4 \times 0.7 = 0.28$ m². Five frames can be placed side by side to form a suite of $5 \times 0.4 \times 0.7 = 1.4$ m². Space is also required for the personnel to work on the M.D.F., i.e. about 1 m on each side (figs. 11 and 12).

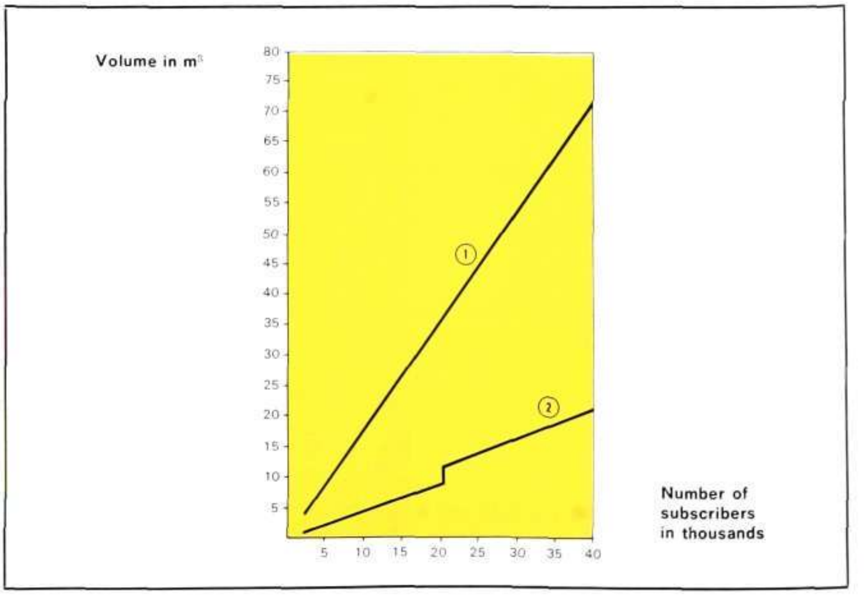
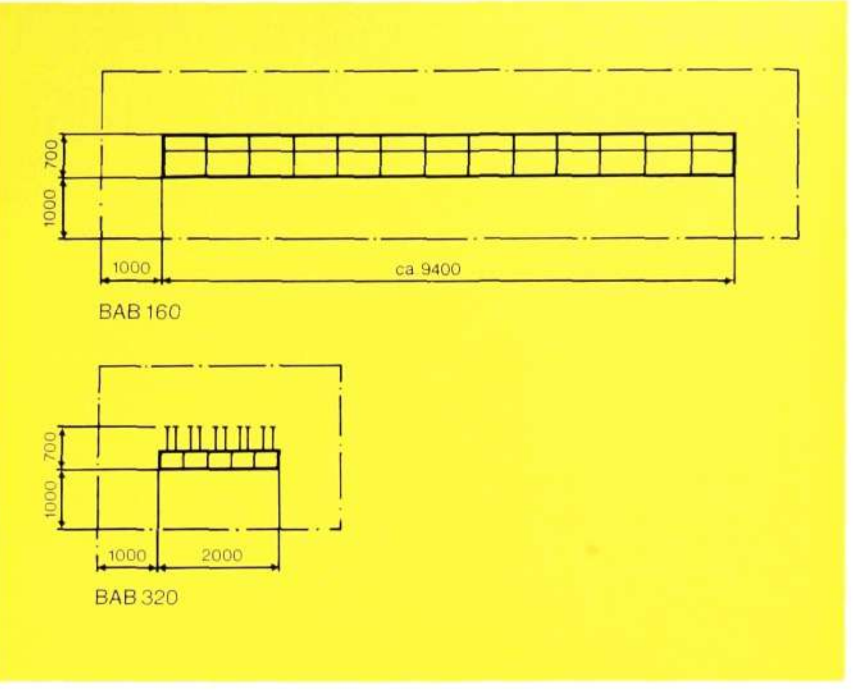


Fig. 11

Size of M.D.F. equipment in m³ as function of number of subscribers

① Conventional M. D. F.
② Mini-M. D. F.

Fig. 12
Layouts for M.D.F. units of 10,000 lines
BAB 160 is a conventional M.D.F. and BAB 320 a Mini-M.D.F.



Other Applications for Frame BAB 320

In the preceding account the frame *BAB 320* has been described for use in a M.D.F. unit, and it was for this purpose that it was designed. The main purpose of the frame, however, is to provide space for a number of cables and elements connecting to the cables. On the frame shelves, therefore, other elements than connector units can be placed, e.g. jack strips, lamp strips, supervisory strips etc. (fig. 13). The frame can therefore be used also as a miscellaneous frame for which various difficultly placed elements can be connected in an efficient manner in a minimal space.

Overfull M.D.F.

Mini-M.D.F.s may be the solution to problems arising when an M.D.F. of older type is overfilled with old jumper wires and the accommodation is limited.

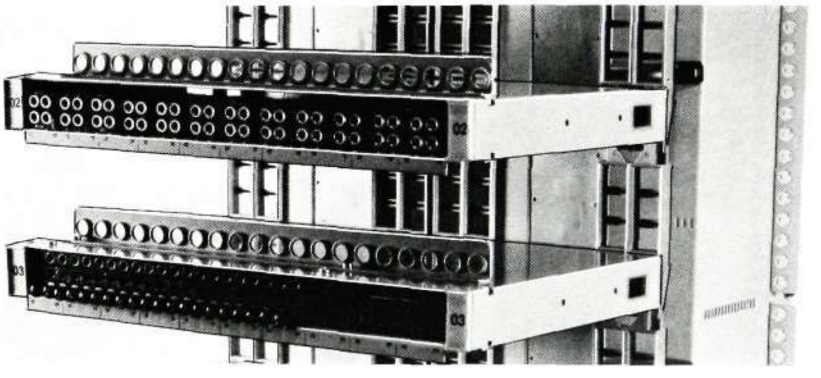


Fig. 13
Frame BAB 320 with supervisory strips, jack strips and lamp strips

H. F. Line Equipment ZAX 120 T for Two-Wire Operation on Small-Diameter Coaxial Cable

P. E. JOHANSSON, TELEFONAKTIEBOLAGET L M ERICSSON, STOCKHOLM

UDC 621.395.4:621.315.212
LME 8421
8424

This article describes L M Ericsson's h.f. line equipment designed to carry 120 telephone channels in both directions on a single small-diameter coaxial pair.

Today's range of metallic line carrier systems for a small number of circuits consists chiefly of 12, 24 and 60-circuit systems on open-wire lines and symmetrical pair cables.

Because of the limited circuit capacity of these h.f. lines and their relatively high line costs per circuit, they are no longer so attractive as more modern alternatives for expanding a network or for providing new circuits.

Between places where the traffic is expected to be relatively limited for some time to come, so that larger coaxial cable systems for 300—960 circuits or more involve too high an initial cost, a need has arisen for a modern h.f. line equipment for a smaller number of circuits.

To meet this need L M Ericsson has developed an h.f. line equipment for 120 circuits, ZAX 120 T, which has made it economically possible to use coaxial cable technique here as well. Experience gained from earlier h.f. lines for 300—960 circuits has been used both in the practical design and for arriving at a realistic compromise between cost per circuit kilometre and technical facilities provided by the equipment.

The h.f. line equipment *ZAX 120 T* consists of terminal repeater equipment comprising amplifiers and matching devices and, along the line, dependent (power-fed) intermediate repeaters.

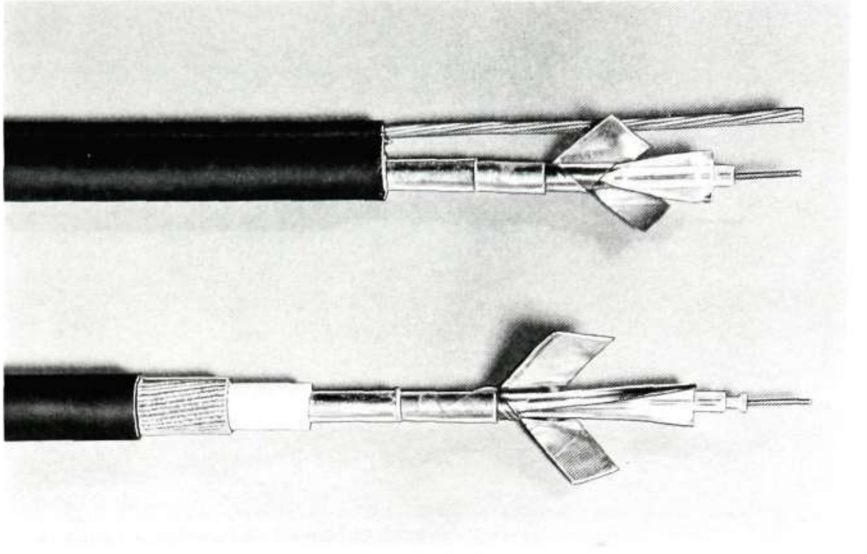
The terminal repeaters of the h.f. line are interconnected on a four-wire basis to the multiplex equipment or other h.f. lines in the frequency range 60—552 kHz, in accordance with CCITT's Recommendation for sending and reception of a 120-channel line group. For transmission over the cable, use is made of segregated frequency bands for the two directions of transmission (sometimes known as two-wire transmission) by modulation with a 1364 kHz carrier frequency.

At the terminal repeater stations as well as at the intermediate stations only one line amplifier is used for both directions of transmission.

All line amplifiers have automatic gain control and are power-fed from terminal repeaters or from power-feeding intermediate stations.

The nominal repeater spacing is 7.8 km at an average coaxial cable temperature of +10° C.

Fig. 1
Small-diameter coaxial cable with balloon insulation
Overhead cable (top) and underground cable



The Coaxial Cable

To make these systems economically attractive it has been necessary to reduce the cable cost as far as possible.

By use of the two-wire principle for the repeater equipment a cable containing a single coaxial pair can be used for both directions of transmission.

The cable specially developed for this purpose may be of two main types. One is an overhead cable with suspension wire for mounting on pole lines. The other main type is an underground cable with simple armouring for burying or ploughing into the soil or running in ducts (fig. 1).

The small-diameter coaxial pair is that standardized by CCITT in Rec. G 342, having a diameter ratio of 1.2/4.4 mm, with a line impedance of 75 Ω.

The outer conductor of the cable consists of a 0.15 mm thick strip of electrolytic copper formed into a tube wrapped with two copper-plated steel tapes. The insulation consists of a polyethylene tube and the inner conductor is centered by compressing it at regular intervals. This provides a continuous, high-class insulation between inner and outer conductor.

The coaxial pair is insulated with two layers of plastic tape. Thereafter follows a screen of 0.15 mm aluminium. This screen is formed by a tape coated with a thin adhesive layer of plastic which, when sprayed with a surrounding cover of polyethylene, fuses with the latter. This screen provides an effective protection against electromagnetic disturbances, for example from adjacent radio transmitters, whose carrier frequencies may lie within the frequency range of the system, and also against the entry of moisture.

Cables for pole mounting have a figure-of-eight configuration including built-in suspension wire consisting of 7 galvanized steel strands. Underground cables have a covering of 1 mm galvanized steel wires, outside which is an additional jacket of polyethylene.

For pole-mounted cable with a non-circular cross-section and of relatively low weight, which is exposed to high wind forces, there is always some risk of galloping.

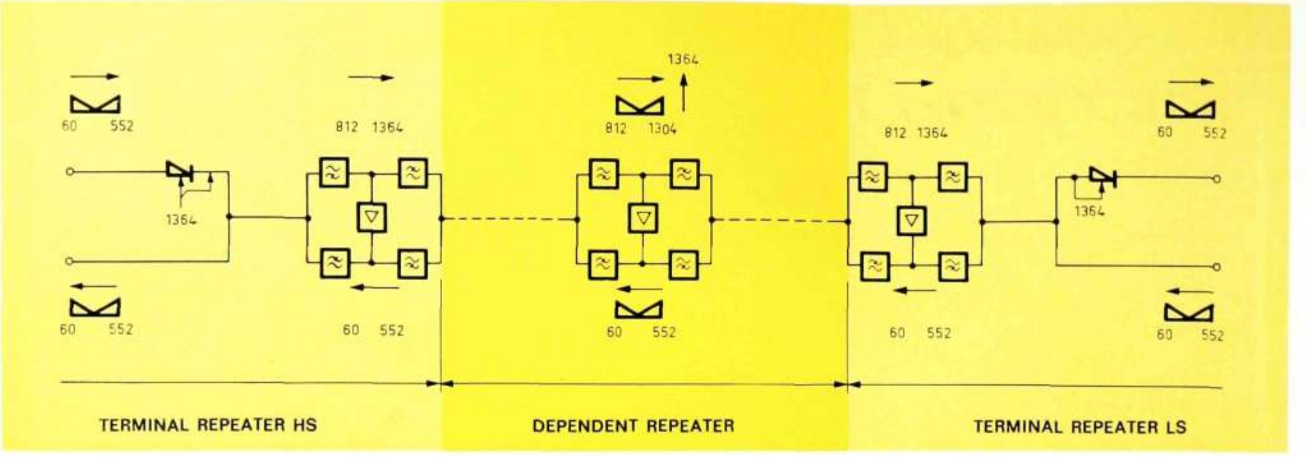


Fig. 2
Two-wire system on submarine cable principle

This places great requirements both on the durability of the cable and on its suspension.

By means of long-time tests, made chiefly in Iceland in cooperation with the Iceland P & T, both the cable and the suspension material have been tested over several years under very severe wind conditions.

These investigations have shown that the attachment of the cable to the pole must be rigid, and that the cable must be rotated around its suspension wire about 1 turn/10 m length and given a sag of 1—2 % at 0 °C. With 50 m pole spacing the cable is thus rotated roughly 5 turns.

These very simple measures have proved to give satisfactory protection against excessive galloping.

The method of jointing the cable is simple and, in principle, similar for both types of cable. The repeater equipment is supplied ready jointed to factory-made stub cables of the same type as the h.f. line cable.

Electrical Design of the H.F. Line

The aim in the development work may be summarized under the following main points:

- An economically attractive solution for a relatively moderate number of circuits and with the possibility of direct branching at line frequencies without demodulation.
- A reliable equipment, easy to install and simple to maintain.
- Suited for interconnection with larger-capacity h.f. lines, e.g. for 300 or 960 circuits.
- Utilization of experience and technical solutions from the development of 300 and 960-circuit systems for four-wire operation with reference to more than 5000 km installed h.f. line equipment in operation within the Swedish Telecommunications plant.

The principle selected for this system, with transmission in both directions on a common coaxial pair and with amplification for both directions of transmission by a common line amplifier in accordance with what is common practice in submarine cable systems, will be seen from the simplified sketch in fig. 2.

The procedure implies briefly that the bandwidth available in the h.f. line equipment is divided into two equal bands, one for each direction of transmission. At every repeater station along the line the two bands are separated by means of directional filters before being amplified.

The principle of transmission on one coaxial pair implies that the frequency band in use must be rather more than twice as wide as that required for transmission on two coaxial pairs for systems with a corresponding number of circuits.

The additional cost of the repeater equipment caused by the directional filters and the broader range is more than well compensated by the lower price of a single-pair coaxial cable compared with a two-pair.

With a common line amplifier for both directions, the advantage is gained that the power consumption, and thus the cost of the power-feeding equipment, is reduced.

Frequency Allocation

The frequency allocation adopted for the system, and shown in fig. 3, corresponds to Plan I A in CCITT Rec. G 356 for 120-circuit systems. This scheme is the one preferred for international traffic between countries with different national allocations.

The following advantages of this scheme may be pointed out:

- Direct interconnection with terminals in frequency range 60—552 kHz, or interconnection with other h.f. lines in the same frequency range, e.g. short cable extension system to 120-circuit radio link.
- Branching from larger 4-wire h.f. lines in the same frequency range, e.g. the supergroups 1 and 2 from a 300 or 960-circuit system without demodulation to basic supergroups.
- Leak dropping from the *ZAX 120 T* line itself without the need for any demodulation, i.e. directly from the 2-wire line.
- The terminal does not require carrier frequencies which are multiples of a 124 kHz master frequency with corresponding high frequency stability.
- In a preliminary stage with 60 circuits (supergroup 2), no supergroup translation stage (for the formation of a 120-channel line group) need be provided.
- The line group modulation does not require a high frequency stability as the carrier frequency for this modulation is identical with the line regulating pilot which is used for demodulation at the receiving terminal.

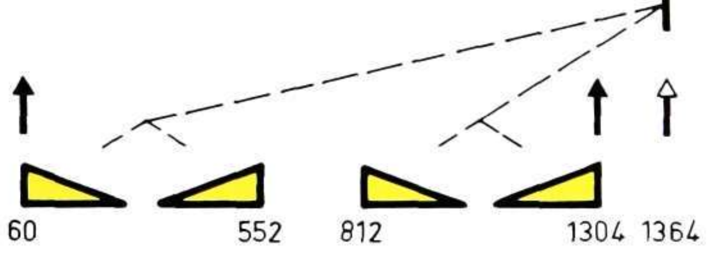


Fig. 3
Frequency allocation for ZAX 120 T
Frequencies in kHz

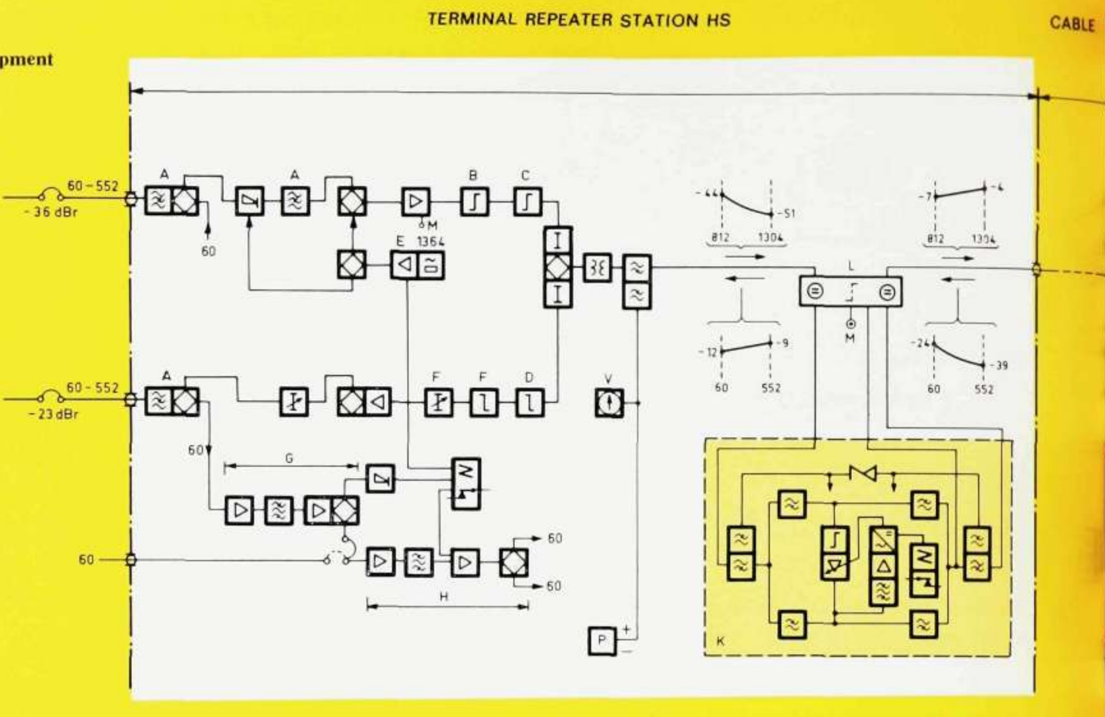
Frequency comparison pilot

Carrier and line pilot

Fig. 4

Block schematic of h.f. line equipment

- A Pilot stop filter
- B Mop-up equalizer, if required, on the sending side
- C Pre-emphasis network
- D De-emphasis network
- E Pilot generation equipment
- F Equalization equipment
- G Equipment for reception of 60 kHz pilot
- H Equipment for distribution of 60 kHz pilot
- K Line amplifier unit
- L Cable terminating box
- M Maintenance test point
- P Remote power feeding unit
- V Instrument for tracing of cable faults



Terminal Repeater Station

Fig. 4 shows a block schematic of two terminal and one dependent repeater stations.

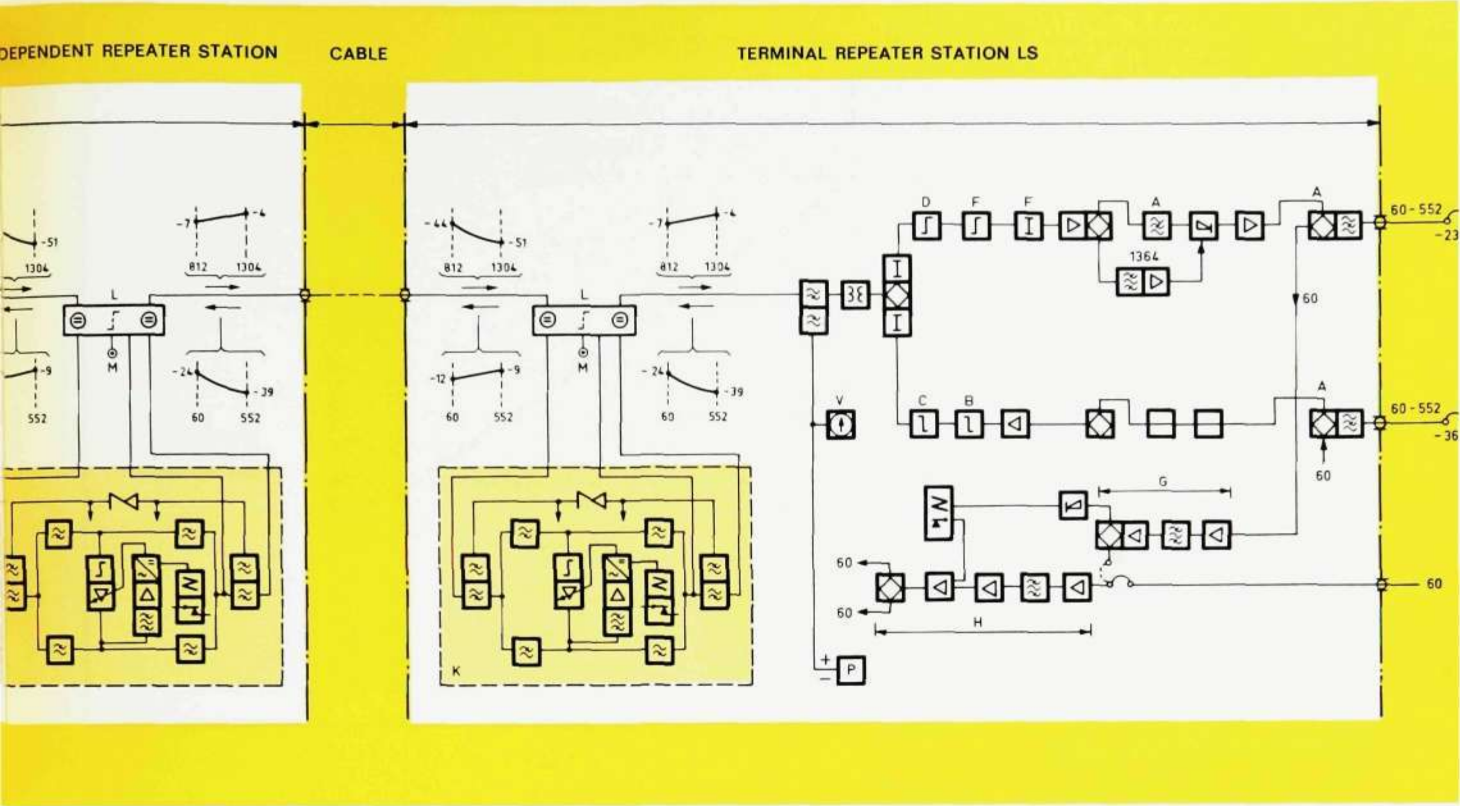
The terminal repeater on the left, denoted *HS* (high-send), constitutes one station which, after modulation of the 120-channel line group with the 1364 kHz carrier frequency, sends the high frequency band 812—1304 kHz and the pilot frequency 1364 kHz, while receiving the 60—552 kHz band from the line.

The *LS* (low-send) terminal repeater is a station which, without modulation, sends the 120-channel line group in the lower frequency band 60—552 kHz and receives from the line 812—1304 kHz for demodulation with the simultaneously received pilot frequency 1364 kHz to the 60—552 kHz range.

Terminal repeaters consist essentially of a line terminating shelf stack and a line amplifier. Apart from its modulating function, the shelf stack pre-emphasizes the line frequency band on the sending side to the standardized output level curve and supplies any necessary line pilot. On the receiving side the equipment must restore the incoming frequency band from the cable to a flat level curve and filter out any line pilot transmitted along with the line group.

The receiver side thus contains equipment for equalization of the attenuation distortion on the h.f. line caused by systematic addition of inevitable small deviations in each intermediate repeater from what would be the ideal gain curve, i.e. the inverse of the cable attenuation for each specific manufacturing batch of coaxial cable. The attenuation distortion is compensated by the insertion of simple correction networks which are calculated individually for each installation.

To render the h.f. line independent of external oscillator equipment, the shelf stack itself can generate the 1364 kHz frequency used as carrier frequency and line group pilot.



The terminal repeater equipment also has equipment for through connection and distribution of the 60 kHz frequency comparison pilot. Injection and extraction of this pilot take place within the line termination shelf stack which permits rearrangements of traffic without affecting the distribution network for the frequency comparison pilot.

The 1364 kHz and 60 kHz pilots are suppressed in both the sending and receiving terminal repeater equipment.

As appears from the block schematic, the sending and receiving directions are interconnected in the shelf stack via a differential transformer and matched to the cable side by means of a line transformer. The advantage of this interconnection is that the same design of line amplifier with directional filters can be used both at terminal and intermediate repeater stations. This means, in other words, that, directly following the line terminating shelf stack, there is a line amplifier which is identical with the intermediate repeaters on the h.f. line.

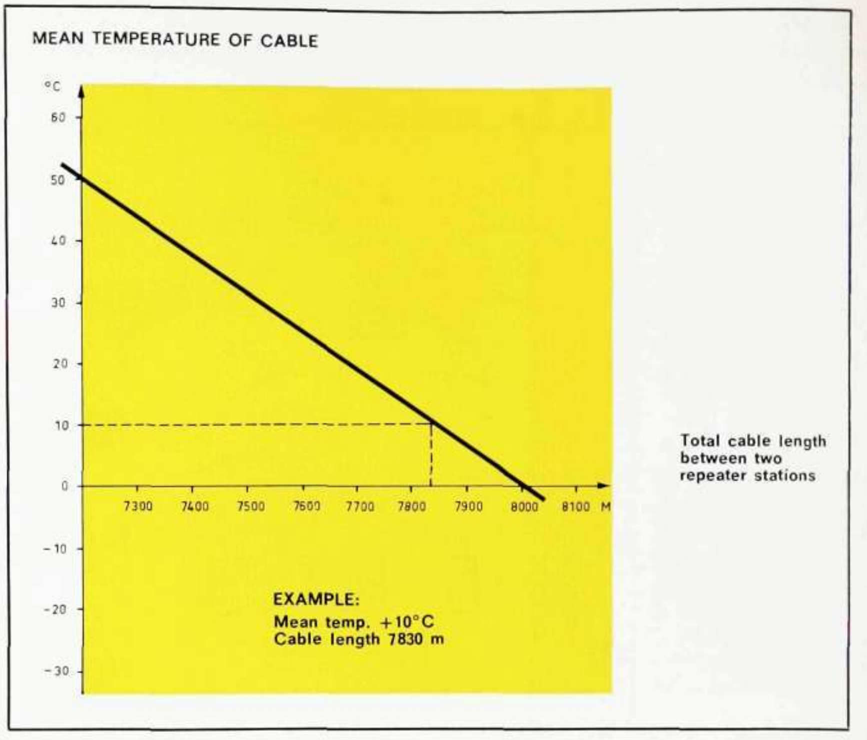
Dependent Repeater Station

The function of the dependent repeater is to compensate for the attenuation which the transmitted frequency band undergoes on a length of cable equal to the repeater spacing.

Having regard to the great significance which must be attributed to the intermediate repeaters on an h.f. line, it was natural to base the design on the line amplifiers which had proved to be extremely reliable on already installed 1.3 MHz h.f. lines for four-wire operation.

The original line amplifier was designed for 8 km spacing. Through the introduction of the directional filters needed for the two-wire system the gain

Fig. 5
Ideal length of cable between two repeater stations as a function of the mean temperature of the cable



is reduced by the same amount as the inherent loss in the filters, which means that the nominal repeater spacing for *ZAX 120 T* is about 7.8 km, corresponding to 48.1 dB at the highest frequency, 1364 kHz.

The gain curve is achieved through a combination of a three-stage amplifier, the gain of which rises with frequency, and a special gain equalizer on its input. The frequency dependence of the gain is achieved by means of a negative feedback varying with frequency.

Every line amplifier has automatic gain control for compensation of the change of attenuation in the cable caused by temperature variation. The regulation range is slightly above ±4 dB at the pilot frequency 1364 kHz.

The line regulating pilot is transmitted only from the *HS* terminal. Since the line amplifier is common to both directions of transmission, the level of the lower frequency band is also regulated by the same pilot.

Since there is a pilot receiver in each repeater, supervision of the repeaters can be effected by checking the outgoing pilot level. For this purpose the pilot receiver has a relay contact unit which is actuated if the pilot level entering the line amplifier falls by more than 6 dB.

Repeater Spacing

The gain of the line amplifier, 48.1 dB at 1364 kHz, corresponds to the cable loss over a 7830 m repeater section at a temperature of +10°C.

In different countries, of course, a cable may have mean temperatures which deviate from the theoretical +10°C used for the above calculation. Such a cable will therefore require other repeater spacings.

Fig. 5 shows the relation between the mean temperature of the cable and the ideal length of cable between two repeater stations. The mean temperature of the cable is calculated on the basis of the minimum air temperature and the maximum temperature which the cable may assume as a result of solar radiation.

In cases where the repeater spacings must for different reasons be shorter than that calculated, line building-out networks can be included.

As already mentioned, each repeater has a regulation range of ±4 dB for compensation of changes of attenuation in the cable owing to temperature fluctuations and for compensation of tolerances in the repeater spacing.

Changes of attenuation in the cable caused by temperature fluctuations are calculated at the rate of 2 ‰ per deg. C. For an overhead cable, in which the temperature variations may be considerable, the regulation range can be best used by allotting ±0.5 dB for compensation of manufacturing tolerances in the cable and for tolerances in repeater spacings, while the remaining ±3.5 dB is used for compensating temperature variations, which in this case means that allowance has been made for cable temperature variations of at least ±35 deg. C.

For a buried cable it can be calculated that the temperature fluctuation is seldom more than ±10 deg. C, corresponding to ±1 dB, which allows much wider tolerances in spacing.

Overvoltage Protection

For protection of the transistorized repeater equipment in the h.f. line against voltages which may be induced into cables with long metallic circuits, it is of great significance for the reliability of operation that the voltage protection should be amply dimensioned.

Every intermediate repeater has three forms of protection.

In the cable terminating box where the line amplifier is connected to the line cable, a spark gap is connected between the earthing point of the station and the outer conductor of the coaxial cable, and a rare gas tube is connected on each side of the amplifier between the inner and outer conductor of the cable pair. These protectors are easily accessible for inspection.

On the inputs and outputs of the line amplifier there is a transversal protector patented by L M Ericsson, based on semiconductors, and a longitudinal protector in the power feed path.

Each line amplifier is tested after manufacture by applying a number of surge voltage pulses, the peak value of the current through the rare gas tube being >1000 A with a decay time to half peak value of about 200 μs.

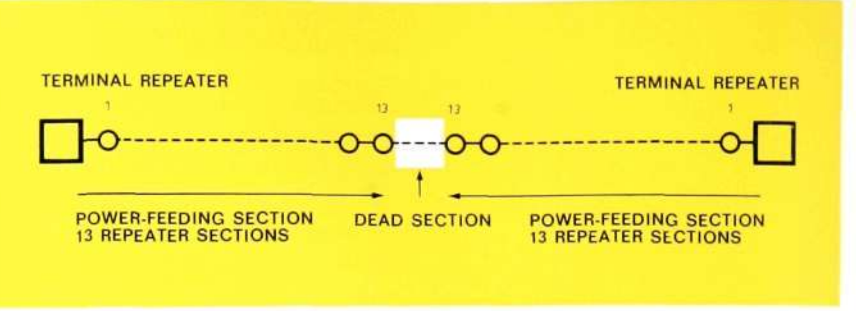
Remote Power Feed

The dependent repeaters on the h.f. line are power-fed from terminal or power-feeding intermediate stations. The power requirement of the dependent repeater is 18 V, 60 mA d.c. The power feed takes place between the inner conductor (+) of the coaxial pair and the outer conductor (—) with a constant current of 75 mA. The repeaters are connected in series and receive their voltage from a zener diode.

The voltage drop per repeater section is about 32 V, varying somewhat with the temperature of the cable.

With a nominal 480 V output voltage, 13 dependent repeaters can be supplied from every power-feeding point. Between two terminals, accordingly, 26 dependent repeaters on an overhead cable line can be power-fed (fig. 6). On longer h.f. lines, power-feeding intermediate repeater stations are used. A station of this kind constitutes a variant of the terminal repeater equipment.

Fig. 6
Remote power feed



The coaxial cable is entirely unearthed, which means that the system is less sensitive to undesired external induction and that unintentional earthing of the outer conductor does not jeopardize the power feed. As a protective measure for the maintenance staff, the outer conductor is automatically earthed at an intermediate repeater station as soon as the cable terminating box is opened.

Branching

A decisive factor in the choice between a metallic h.f. line equipment and a radio link is the possibility of arranging circuit branching, which can be obtained only in the former case.

With the frequency allocation chosen for *ZAX 120 T*, and since the carrier frequency for the line group is available along the h.f. line, it is easy to arrange both for four-wire and two-wire branching.

A four-wire branching station may be described briefly as a pair of terminal repeaters placed back to back providing line group level adjustment as well as the line group modulations involved between the segregated line frequency bands used on the 2-wire line and the 60—552 kHz line group at the 4-wire system interconnection point. In addition, such a station includes the required branching equipment at the system interconnection point. At a station of this kind it is also possible to provide equalization and power feed and, without extra cost, to arrange for frequency frogging, which may be advantageous from the noise point of view on very long h.f. lines.

At a two-wire branching station, on the other hand, branching can be arranged from an h.f. line without the through-traffic being affected by the local arrangements.

The station can be arranged in direct connection with a dependent repeater on the h.f. line, the traffic in the branched direction being connected via a special hybrid.

This method only allows leak dropping but is advantageous, especially on economic grounds, when it is desired to drop a small number of channels at one or more positions along the h.f. line.

For such cases a complete equipment has been made up which permits separation of any desired subgroup from a basic group in the 60—108 kHz range.

Fault Location and Speaker Circuit Equipment

In accordance with the principle of restrictive economy for the h.f. line equipment, and the experience that most faults on an h.f. line today are due to mechanical damage to the cable, the arrangements provided as a standard feature for tracing of cable faults are only quite simple. For administrations which so desire there is also an optional supervisory device for locating faults in the intermediate repeater equipment. A v.f. speaker circuit can also be arranged over the h.f. line, consisting of amplifier equipment in a terminal or attended intermediate repeater station and a field telephone for connection to unattended intermediate repeater stations.

Tracing of Cable Faults

The voltage fed from the remote power-feeding unit is, owing to the constant-current feeding, directly proportional to the load in the power feed loop. At the power-feeding station there is a pointer instrument, connected across the power-feeding voltage, which is graduated in number of repeater sections. In each intermediate repeater there is a relay which, in the event of a break in the cable on the following section, closes the power-feeding circuit so that all repeaters between the power-feeding station and the fault point still receive power (fig. 7).

As a result of the reduction of the load in the power feed loop the pointer instrument will indicate the remaining number of intact repeater sections, and thus the area in which the fault lies.

Tracing of Repeater Faults

This equipment is based on the indication of alarms by the pilot receiver in the intermediate repeaters in the event of too low a pilot level.

The equipment consists essentially of a remote alarm indicator which is connected to the power feed at a feeding station.

In the event of a fault in the repeater equipment at an intermediate station the alarm relay of the pilot receiver closes a contact, whereupon a current from the power feed individual to each intermediate repeater is discharged to earth. In the remote alarm indicator this current is registered in the form of a potential. A transistor circuit compares this potential with a reference voltage which can be varied in fixed steps with a knob graduated in number of dependent repeater stations. The output of the transistor circuit is connected to a relay with alarm lamp. When an alarm is received from a dependent repeater, the known and unknown potentials assume different values and the lamp lights.

For tracing of the faulty point through operation of the knob the two potentials are compared and, when the values obtained are similar, cause the lamp to go out.

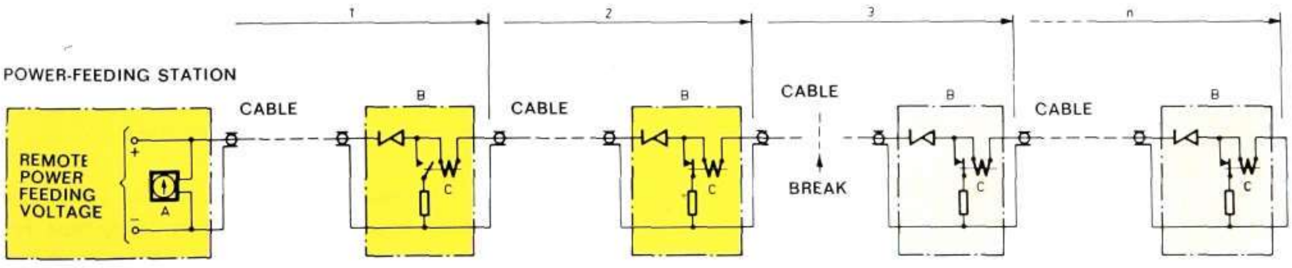
Speaker Circuit Equipment

The chief advantage of having access to a speaker circuit may be said to be in connection with faults in dependent repeater stations on the h.f. line. For

Fig. 7

Equipment for tracing cable faults
Simplified circuit diagram

Example showing a cable break on repeater section 3
A Pointer instrument graduated in number of repeater sections
B Line amplifier
C Relay



this reason a speaker circuit should be independent both of the line amplifiers and of the remote power feed.

From the earlier description of the make-up of the cable it is apparent, however, that it would be both difficult and expensive to introduce an extra pair for a physical speaker circuit.

The solution adopted, therefore, is based on the use of the physical circuit constituted by the coaxial cable itself.

To obtain a usable speaker circuit on the coaxial pair without power-fed amplifiers it is necessary to improve its attenuation characteristic within the speech band through a certain degree of loading.

On economic and practical grounds such an arrangement can be adopted only at every intermediate repeater point, where the speech band is separated from the carrier band by the power separation filters.

With this loading the upper cut-off frequency will be limited to 2000 Hz, which, however, is ordinarily sufficient for a circuit for the service facilities needed purely for system maintenance.

The attenuation at 1000 Hz is rather more than 0.4 dB/km. With the repeater equipment used in the terminal stations a speaker circuit of 100 km can be set up, which corresponds to the length of a power-feeding section of about 13 dependent repeaters.

The speaker equipment at the dependent repeaters consists of a telephone attachment unit containing loading coils and filters with means for connection of a field telephone.

At the terminal stations the equipment comprises a signalling repeater, voice-frequency amplifier and hybrid, and a signalling receiver and signalling oscillator.

This equipment is served by means of the ordinary telephone unit on the terminal repeater bay.

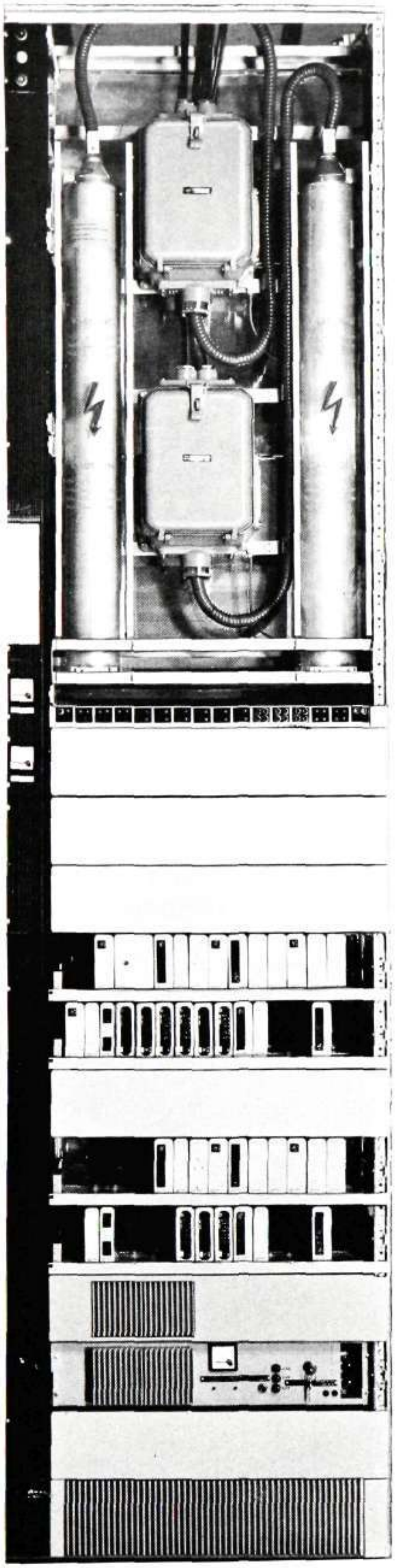


Fig. 8
Terminal repeater bay for ZAX 120 T equipped for two systems, with the cover plates partially removed

Mechanical Design

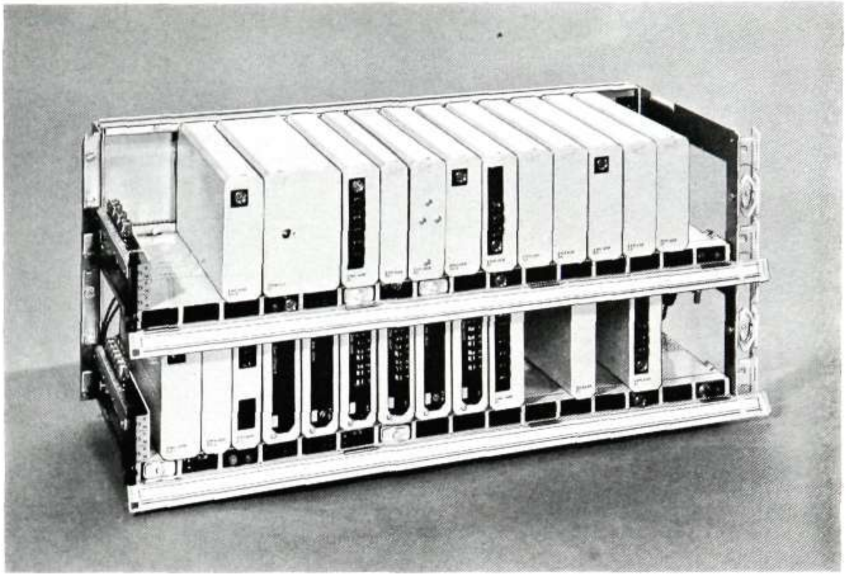
Terminal Repeaters

The terminal repeater, containing high-frequency equipment, equipment for power feed, speaker circuit, fault tracing and alarm, is made up of plug-in, electrical and mechanical functional units in the form of shelves and shelf stacks for mounting on single-sided bays in accordance with L M Ericsson's M4 construction practice described in Ericsson Review No. 3, 1966. The exception is the line amplifier and its cable terminating box, which may be mechanically combined in pairs either in a special framework for placing on a standardized bay serving two h.f. lines, or in a special narrow line amplifier bay.

The latter is used in conjuction with a variety of equipment combinations using a standard bay frame, each of which combinations has been arranged to meet the specific traffic requirements of a particular application.

Fig. 8 shows a bay containing all h.f. repeater equipment for two 120-circuit line systems as well as the associated supergroup translating equipment for assembling four 312—552 kHz basic supergroups into two 120-channel line groups and vice versa.

Fig. 9
Line terminating shelf stack of HS type, without cover plates and with the designation strips folded down



The bay is intended primarily for use in large larger-capacity terminal stations and power-feeding or frequency-frogging intermediate repeater stations.

Another bay type combines the equipment for a complete 120-circuit carrier terminal from the 4-wire termination to the line group equipment, and for all necessary carrier and pilot generation. The line amplifier and cable terminating box should in this case be placed in the aforementioned narrow line-amplifier bay.

The h.f. line terminating equipment consists of a stack of two shelves as shown in fig. 9. The stack is equipped with different units depending on whether it is used for *HS* or *LS* termination or for power-feeding intermediate stations.

Dependent Repeater Station

To maintain a low first cost, the external arrangements for an unattended intermediate repeater station must be reduced to a minimum and the equipment must be simple to handle.

The repeater equipment must be of a type which can be buried in the ground but nevertheless accessible for fault tracing and rapid replacement. The replaceable part of the repeater must consist of a hermetically sealed unit in order to withstand moisture and temperature fluctuations.

The connection between the h.f. line cable and the repeater equipment should be of plug-in type to permit sectioning of the cable for tracing of cable faults and to allow rapid replacement of a faulty line amplifier.

To meet these requirements the dependent repeater station has been made up in the form of two units consisting of a cable terminating box with stub cables and a line amplifier (fig. 10).

The cable terminating box may be either ventilated or sealed for mounting above ground or, together with the line amplifier, in a simple concrete manhole

Fig. 10

Equipment for dependent repeater station ZAX 120 T

Cable terminating box with stub cables, cover and line amplifier

below ground. It is connected to the h.f. line cable via stub cables, which can be led into the upper or lower side of the box to suite either an overhead or underground cable installation.

The cable terminating box, which constitutes the plug-in terminating point for the repeater equipment, contains an overvoltage protector and test point terminals, and has space for a line building-out network and attachment unit for a speaker circuit telephone (fig. 11).

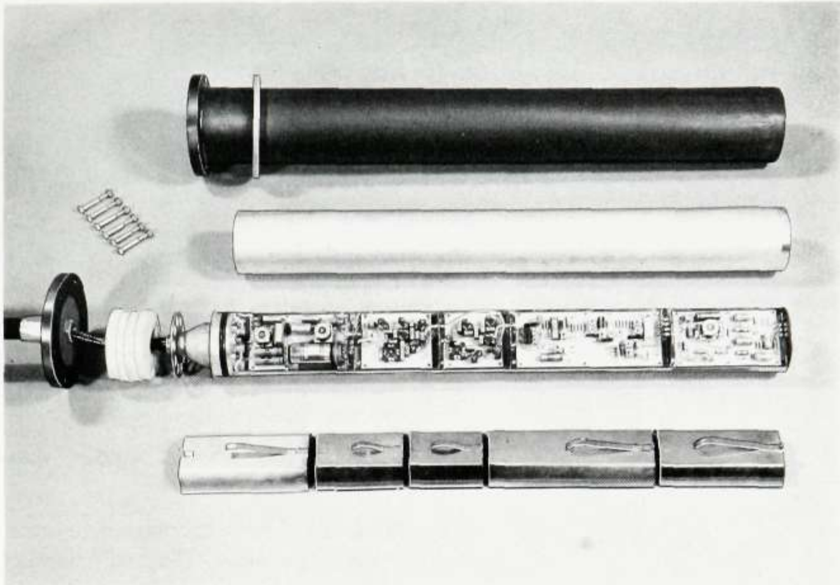
The line amplifier (fig. 12) with its flexible connecting cables is hermetically sealed and can be directly buried in the soil. The cylinder-shaped unit is protected by a polyethylene sheath and the connecting cables by a steel-braid armoured rubber hose. This hose is screwed to the lower flange of the cable terminating box, and connection of the line amplifier takes place inside the box with two double coaxial plugs and a multiway connector.

Fig. 11

Cable terminating box with line amplifier connecting cables and stub cables connected

Inside the box at the far right is the attachment unit for the speaker circuit telephone

Fig. 12
Line amplifier for ZAX 120 T



System Economy

Fig. 13 shows the relative cost per circuit kilometre as a function of the number of circuits installed for some alternative systems. For the four-wire coaxial cable systems *(ZAX 300* and *ZAX 900)* the figures relate to the cost of cable including digging, as well as of electronic equipment and installation. The curves for *ZAX 120 T* and *ZAA 12* apply to overhead cable and bare wire, respectively, on an existing pole line.

The costs are greatly affected by local conditions, but the curves shown may be considered typical.

On light routes where the need for circuits does not warrant the installation of four-wire coaxial systems, *ZAX 120 T* is an extremely economical alternative. Compared with an open-wire system, *ZAX 120 T* is more economical even with as few circuits as 24 if the route length exceeds 60 km. If 36 circuits are required, the corresponding route length would be about 10 km. *ZAX 120 T* also permits a future increase of the number of circuits at a very low cost.

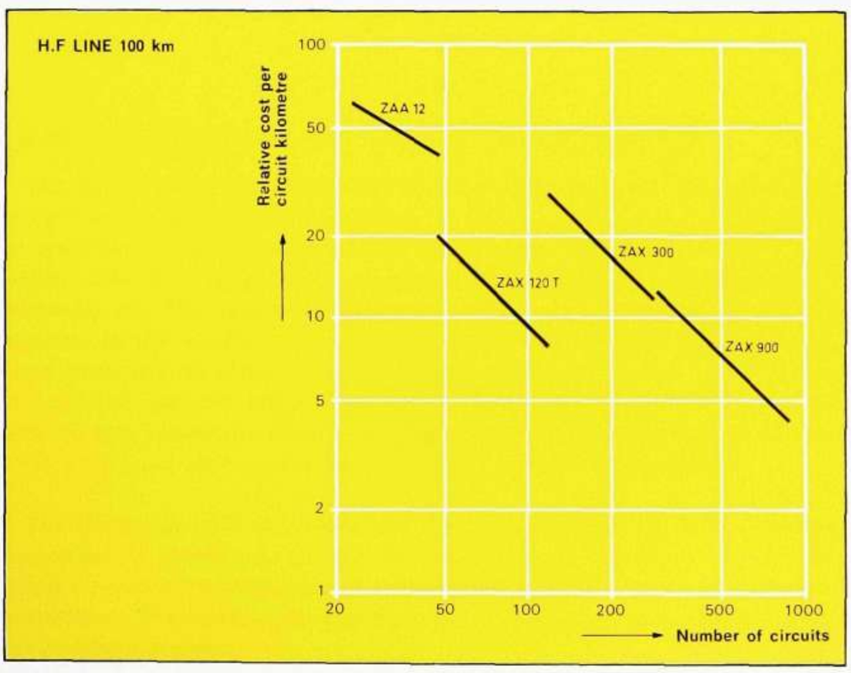


Fig. 13
Relative cost per circuit kilometre as function of number of circuits

Technical Data

Frequency band	60—552/812—1304 kHz
Number of circuits	120
Signal levels to terminal (multiplex). Send/receive	min. —37/max. —22 dBr
Nominal levels at system interconnection point. Send/receive	—36/—23 dBr
Impedances for inputs and outputs	75 Ω unbal.
Output level to cable for highest channel	—3.8 dBr
Pre-emphasis (for 60—1364 kHz)	10 dB
Gain per intermediate repeater station at pilot frequency 1364 kHz	48.1 dB
Weighted noise per channel at zero level point for loaded system (—15 dBm0/channel)	<3 pW/km
Near-end and far-end crosstalk attenuation per station within and between systems	85/90 dB
Line regulating pilot	1364 kHz
Pilot level	—10 dBm0
Regulation range per intermediate repeater station at the pilot frequency	±4 dB
Equipment for frequency comparison pilot	60 kHz
Remote power feed	D.C., series
Max. number of power-fed intermediate repeater stations per power-feeding unit	13
Max. spacing between power-feeding stations	210 km
Power-feeding current	75±5 mA
Power-feeding voltage	480 V

Equipments for Test Traffic in Multi-Exchange Networks

A. WATTVIL, TELEFONAKTIEBOLAGET L M ERICSSON, STOCKHOLM

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LME 1548
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Supervision of the reliability of operation of telephone networks, based on simulated test traffic, has been functioning very satisfactorily for many years. This type of supervision is an important cornerstone in L M Ericsson's modern maintenance philosophy, controlled corrective maintenance. This method results in great savings in maintenance costs.[1]

In the mid-1950's a number of articles were published in Ericsson Review concerning the basic principles of the method and the equipment developed for this purpose, the traffic route tester LTR 1050 and its auxiliary units.

Further developments since that time have related to extension of the test traffic facilities. No essential changes in the previously described method have, however, been made.

Many administrations have already been able to acquire a thorough experience of the whole of this technique and have shown a constantly growing interest in the extended application. For those, however, who have not had the occasion to get to know either the basic principles or the special equipments which L M Ericsson can offer, references are made in the present article to previous articles and a survey is given of the test traffic equipment in present use.

General Features of the Test Traffic Equipment

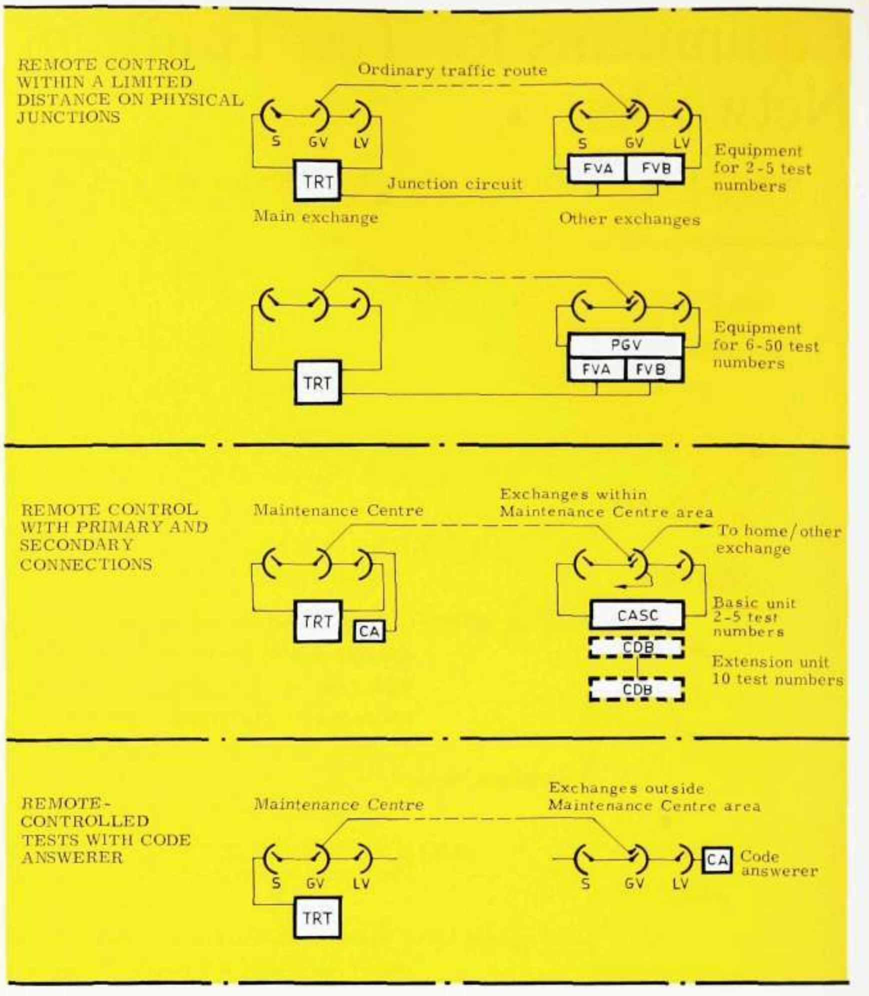
The special test traffic equipment made by L M Ericsson is intended, irrespective of the type of switching system, to permit supervision of the reliability of operation in the telephone network in the same way as for testing of subscriber calls. The equipment is therefore connected to the exchange like a telephone set. The subscriber numbers reserved for the test equipment are regarded as test numbers representing a group of subscribers. The test equipment supervises an area consisting of many exchanges through the provision of a central unit, the traffic route tester *(TRT)*, at a main exchange in the network and various auxiliary units such as remote-controlled selectors *(FVA, FVB, PGV)* and code answerers *(CA, CASC)* at the other exchanges.

The latest type of traffic route tester, entirely detached from the switching equipment, is denoted *LTR 1054*. In relation to its predecessor *LTR 1050*, it has equipment for checking of transmission and for routing of secondary connections. The method for determination of test numer with strapped plugs has also been changed.

Fig. 1

Recommended applications for TRT auxiliary equipment

S	Finder
GV	Group selector
LV	Final selector
TRT	Traffic route tester
FVA	Remote-controlled selector for A test numbers
FVB	Remote-controlled selector for B test numbers
PGV	Test number group selector
CASC	Code answerer with facility for setting up secondary connections
CDB	Additional equipment for extension of test number capacity of CASC
CA	Code answerer with answering function alone



A rack-mounted type *LTR 10523* is specially suited for large maintenance centres. It comprises a basic unit for 100 test numbers with additional rack-mounted equipment for a second group of 100 test numbers.

These two types are described below and a more detailed account is given of the auxiliary equipment.

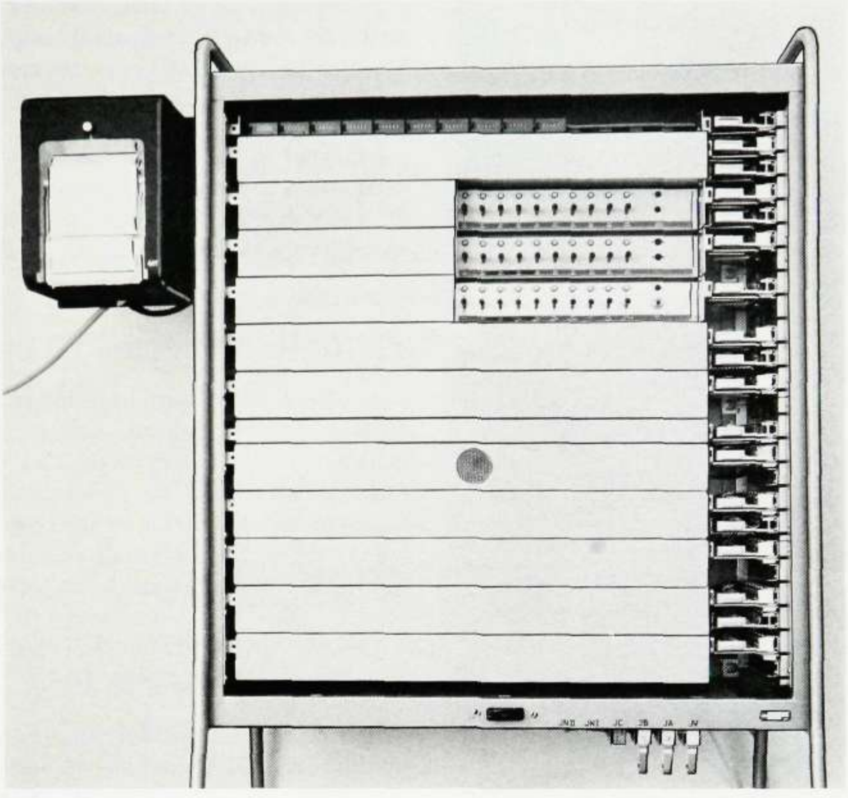
Fig. 1 shows a survey of the recommended applications for auxiliary units of the traffic route testers *(TRT)*.

A few comments on the various methods should be of interest.

First it may be recalled that the *TRT* works automatically with a programme block comprising tests of 10 selected *A* test numbers to 10 *B* numbers. In order that the *TRT* may be programmed as desired to generate traffic both to and from all test numbers within its area, selectors are required which can be remote-controlled on physical circuits. Through these physical circuits between *TRT* and the test numbers all supervisory facilities of *TRT* can be utilized. As the traffic route tester should function as an ordinary subscriber in relation to the switching equipment, the normal subscriber's line resistance between *TRT* and the test numbers should not be exceeded.

Within the "limited area" around the exchange equipped with *TRT*, which may thus be formed on condition that the loop resistance does not exceed 1800 ohms, the test connections are set up with the aid of remote-controlled selectors *(FVA, FVB)*. The latter set up connections to the test numbers as *A* or *B* numbers as desired. These selectors permit connection of up to 10 test numbers and require a total of 8 physical conductors to the *TRT*. Two of the

Fig. 2
Detached traffic route tester LTR 1054



conductors are used for operation of the remote-controlled selectors for the *A* test numbers *(FVA)*, three for the *B* test numbers *(FVB)*, two for through-connection of the speech wires, and one for checking of subscriber metering. At large exchanges, requiring more than 10 test numbers, the connection facilities are extended by means of a test number group selector *(PVG)* to comprise a total of 50 test numbers. Further details concerning these units can be studied in fig. 9, and they are also described below.

For an adjacent exchange with few test numbers, the test numbers can of course be directly connected to the *TRT*. Within the limited area, accordingly, for exchanges of type *ARF*, which are normally given one test number per 200-line group, $50 \times 200 = 10{,}000$ subscribers' numbers can be covered by means of these selectors.

Remote-controlled testing from *TRT* to and from remote exchange areas on ordinaryt raffic routes, and independent of separate physical circuits, is made possible by connection of a special auxiliary equipment. This equipment consists of a code answerer with the facility of setting up secondary connections *(CASC)* and associated extension units *(CDB)*.

CASC is an automatic code answerer which can be ordered by *TRT* to set up a new test connection. *TRT* calls *CASC* by setting up a primary connection from the selected *A* test number in accordance with the programme. By means of the code answer in *CASC* the circuit is checked, after which *CASC* is ordered to set up a secondary connection from one of its test numbers to another test number in accordance with the programme.

On the secondary test connections no check of metering can be made. Using only the basic equipment *CASC* a total of 5 test numbers in the remote exchange can be connected.

The extension unit *CDB* is designed for 10 test numbers. An arbitrary number of extension units can be connected to *CASC*.

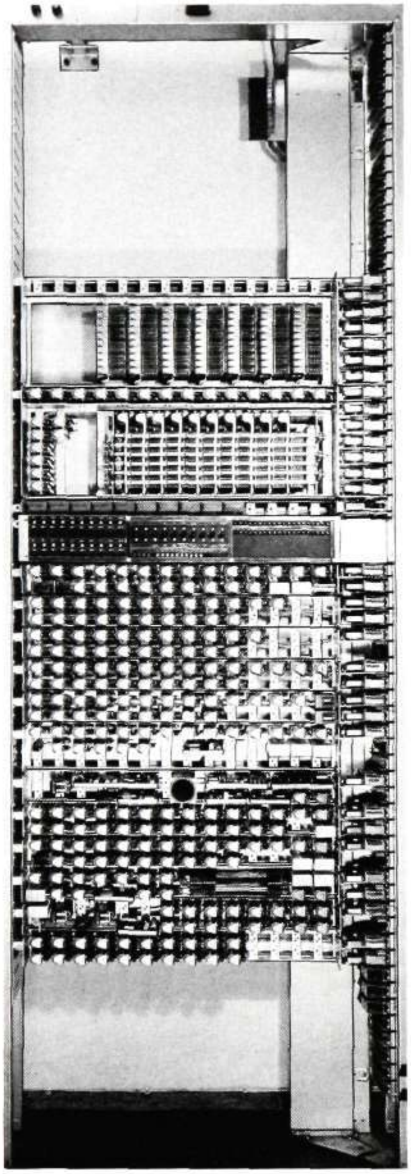


Fig. 3
Rack-mounted traffic route tester LTR 10523
Relay set covers removed

Simpler automatic code answerer devices *(CA)* solely for incoming test traffic are available as standard units for connection of 1, 2, or 5 test numbers. The smaller type, *CA 1*, can be supplied with or without facility for maintaining the answer loop for check of metering.

Examples of the use of this equipment both in urban and fully automatic rural networks are given in an article in Ericsson Review No. 2, 1966.[2] It should be noted that the test subscriber equipment referred to in that article corresponds to the *CASC* described in the present article.

Traffic Route Tester (TRT)

As already mentioned, traffic route testers are available in two mechanically differing types: a detached rack-mounted *LTR 1054* (Fig. 2) and *LTR 10523* mounted on a standard *BDH* rack (Fig. 3). A general brief description of traffic route testers was presented in Ericsson Review No. 2, 1969,[3] and a more detailed description of the previous type *(LTR 1050)* in Ericsson Review No. 1, 1958.[4] The following account, therefore, will be concerned only with functional and mechanical differences between the three types.

Detached Type LTR 1054

Apart from the functions described for *LTR 1050*, equipment for checking of transmission and for routing of secondary connections has been added. The test number jacks *PJ1—PJ10* have also been removed, so that the determination of test number now takes place merely through insertion of strapped plugs into jacks *JNI* and *JNII*.

A check of transmission can be made only to code answerers designed for this purpose, the *TRT* sending a 900 Hz tone (strappable 600 mV or 900 mV measured across 600 ohms) to the code answerer after reception of the first code answer tone. If the code answerer detects the tone signal from *TRT*, it sends a second code answer tone, so confirming that acceptable transmission conditions exist in both directions.

The routing and checking of secondary connections by the traffic route tester is done as follows. A normal test connection is set up from *TRT* to a special equipment, *CASC*, placed in the exchange from which the secondary connection is to be set up. *CASC* answers the call by sending a code answer (900 Hz for about 6 s), after which *TRT* sends a signal (900 Hz for about 3 s) to *CASC*, which is thereby ordered to make a call within its home exchange and set up a connection to a test number predetermined by strapping in *CASC*. This number must be connected to a code answerer in the home exchange or other exchange (possibly the *TRT* exchange). The tone signals received from the secondary connection are repeated at 900 Hz by *CASC* to *TRT*, which can thus decide the course of events on the secondary connection and record the result on the following service observation counters:

Counter 1 = number of attempted connections from *A* test number
Counter 2 = number of successful primary connections
Counter 3 = number of unsuccessful primary connections
Counter 4 = number of calls receiving dial tone at 1st attempt
Counter 5 = number of calls receiving dial tone at 2nd attempt
Counter 6 = number of calls receiving dial tone at 3rd attempt
Counter 7 = spare
Counter 8 = number of attempted connections from *CASC* (secondary connections)
Counter 9 = successful secondary connections
Counter 10 = unsuccessful secondary connections.

For fault recording the CENTRALOGRAPH printing arms are used as follows:

Printing arm no.		Type of fault
Primary connection	1—10	Connected *A* test circuit
	11—20	Connected *B* test circuit
	21	Fault in digit transmission
	22	Attempted call unsuccessful (no register connection)
	23	Congestion tone sent to *A* test circuit more than 2 s after transmission of *B* test number
	24	Congestion tone sent to *A* test circuit within 2 s after transmission of last digit of *B* test number
	25	Ringing signal transmitted but no answer received
	26	No intermittent ringing signal *(RGi)*
	27	No ringing signal to *B* test circuit or no connection established from code answerer or *CASC* to *TRT*
	28	No intermittent ringing tone *(SU3)*
	29	Connection not cleared on disconnection from *B* test number
	30	More than one meter pulse received by the test equipment within the interpulse interval for the exchange
	31	No meter pulse received by the test equipment within the interpulse interval for the exchange
	32	Test connection unwarrantedly broken during a period of at least 2 s
	33	Test connection subjected to noise of higher level than that for which the tone receiver is set, e.g. crosstalk or when third party on the line
	34	No busy tone received on test to engaged *B* number
	35	Connection not established from *TRT* to code answerer or *CASC*
Secondary connection	23 + 36	Congestion or busy tone sent to *A* test circuit
	26 + 36	No dial tone *(SU2)*
	36	Attempted secondary connection by *CASC* unsuccessful *(CASC* receives no *B* answer signal)
	37, 38	Spare
	39, 40	Available for time indications

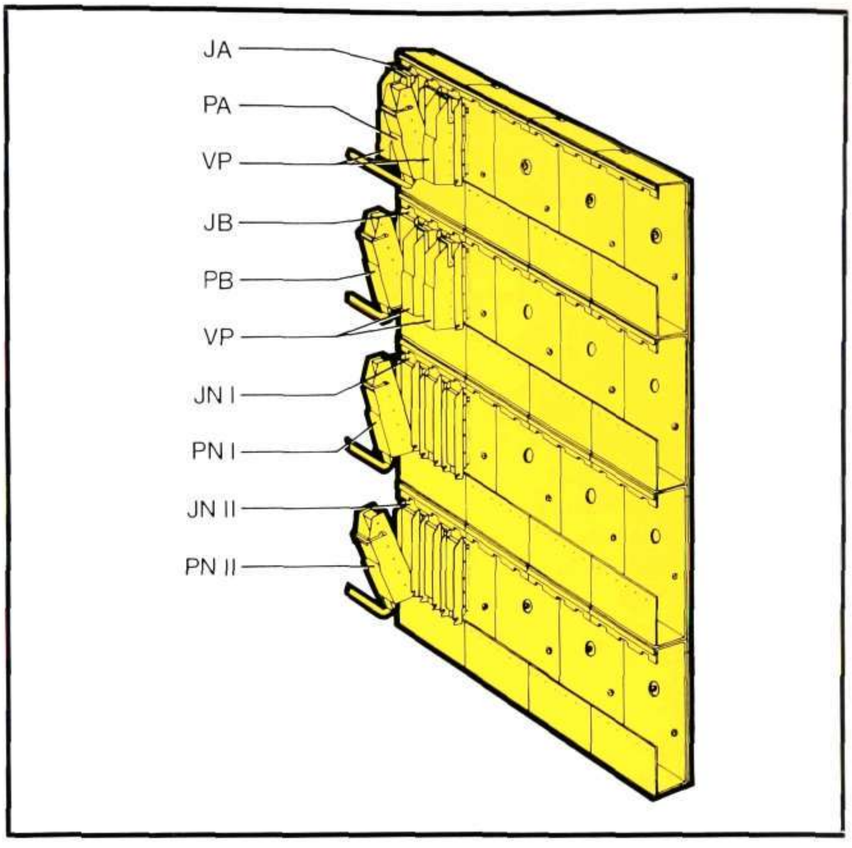
It should be noted that metering *cannot* be checked on a secondary connection.

The connection of test numbers to *LTR 1054* is done on a number concentrator. This consists of a jack field which can be built up in sections of twelve 80-point jacks which allow connection to 30 test numbers (Fig. 4). The *a* and *b* wires of the test numbers, and the *c* and *r* wires when required, are taken to jacks *JA* and *JB*. The same ten test numbers as are connected to *JA* appear also on *JB* and can thus be used as *A* or *B* test numbers on different occasions. The meter wire of the *A* test numbers must be disconnected and run to the *JA* jack. If several rates, i.e. not the local rate alone, are to be checked, the wires must be run from the exchange rate equipment to *JNI*. Strapping in jacks *JNI* and *JNII* determines which *B* number is to be sent. Ten numbers can be strapped per two 80-point jacks.

Fig. 4

Test number concentrator

- JA — Jack for A test number
- PA — Plug for connection of A test number to TRT
- JB — Jack for B test number
- PB — Plug for connection of B test number to TRT
- JNI, JNII — Jacks for strapping of B number
- PNI, PNII — Plugs for connection of B number to TRT
- VP — Through-connection plug



The wires for control of *FVA* and *FVB* must also be connected via this number concentrator.

If for any reason the same numbers must be used as the normal service and test numbers in the jack boxes for the switching equipment racks, they must be connected to *JA* and *JB* in such a way that, when used by the traffic route tester, they are disconnected from the *TJ* of the exchange. When not used for *TRT*, they are connected to *TJ* by insertion of a through-connection plug *VP* in *JA* and *JB*. The wiring is shown schematically in fig. 5.

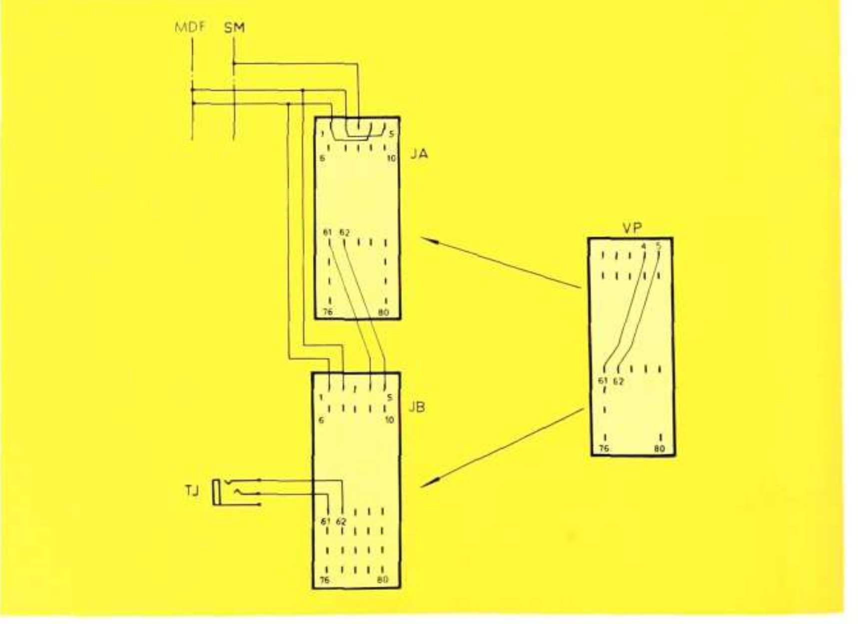


Fig. 5

Connection of TRT test number to exchange service jacks

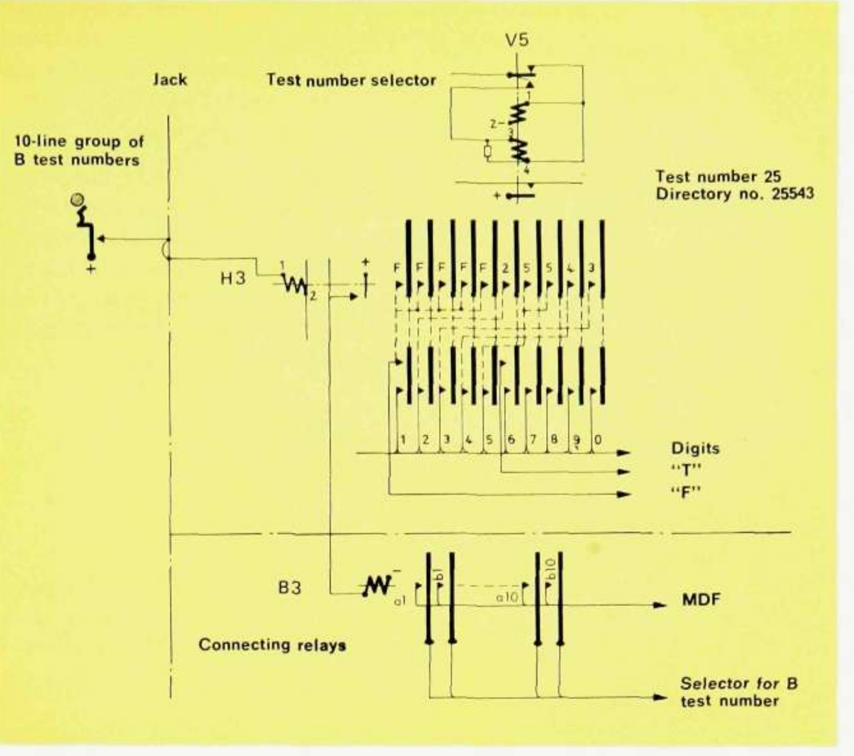
- MDF — Main distribution frame
- SM — Subscriber's meter
- JA — Jack for A test number
- JB — Jack for B test number
- VP — Through-connection plug
- TJ — Service jack

Fig. 6

Example of strapping of directory numbers of B test circuits

T Tone check

F Bypassing



The connection between *TRT* and the test number concentrator is effected with flexible cables with 80-point plugs at each end, designated *PA*, *PB*, *PNI* and *PNII*.

Rack-Mounted Type LTR 10523

This tester is functionally identical to *LTR 1054* but differs in the method of connection of test number and of test number determination. For these purposes the tester has been supplemented by the following relay sets:

- *Connecting relays, remote-controlled selectors*

  The relay set contains 20 facilities for connection of control wire circuits to remote-controlled selectors. The push-button on the jack box for a 10-line group of *A* and *B* test numbers can be strapped in the relay set jack for any desired relay.

- *Connecting relays, test numbers*

  The relay set contains multicoil relays for connection of the *a*, *b* and *r* wires of the *A* test numbers in groups of 10, for connection of the *a*, *b* and *c* wires of the *B* test numbers in groups of 10, and of the rate applying to each individual *B* test line.

  A total of 100 test numbers can be connected to one such relay set.

- *Test number selector*

  The relay set contains a 6-bar 10-pole crossbar switch and 22 relays. Twenty of the relays are used for disconnection of the circuit between test jack and test number and prevent disturbances when the traffic route tester is working within the group concerned. Ten of the horizontal positions within the crossbar switch correspond to a group of 10 test numbers and each vertical in combination with the horizontal position corresponds to an individual within the group. The two other horizontal positions are used only as suspension points for the digit wires, bypassing and check of tone. The directory numbers of the test circuits plus any area code digits are strapped on the rear of the crossbar switch (Fig. 6).

Fig. 7
Observation desk

Keys and signal lamps are placed on the rack jack box and connected to the relay equipment by means of three 80-point strapping plugs at the bottom of the rack. By moving these plugs to three other rack jacks, the relay equipment can instead be connected to keys and lamps on an observation desk which also accommodates CENTRALOGRAPH, loudspeaker and service observation counter (Fig. 7).

LTR 10523 contains all equipment required for connection of 100 test numbers. The cabled capacity of the rack is 200 test numbers, which is achieved by the addition of two relay sets, a test number selector and connecting relay set (Fig. 8). Other additions to the equipment must be made outside the rack, elsewhere in the exchange.

Equipment Remote-Controlled from TRT

Remote-Controlled Relay Selectors for A Test Numbers (FVA) and B Test Numbers (FVB)

The *FVA* and *FVB* selectors are used exclusively for connection of test numbers at another exchange (*FVA* and *FVB* exchanges respectively) than that at which the traffic route tester is located (*TRT* exchange). *TRT* controls the *FVA* selector on four wires and the *FVB* on three wires. If a check of metering is desired, an additional wire is required for operation of the *FVA*-selector.

The remote-controlled selectors are used principally between large adjacent exchanges linked by so large a number of circuits that permanent or "loaned" control circuits can be arranged.

The function of the *FVA* and *FVB* selectors is to connect one at a time of max. 10 *A* test numbers at the *FVA* exchange and max. 10 *B* test numbers at the *FVB* exchange to *TRT*.

There is some limitation on the range of use of the selector, however, since the line resistance and the attenuation of the control conductors must not be so high that dial pulses and signal tones cannot be transmitted between the exchanges with full reliability. The line resistance must not exceed 900 ohms per conductor.

The remote-controlled selectors *FVA* and *FVB* work in parallel with the local *A* and *B* selectors in *TRT*, which means that test numbers can be connected only via *either* local *or* remote-controlled selectors. *FVA* and *FVB*, accordingly, *do not* increase the test number capacity of the traffic route tester.

Test Number Group Selector (PGV)

PGV is a 40-point relay selector with two inlets and five outlets. It is designed primarily for increasing the number of test numbers to be connected to *TRT* via *FVA* and *FVB*. Operation can take place without regard for the line resistance.

Ten test numbers can be connected to each outlet, and *FVA*, *FVB* or two five-line code answerers to the inlets. The latter may be necessary when *FVA* and *FVB* cannot be used.

The operation of *PGV* is effected by ringing up from two telephone sets a combination of two test numbers out of eight in a simplified answering device built into *PGV*. Three of these numbers are used solely for operation of *PGV* while five are used also as the *PGV* test numbers.

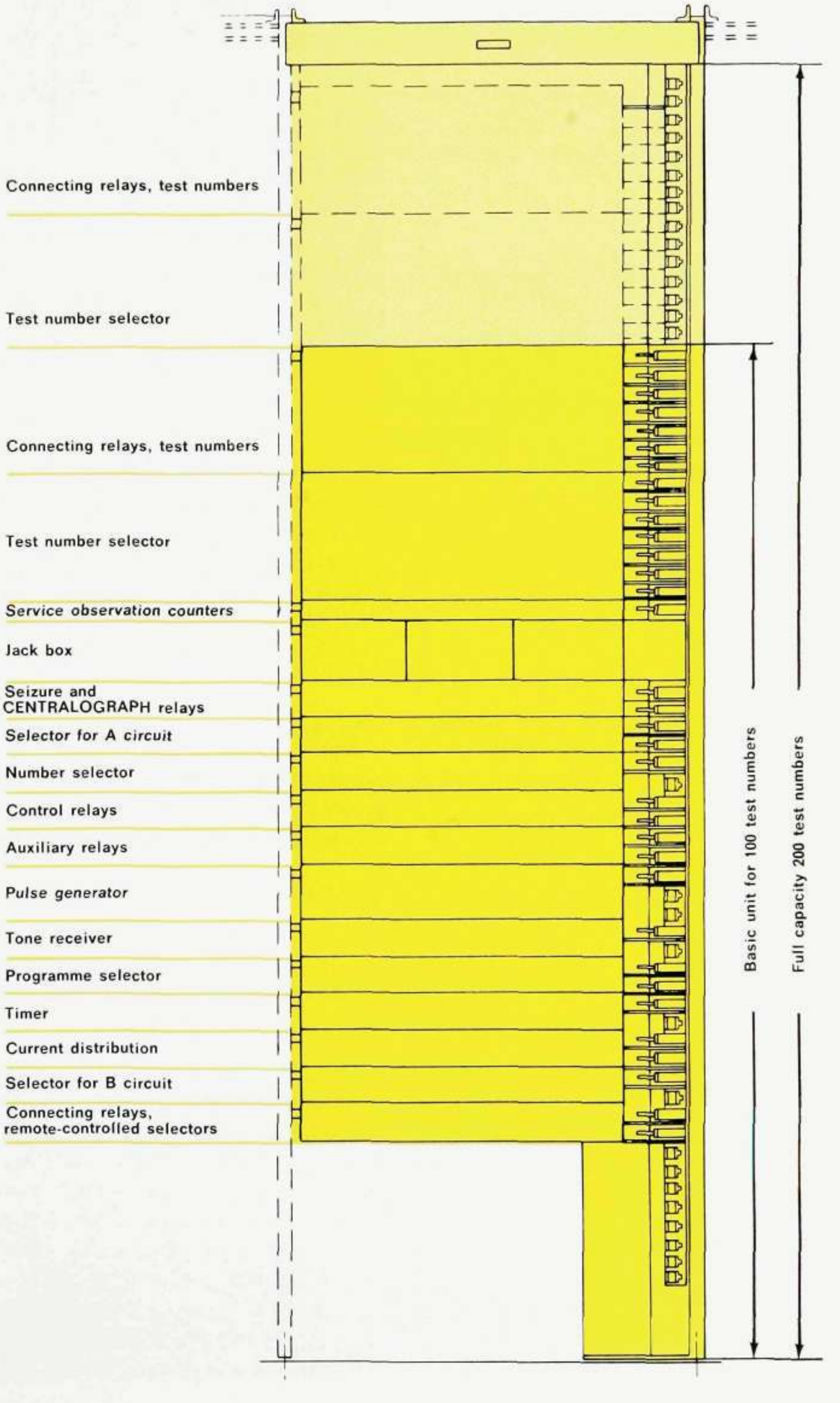
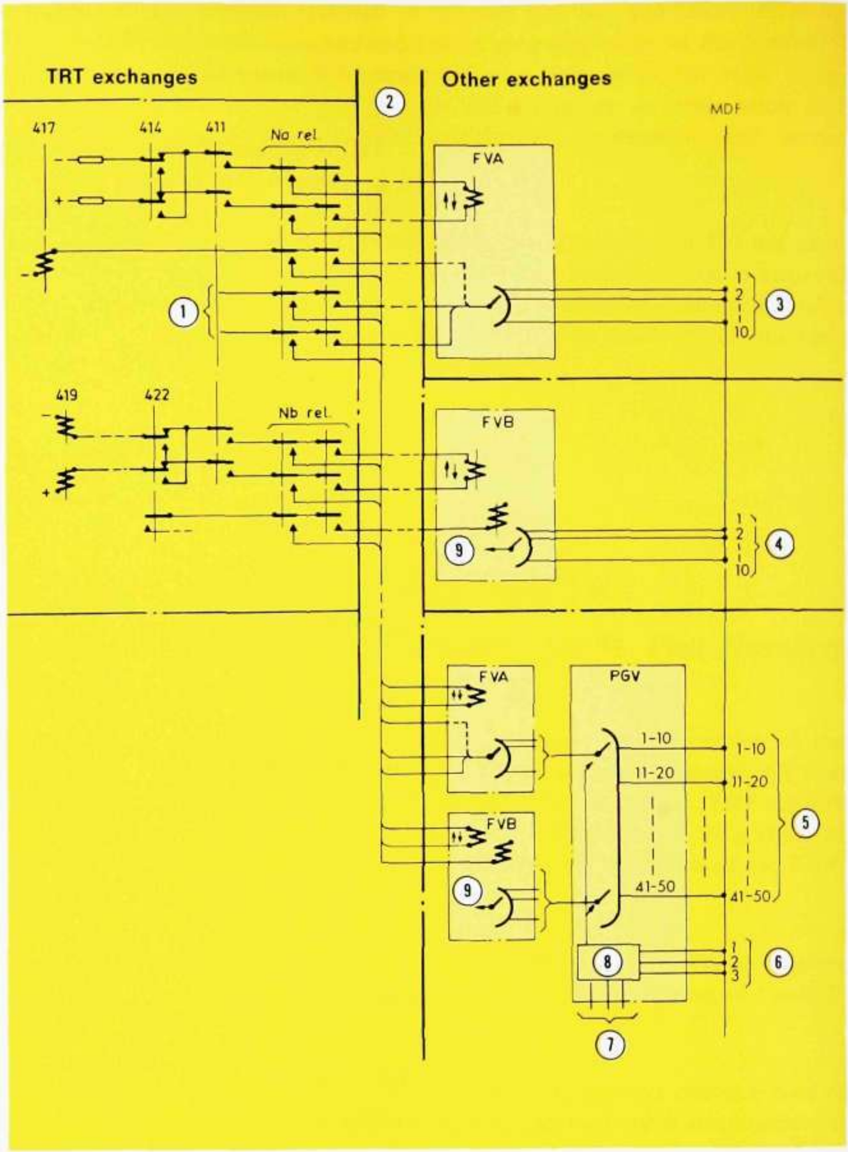


Fig. 8
Layout of rack for traffic route tester LTR 10523

Fig. 9

Connection of FVA, FVB and PGV to TRT

FVA Remote-controlled selector for A test number
FVB Remote-controlled selector for B test number
PGV Test number group selector
① Call and digit transmission
② Physical circuit
③ Test numbers
④ Test numbers
⑤ Test numbers
⑥ 3 test numbers for operation of PGV
⑦ 5 test numbers common to 5 of the 50 test circuits
⑧ Control relays
⑨ Answer circuits



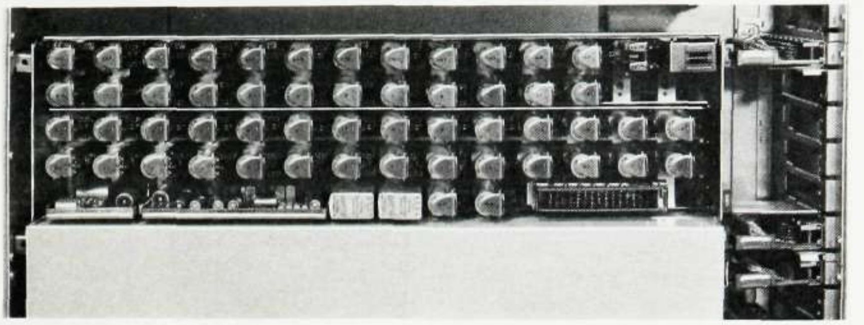
PGV delivers to the manually operated telephone sets information concerning its status or an acknowledgement of a switching operation performed by it. This information is given in the form of a continuous or intermittent tone signal which alternates between the two telephone sets.

The interworking between *TRT*, *FVA*, *FVB* and *PGV* is shown in fig. 9.

Code Answerer with Facility for Setting up Secondary Connections (CASC)

To further increase the ability of the traffic route tester to supervise large telephone networks, a code answerer with facility for setting up secondary connections, *CASC* (Fig. 10), has been designed. *CASC* consists of a code answerer to which circuits have been added for digit transmission, a programme relay chain and a tone receiver. The function of *CASC* is, on order from *TRT*, to set up one connection at a time (secondary connection) to a code answerer or other *CASC* (solely code answering functions). Five test numbers can be connected to *CASC* and can be used both for receiving calls from *TRT* and for setting up a secondary connection within the home exchange. It is also possible to use separate test numbers for these two functions, in which case, accordingly, ten test numbers are required.

Fig. 10
Code answerer CASC
Relay set cover removed



The number of test numbers for *CASC* can be increased by connection of additional equipment consisting of one or more relay sets *(CDB)* containing seizure relays and digit storage relays for ten test numbers (Fig. 11).

The digits to be transmitted for setting up a secondary connection are programmed by strapping of an 80-point plug in *CASC* or a 200-point plug in *CDB*. The operating voltage is 48 V and the code answerer is built up on a 5-bar *BCH* relay set.

CASC works as follows. It

a) is called on a normal switching path set up from *TRT* (primary connection)
b) answers the primary call after two ringing signals by transmitting a code tone, 900 Hz, for about 6 s
c) waits for a signal from *TRT* concerning a secondary connection
d) calls a test number within the home exchange
e) checks dial tone for the secondary connection and repeats it to *TRT*
f) transmits the digits of the secondary connection
g) checks and repeats to *TRT* any tone prior to transmission of the last digit
h) receives code tone (possibly congestion or busy tone) on the secondary connection and repeats it via the primary connection to *TRT*.

Code Answerer with Solely Answering Function (CA)

These code answerers are automatic answering devices designed for use on traffic from *TRT* or an exchange tester. The code answerers are supplied in several different types, but common to them all are the following features:

- two-wire connection to test number
- can operate on 24, 36, 48 or 60 V exchange voltage
- call with ringing signal *(RG)*, whereupon an answer loop is formed and 900 900 Hz answer tone is sent for about 6 s.

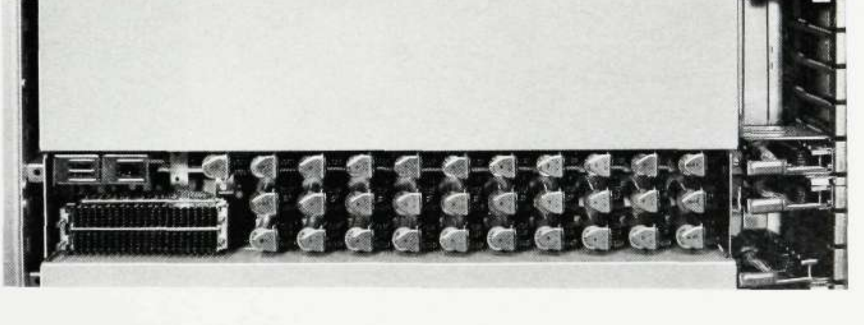


Fig. 11
Additional equipment CDB
Relay set cover removed

Time relays and tone generators in code answerers are transistorized and made up on printed circuit boards of type *ROA*.

The following types of code answerers exist:

Number of test numbers	Function
1	Code answer alone
1	Code answer and possibility of maintaining the answer loop for check of metering
2	Code answer and possibility of maintaining the answer loop for check of metering—one call at a time can be answered
5	Code answer and possibility of maintaining the answer loop for check of metering—one call at a time can be answered

Summary

Owing to the large savings that are possible and the increased reliability, the interest in the use of automatic test traffic equipment for supervision of reliability based on simulated traffic is constantly growing.

L M Ericsson's test traffic equipment, which consists of several units, is very flexible and can be adapted to any requirement. The ordinary exchange equipment is supplemented by test traffic equipment which is installed as required in each particular case. In this way a widespread supervision network can be created, covering several exchanges and routes both in urban and rural networks. No difficulties arise in exchanges of different types or makes, since the test traffic equipment operates independently of the system.

References

1. Letter of reference 12030 of Aug. 4, 1970, from the Central Administration of the Netherlands PTT.
2. Ericsson, O.: *Centralization Trends in Exchange Maintenance.* Ericsson Rev. *43*(1966): 2, pp. 56—66.
3. Eriksson, V.: *Equipment for Maintenance of ARF 102 Automatic Telephone Exchanges.* Ericsson Rev. *46*(1969): 2, pp. 30—48.
4. Hansson, K. G.: *The Traffic Route Tester—a New Tool for Service Observation at Automatic Telephone Exchanges,* Ericsson Rev. *35*(1958): 1, pp. 2—12.

ERICSSON News

from All Quarters of the World

Large Growth of Order Bookings in LM Ericsson's Half-Year Report

"Increased need for telecommunications in many of the Group's important markets characterized the first six months of 1970", states the Ericsson Group Interim Report for the period January 1—June 30, 1970. This growing need was based on the strong industrial activity in these countries during the past years and on rising standards of living for significant segments of the population.

Group order bookings during the first half of 1970 amounted to 1833 Mkr, an increase of 21 % compared with the same period in 1969 (1515 Mkr).

Orders from European customers amounted to 69 % (for Sweden 29 %), 20 % for customers in Latin America, while other parts of the world accounted for 11 % of the orders.

The Group's backlog of orders, which at the beginning of the year amounted to 3018 Mkr, rose as a result of the high bookings to 3480 Mkr at the end of the first half-year.

Group sales amounted to 1371 Mkr and exceeded the figure for the corresponding period in 1969 (1208 Mkr) by 13 %. The rate of growth was highest within Europe (apart from Sweden) and Latin America.

Group income prior to special adjustments and income taxes amounted to 201.8 Mkr (185.9 Mkr), corresponding to 14.7 % of sales (15.4 %).

Scarcities of components and certain raw materials eased but still caused production difficulties. Shipments were consequently not entirely up to the desired level, despite an increase of 11 % over the same period in the preceding year.

The number of Group employees since the beginning of the year has risen from 53,600 to 57,500, a rise of 1640 for the Swedish sector and 2260 for foreign companies.

Foundation Stone Laid for New Finnish Factory

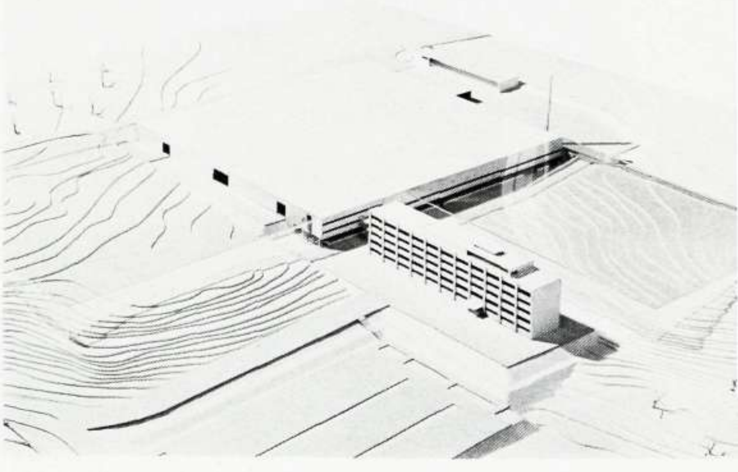
On September 8 the foundation stone for the O/Y L M Ericsson A/B factory at Jorvas, Kyrkslätt, about 25 km east of Helsinki, was laid under ceremonial forms. A number of prominent people were present, headed by the Finnish President, Mr U. Kekkonen, who handed on the trowel to Mr Olavi J. Mattila, Minister of Planning. Among others may be noted the Chairman and President of L M Ericsson, Dr Marcus Wallenberg and Mr Björn Lundvall, Hilding Frostell and Gösta Söderström, Chairman and Member of the Local Council, and representatives of the planners, the main contractor, building workers and the Finnish L M Ericsson company, all of whom took their part in the plastering work on the stone.

The factory building, which will be on two floors, will have a total floor area of 26,000 m², and the 7-floor office building an area of about 6,700 m².

According to the plans the factory is to be opened in the autumn of 1971. During the year the company staff will be increased to more than 800 persons.

The Finnish company's production, which earlier comprised chiefly telephone sets, outside plant material and signalling equipment of different kinds, has increasingly changed to racks and relay sets for automatic telephone exchanges, both for Finnish customers and for export.

President Kekkonen is welcomed to Jorvas by Dr Marcus Wallenberg. (From left, in the background) Yngve Ollus, President of O/Y L M Ericsson A/B, Björn Lundvall, President of L M Ericsson, and Ingmar Horelli, Chairman of the Board of the Finnish company.
On the right a miniature model of the new factory and office buildings at Jorvas.



From the signing of the contract with Venezuela. (From left) Bruno Olsson, Compañía Anónima Ericsson, Dr Andres Sucre E., CANTV, Dr Ramon J. Velazquez, Venezuelan Ministry of Communications, and Fred Sundkvist, L M Ericsson.

From L M Ericsson Order Book

Brazil

Ericsson do Brasil, the Ericsson Brazilian subsidiary, has recently received orders from four Brazilian customers to a total value of 80.4 Mkr.

The telephone enterprise in the State of Goiás has ordered for the capital Goiánia and a neighbouring town equipment for extension of existing telephone exchanges to a total value of 13 Mkr.

A new automatic telephone exchange and equipment for extension of four existing exchanges have been ordered by the telephone enterprise in the State of Ceará for the capital Fortaleza. The order includes 15,000 DIALOG telephones and amounts to some 22 Mkr.

Companhia Telefônica da Borda do Campos has ordered two new automatic telephone exchanges and equipment for extension of five other exchanges to a value of about 28 Mkr. All of these exchanges are situated within the so-called ABC area outside São Paulo.

The government-owned Companhia Telefônica Brasileira has hitherto during 1970 ordered equipment for 17.4 Mkr for installation in several States.

Venezuela

L M Ericsson's Venezuelan subsidiary has signed an agreement with the Venezuelan Telephone Administration, CANTV, for delivery and installation of telephone exchange equipments. The agreement covers 162,000 local lines, extension of existing Ericsson automatic trunk exchanges, and equipment for local tandem traffic in Caracas and for interworking with local exchanges supplied by other manufacturers.

According to the agreement L M Ericsson will deliver and install crossbar exchange equipments during the years 1971—1974. A preliminary order under the agreement for installation during 1971—1972 has been received for an amount of 84 Mkr.

The agreement forms part of the long term plan of the Venezuelan Telephone Administration for vigorous expansion of the national telephone service. L M Ericsson has already delivered a large part of the Venezuelan telephone network.

Spain

Between the Compañía Telefónica Nacional de España (CTNE), the majority of shares in which are owned by the Spanish state, and L M Ericsson's Spanish subsidiary Compañía Española Ericsson S. A. (CEE) an agreement has been concluded for the delivery of telephone equipment from CEE during a five-year period starting in 1972. CTNE is responsible for the telephone service in Spain and for the international circuits.

The deliveries will comprise primarily automatic trunk and local exchanges of crossbar type, and PABX. As a result of the agreement CEE's production capacity must be increased, and plans have been prepared for a new factory in one of the Madrid suburb. In conjunction with the agreement CTNE has been offered to enter as shareholder in CEE.

The Spanish telephone network is at present growing very fast, the percentage rate of increase being among the highest in the world. Earlier during the year agreements were concluded between CTNE and CEE for deliveries of terminal equipments for LME carrier systems on cables and radio links for extension of the Spanish trunk network.

Czechoslovakia

An agreement has been concluded between L M Ericsson and the Czechoslovakian trade organization KOVO and Telephone Administration of the Czechoslovakian Republic for delivery of automatic telephone exchanges.

The contract covers national and international trunk exchanges of crossbar type, both for telephony and telex. The value of the equipments and of additions foreseen in the contract amounts to 50 Mkr.

With this contract L M Ericsson's telephone exchange system has been introduced to an additional market and won a footing in a fourth Comecon country.

L M Ericsson's undertakings, apart from deliveries of materials, include consultation during the installation period and training of technicians both in Sweden and Czechoslovakia.

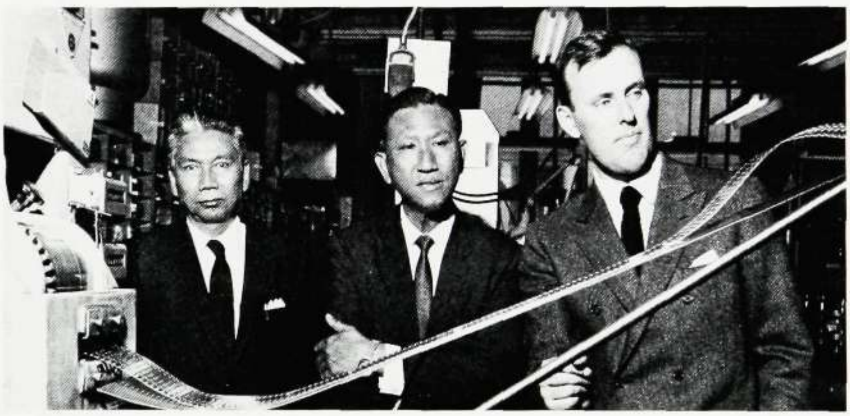
Czechoslovakia has for a long time had a well developed telephone service. Its telephone density is the highest in East Europe and is not far behind that of many West European countries. Through the present installations the country is taking a large step forwards in the automatization of its national and international connections.

In September the Ethiopian Finance Minister Ato Mammo Tadessa visited the Head Factory in Stockholm. (From left) Mr K.-G. Kahnlund, L M Ericsson, the Finance Minister, and the Swedish Ambassador to Ethiopia Carl Bergenstråhle.

The Rumanian Ambassador to Sweden. Eduard Mezincescu (left), and the Second Secretary at the Embassy, Ioan Scarlat, arrive at L M Ericsson to visit the main plant at Midsommarkransen.

In June this year the Brazilian Minister of Communications, Col. Higyno Corsetti (left), visited the Ericsson do Brasil factory at São José dos Campos. The President of EDB, Gunnar Vikberg (centre), presents to the Minister a DIALOG, with the Chairman of the Board of EDB, Juracy Magalhães, looking on.

In the summer L M Ericsson, Midsommarkransen, was visited by the Chairman of the Singapore Telephone Board, C. H. Yang (centre) and Vice Chairman, P. C. Tan (left), here seen with Håkan Ledin, L M Ericsson, during a tour of the factory.



L M Ericsson's stand at Ships Gear, London, at which the British subsidiary, Swedish Ericsson Co. Ltd., and the Norwegian A/S Elektrisk Bureau showed a selection of the Group's products.

The contract with Czechoslovakia is signed by (seated from left) Vice Minister of the Czechoslovakian PTT, Jan Moravec, Director General Otto Kocour, KOVO, and the President of L M Ericsson, Björn Lundvall. (Standing) C. H. Ström, LME.

From the signing of the licence agreement with Egypt. (From left) Ezz El Din Heikal, Technical Director, Akl Moh. Helmy, Chairman of the Board and President, both of El Masara Company for Telephones, Arne Stein and Hans Sund, L M Ericsson.

New Licence Agreement with Egypt

A new 10-year licence agreement has been signed by L M Ericsson and the Egyptian telephone manufacturing company, El Masara Company for Telephones. At the same time an agreement was signed under which L M Ericsson undertakes to deliver raw materials, components and semi-manufactured products to a value of 41 million kronor, and also to provide technical know-how and certain financing for the company's production of switching equipment and telephone sets for Egypt's rapidly growing need of telecommunications.

The licence agreement gives the Egyptian telephone company the continued right up to 1980 to manufacture L M Ericsson's crossbar exchanges, private exchanges and telephone sets.

The telephone factory, which is situated in Cairo, employs about 600 persons and produces a large part of the equipment for the Egyptian telephone network. The factory has an annual production capacity of switching equipment for about 30,000 subscriber lines, PABX and PMBX for about 20,000 exchange lines, and about 60,000 telephone sets.

The first licence agreement with the Egyptian company was signed in 1959 to remain in force until 1970. For financing of the licenced production a credit/delivery agreement covering 62 Mkr was signed during the period.

The expansion of telecommunications during the period 1960—1970 was considerably greater than the domestic telephone factory could meet.

The Egyptian Telephone Administration, UARTO, therefore purchased during the period switching equipment from LME to a value of more than 100 Mkr. Transmission equipment was also purchased for extension of the telephone network to a value of over 38 Mkr, and telex exchanges and other equipment for about 10 Mkr.

Change of Name

Instruktionsteknik AB, a member of the Ericsson Group, has changed its name as from November 1, 1970, to L M Ericsson Instruktionsteknik AB.

New Factory Being Built in Norway

For L M Ericsson's Norwegian subsidiary A/S Elektrisk Bureau, Oslo, a new factory and office building with a floor area of 35,000 m^2 is being planned. The new building will be situated at Billingstad west of Oslo and is expected to be completed by the middle of 1972. The building will house administration, technical development, sales and production management and production units which require close collaboration with the technical departments.

Continuing Growth in Number of Telephones

The total number of telephones in the world increased during 1968 by about 6 %, i.e. from 222 million in 1967 to 237 million in 1968.

The most marked increase is in countries where the telephone is still comparatively young, while those which have for a long time topped the list account for a smaller proportion of the increase.

In the last 14 years the total increase has been above 6 % per annum. Here are a few figures for the latest 10-year period.

They are taken from AT & T's "The world's telephones", January 1, 1969.

Country	Number of telephones in service (mill.) Jan. 1, 1969	Per cent increase		Number of telephones per 100 population
		1968	10 years	
United States	109.2	5.3	63.9	54.02
Sweden	4.1	4.5	62.7	51.76
Switzerland	2.7	6.0	82.1	43.42
Canada	8.8	5.2	72.3	42.12
New Zealand	1.2	3.2	80.2	41.56
Denmark	1.5	3.2	55.3	30.88
Australia	3.4	6.7	65.0	28.20
Norway	1.0	4.9	51.7	27.02
Netherlands	2.9	7.4	108.1	22.80
Japan	20.5	12.7	302.7	20.12
Finland	1.0	6.2	85.1	21.50
Germany, Western	11.2	9.0	121.0	18.65
France	7.5	7.2	102.6	14.98
Italy	7.8	9.8	143.6	14.37
South Africa	1.3	5.7	57.5	7.29
U.S.S.R.	9.9	8.8	159.8	4.14

The Ericsson Group

Associated and co-operating enterprises and technical offices

· EUROPE ·

Denmark

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GNT AUTOMATIC A/S *DK-2860 Søborg*, Telefonvej 6, tel: (01) 69 5188, tgm: nortelmatic, telex: 5264, "GNT AUTOMATIC KH"

Dansk Signal Industri A/S *DK-2650 Hvidovre*, Stamholmen 175, Avedøre Holme, tel: (01) 49 0333, tgm: signaler københavn, telex: 6503, "6503 DSI DK"

Finland

O/Y L M Ericsson A/B *Helsinki 13*, P.O.B. 13018, tel: (90) 121 41 tgm: ericsons, telex: 12546, "LME SF"

France

Société Française des Téléphones Ericsson *F-92-Colombes*, 36, Boulevard de la Finlande, tel: Paris (1) 781 3535, tgm: ericsson colombes, telex: 62179, "ERICSSON CLOMB"

F-75-Paris 17e, 147, rue de Courcelles, tel: Paris (1) 227 9530, tgm: eric paris, telex: 29276, "ERICSSON PARIS"

Etablissements Ferrer-Auran, *13 Marseille*, 2, Rue Estelle, tel: 20 6940, tgm: etabferrer, telex: 42579, "RINGMARS"

Great Britain

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Production Control (Ericsson) Ltd. *Morden, Surrey*, Crown House, London Road, tel: (01) 542 1001, tgm: productrol, telex: 935979, "SWEDERIC LDN"

Centrum Rentals Ltd. *Morden, Surrey*, Crown House, London Road, tel: (01) 542 1001, tgm: celefon, telex 935979 "SWEDERIC LDN"

Ireland

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Italy

FATME, Soc. per Az. *1-00100 Roma*, C. P. 4025 Appio, tel: (06) 4694, tgm: fatme, telex: 61327, "61327 FATME"

SETEMER, Soc. per Az. *1-00198 Roma*, Via G. Paisiello 43, tel: (06) 86 8854, tgm: setemer

SIELTE, Soc. per Az. *I-00100 Roma*, C.P. 5100, tel: (06) 577 8041, tgm: sielte, telex: 61225, "61225 SIELTE"

Netherlands

Ericsson Telefoonmaatschappij N.V. *Rijen (N.Br.)*, P. O. B. 8, tel: (01612) 3131, tgm: erictel, telex: 54114, "ERICTEL RIJEN"

Voorburg 2110, P. O. B. 60, tel: (070) 81 4501, tgm: erictel den haag, telex: 31109, "ERICTEL DEN HAAG"

Norway

A/S Elektrisk Bureau *Oslo 3*, P.B. 5055 Maj, tel: (02) 46 1820, tgm: teleb, telex: 11723, "TELEB N"

A/S Industrikontroll *Oslo 6*, Grenseveien 86/88, 3. etg., tel: (02) 68 7200, tgm: indtroll

A/S Norsk Kabelfabrik *Drammen*, P.O.B. 369, tel: (02) 83 7650, tgm: kabel, telex: 18149, "KABEL N".

A/S Telesystemer *Oslo 6*, Tvetenveien 32, Bryn, tel: (02) 68 7200, tgm: telesystemer, telex: 16900, "ALARM N"

Poland

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Portugal

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Spain

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Sweden

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Bjurhagens Fabrikers AB, *S-212 15 Malmö*, Fack, tel: (040) 93 4770

AB Rifa, *S-161 30 Bromma 11*, tel: (08) 26 2600, tgm: elrifa, telex: 10308, "ELRIFA STH"

L M Ericsson Instruktionsteknik AB, *S-117 47 Stockholm 44*, tel: (08) 68 0870, tgm: instruktec

L M Ericsson Telemateriel AB, *S-135 01 Stockholm-Tyresö 1*, Fack, tel: (08) 712 0000 tgm: ellem, telex: 1275, "1275 TELERGA S"

Sieverts Kabelverk AB, *S-172 87 Sundbyberg*, tel: (08) 28 2860, tgm: sievertsfabrik, telex: 1676, "SIEVKAB STH"

Svenska Radio AB, *S-102 20 Stockholm 12*, tel: (08) 22 31 40, tgm: svenskradio, telex: 10094 "SRA S"

AB Transvertex, *S-140 11 Vårby*, Fittja industriområde, tel: (08) 710 0935

Switzerland

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Turkey

Ericsson Türk Ticaret Ltd. Sirketi *Ankara*, Rumeli Han, Ziya Gökalp Cad. tel: 12 3170, tgm: ellem

West Germany

Deutsche Ericsson G.m.b.H. Telematerial, *4 Düsseldorf 1*, Postfach 2628, tel: (0211) 35 3594, tgm: eric-tel: telex: 8587912, "ERIC D"

Ericsson Centrum GmbH. *3 Hannover*, Postfach Dornierstrasse 10, tel: (0511) 63 1018, tgm: ericen, telex: 0922913, "ERICE D"

· ASIA ·

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New Delhi 49, L25, South Extension Part II, tel: (011) 62 6505, tgm: inderic

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Ericsson Telephone Sales Corporation AB *Djakarta*, P.O.B. 2443 tel: (07) 463 97, tgm: javeric

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Iraq

Telefonaktiebolaget L M Ericsson, Installation Branch, *Baghdad* P.O.B. 2388, Alwiyah, tel: 947 14, tgm: ellemco

Kuwait

Telefonaktiebolaget L M Ericsson, Technical office, *Kuwait, State of Kuwait*, P.O.B. 5979, tel: 200 74 tgm: erictel

Lebanon

Société Libanaise des Téléphones Ericsson, *Beyrouth* B.P. 8148, tel: 25 2627, tgm: ellem, telex: 876, "ELLEM BERYT"

Malaysia

Ericsson Talipon SDN BHD, *Petaling Jaya*, P.O.B. No 9, tel: Kuala Lumpur (03) 56 1523, tgm: kuleric, telex: 265 "ERICMAL KL"

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Singapore

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Telephone Industries of Singapore Private Ltd. *Singapore 1*, P.O.B. 3079, tel: 98 1155, tgm: sineric

Thailand

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· AFRICA ·

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Ethiopia, Sudan

Telefonaktiebolaget L M Ericsson, Technical office, *Addis Ababa*, P.O.B. 3366, tel: (01) 492 60, tgm: ericsson, telex: 21090 "MOSFIRM ADDIS"

Libya

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Malawi

Ericsson Telephone Sales Corporation AB, *Blantyre*, P.O.B. 431, tel: 300 95, tgm: ericofon

Morocco

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South Africa, Southwest Africa, Botswana, Lesotho, Swaziland

L M Ericsson (Pty.) Ltd, *Marshalltown, Transvaal*, P.O.B. 61391, tel: 836 0956, tgm: ericofon johannesburg

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· AMERICA ·

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Cía Argentina de Teléfonos S.A. *Buenos Aires*, Belgrano 894, tel: 33 2076, tgm: catel, telex: 0122196, "CATEL BA"

Cía Entrerriana de Teléfonos S.A. *Buenos Aires*, Belgrano 894, tel: 33 2076, tgm: catel, telex: 0122196, "CATEL BA"

Industrias Eléctricas de Quilmes S.A. *Quilmes FNGR*, 12 de Octubre 1090, tel: 253 2775, tgm: indelqui buenosaires, telex: 0122196, "CATEL BA"

Brazil

Ericsson do Brasil Comércio e Indústria S.A. *Sao Paulo*, C.P. 5677, tel: 298 0437, tgm: ericsson, telex: 021817, "ERICSSON SPO"

Fios e Cabos Plasticos do Brasil S.A. (FICAP), *Rio de Janeiro*, caixa postal: 1828, tel: 29 0185, tgm: ficap, telex: 031563, "FICAP RIO"

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L M Ericsson Limited *Montreal 381, Quebec*, 2300 Laurentian Boulevard St. Laurent, tel: (514) 331 3310, tgm: caneric, telex: 05-267682, (TWX) 610-421-3311, "CANERIC MTL"

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Colombia

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Fabricas Colombianas de Materiales Eléctricos Fácomec S.A. *Cali*, Apartado Aéreo 4534, tel: 42 1061, tgm: facomec, telex: 55673, "FACOMEC CLO"

Costa Rica

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Cont. on next page

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Latinoamericana de Cables S.A. de C.V. *Mexico 12 D.F.*, Apartado Postal 12737, tel: (2) 549 3650, tgm: latincasa, telex: 01772485, "ERICSSON MEX" PARA LATINCASA

Teleindustria, S.A. de C.V. *Mexico 1, D.F.*, Apartado Postal 1062, tel: (2) 546 4640, Factory: (2) 576 3166, tgm: ericsson, telex: 01772485, "ERICSSON MEX"

Telemontaje, S.A. de C.V. *Mexico 1, D.F.*, Apartado Postal 1062, tel: (2) 576 4044, tgm: ericssonmexicodf, telex: 01772485, "ERICSSON MEX" PARA TELEMONTAJE

Peru

Cía Ericsson S.A. *Lima*, Apartado 2982, tel: 31 1005, tgm: ericsson, telex: 3540202, "ERICSSON 3540202"

Soc. Telefónica del Perú, S.A. *Arequipa*, Apartado 112-1012, tel: 6060 tgm: telefonica

El Salvador

Telefonaktiebolaget L M Ericsson, Technical office *San Salvador*, Apartado 188, tel: 21 7640, tgm: ericsson

Uruguay

Cía Ericsson S.A. *Montevideo*, Casilla de Correo 575, tel: 926 11, tgm: ericsson

USA

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Ericsson Centrum Inc. *New York, N.Y. 10016*, 16, East 40th Street, tel: (212) 679 1000, tgm: erictel, telex: 620149, "ETELSAC 620149"

Venezuela

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• AUSTRALIA & OCEANIA •

Australia

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Rushcutters Bay N.S.W. 2011, 134 Barcom Avenue, tel: (02) 31 0941, tgm: ericsyd, telex: AA 21358 "ERICSYD"

Port Moresby, Territory of Papua and New Guinea, P.O.B. 1367, Boroko, tel: 569 65, tgm: ericpor

Teleric Pty. Ltd. *Broadmeadows, Victoria 3047*, P.O.B. 41, tel: (03) 309 2244, tgm: teleric, telex: AA 30555, "ERICMEL"

Rushcutters Bay N.S.W. 2011, 134 Barcom Avenue, tel: (02) 31 0941, tgm: teleric, telex: AA 21358, "ERICSYD"

Conqueror Cables Pty. Limited, *Dee Why, N.S.W. 2099*, P.O.B. 69, tel: (02) 98 0364, tgm, concab sydney

A.E.E. Capacitors Pty. Ltd. *Preston, Victoria 3072*, 202 Bell Street, P.O.B. 95, tel: (03) 480 1211, tgm: engiquip melbourne

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• EUROPE •

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Spain

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Santa Cruz de Tenerife, Sabino Berthelot, 3, tel: 24 5897, tgm: transa

Yugoslavia

Merkantile Inozemna Zastupstva *Zagrep* pošt pretinac 23, tel: (041) 41 6655, tgm: merkantile, telex: 21139, "21139 YU MERTIL"

Beograd, Ul. 7. jula br. 18, tel: (011) 62 1773, tgm: merkantile, telex: 11506, "YU MERKAN"

• ASIA •

Bahrain & Trucial States

Yusuf Bin Ahmed Kanoo, *Bahrain, Arabian Gulf*, tel: 40 8188, tgm: kanoo, telex: BHN 215

Burma

Myanma Export Import Corp., Agency Div. *Rangoon*, P.O.B. 404, tel: 146 18, tgm: myanimport

Cambodia

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

Cyprus

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

S.A. Petrides & Sons Ltd. *Nicosia*, P.O.B. 1122, tel. 627 88, tgm: armature, telex: 2308, "ARMATURE"

Hong Kong and Macao

Swedish Trading Co. Ltd. *Hong-Kong*, P.O.B. 108. tel: 23 1091, tgm: swedetrade

Iran

Irano Swedish Company AB, *Teheran* Khiabane Sevom Esfand 29, tel: 31 4160, tgm: iranoswede

Jordan

The Arab Trading & Development Co. Ltd. *Amman*, P.O.B. 6141, tel: 259 81, tgm: aradeve

Kuwait

Morad Yousuf Behbehani *Kuwait, State of Kuwait*, P.O.B. 146, tel: 270 71, tgm: barakat, telex: 048, "BEHBEHANI KUWAIT"

Lebanon

Swedish Levant Trading (Elié B. Hélou) *Beyrouth*, P.O.B. 931, tel: 23 1624, tgm, skefko

Pakistan

Panasian Marketing Service Ltd., *Karachi*, P.O.B. 3941, tel: (90) 51 2051, Ext. 53, tgm: panasian

Philippines

USIPHIL Inc. *Manila*, P.O.B. 125, tel: 88 9351, tgm: usiphil, telex: PN 3550, "USIPHIL"

Saudi Arabia

Engineering Projects & Products Co. Ltd. (Eppco), *Riyadh*, P.O.B. 987, tel: 222 22, tgm: eppcol

Yeddah, P.O.B. 1502, tel: 4567, tgm: eppcol

Dammam, P.O.B. 450, tel: 222 22, tgm: eppcol

Syria

Constantin Georgiades, *Damas*, P.O.B. 2398, tel: 266 73, tgm: georgiades

Taiwan

Trans-Eurasia Enterprise, Ltd. *Taipei*, P.O.B. 3880, tel: 51 7038, tgm: esbtrading

Republic of Vietnam

Vo Tuyen Dien-Thoai Vietnam, *Saigon*: P.O.B. 1049, tel: 226 60, tgm: telerad

International Business Representative, *Saigon*, 26—28, Hai Ba Trung Street, tel: 226 60, tgm: ibur

• AFRICA •

Congo (Kinshasa)

I.P.T.C. (Congo) Ltd. *Kinshasa 1*, P.O.B. 8922, tel: 253 45, tgm: induexpan, telex: 327, "PTC KIN"

Ethiopia

Mosvold Company (Ethiopia) Ltd. *Addis Ababa*, P.O.B. 1371, tel: (01) 101 00, tgm: mosvold, telex: 21090 "MOSFIRM ADDIS"

Ghana

R.T. Briscoe Ltd. *Accra*, P.O.B. 1635, tel: 669 03, tgm: briscoe, telex:295, "BRISCOE ACCRA"

Liberia

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Libya

ADECO African Development & Engineering Co *Tripoli*, P.O.B. 2390, tel: 339 06, tgm: adeco

Mozambique

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

Sudan

El Rahad Trading Corporation *Khartoum*, P.O.B. 866, tel: 776 95, tgm: suconta, telex: BHN 251

• AMERICA •

Bahama Islands

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

Bolivia

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Costa Rica

Tropical Commission Co. Ltd. *San José*, Apartado 661, tel: 22 5511, tgm: troco

Dominican Republic

Humberto Garcia, C. por A. *Santo Domingo*, Apartado 771, tel: 3645, tgm: gartier

Guatemala

Nils Pira *Ciudad de Guatemala*, Apartado 36, tel: (021) 622 57, tgm: nilspira

Guyana

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

Honduras

Quinchón Leon y Cía *Teguicigalpa*, Apartado 85, tel: 251 71, tgm: quinchon

Netherlands Antilles

S.E.L. Maduro & Sons, Inc. *Willemstad, Curaçao* P.O.B. 304, tel: 130 00, tgm: madurosons, telex: CU 92

Nicaragua

Roberto Teran G. *Managua*, Apartado 689, tel: 224 00, tgm: roteran

Panama

Sonitel, S.A. *Panama 5, R.P.*, Apartado 4349, tel: 64 3600, tgm: sonitel, telex: 368674, "368674 SONITEL"

Paraguay

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

El Salvador

Dada-Dada & Co. *San Salvador* Apartado 274, tel: 21 7940, tgm: dada

Surinam

W.E. van Romondt's Trading Company Ltd., *Paramaribo*, tel: 2831, tgm: vanromondt

Trinidad, W.I.

Leon J. Aché Ltd. *Port-of-Spain*, 100 Frederic Street, tel: 323 57, tgm: achegram

• AUSTRALIA & OCEANIA •

New Zealand

ASEA Electric (NZ) Ltd. *Wellington C. 1.*, P.O.B. 3239, tel: 706 14 tgm: asea, telex: 3431, "ASEAWELL NZ 3431"

SATHERLUND & KROOK