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On cover: DIRIVOX—master set for L M Ericsson's loudspeaking communication system.

DIRIVOX — L M Ericsson's Loudspeaking Communication System with Natural Speech Control

A. BERGQUIST, L M ERICSSON TELEMATERIEL AB, STOCKHOLM

UDC 621.395.24
LME 8372

Advanced electronics for automatic speech control, numerous standard traffic facilities and individual name calls are some of the advantages offered by L M Ericsson's new DIRIVOX loudspeaking communication system.

DIRIVOX is the outcome of an intense development project aimed at a flexible loudspeaking system with at least as good voice reproduction as in a non-loudspeaking system, but much more convenient to use. The goal has been to offer loudspeaking communication of so high a class that it constitutes a real alternative to natural conversation.

Natural Speech Control

In an ordinary loudspeaking system the direction of speech is controlled manually. This makes "natural" conversation difficult as one party must have one hand occupied throughout the conversation. This method is best adapted for orders, brief questions and quick replies.

One method of avoiding manual speech control would be to have both channels open at the same time. But as the overall loop gain (ratio between loss and gain) must not exceed 1 if singing is not to take place, the level and fidelity of sound would be unsatisfactory.

Fig. 1
Considerable care has been devoted to the design of the DIRIVOX

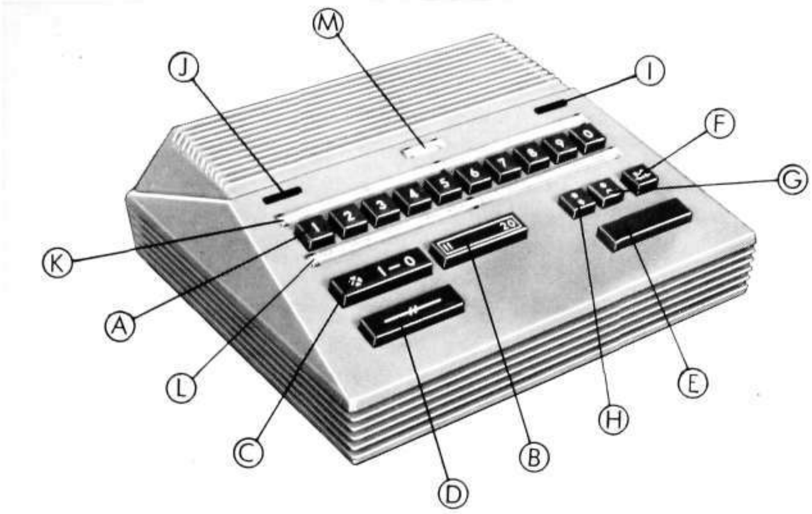

Fig. 2
DIRIVOX master set
A Call buttons
B Preselection bar for name calls
C Answering bar and preselection of digit calls
D Clearing bar
E Talk-listen bar
F Microphone cut-off button
G Secretary transfer switch
H Privacy switch
I Busy lamp
J Privacy lamp
K Name labels (1—10)
L Name labels (11—20)
M Extension number

In practice, however, a person does not speak and listen at the same time. Only one channel, therefore, need be open at a time. Through the introduction of sensitive control circuits, which all the time "listen" and quickly switch the direction of speech after each party has stopped speaking, adequate gain can be used. There is no danger of singing, since one channel is always cut-off when the other is transmitting sound.

For satisfactory operation the speech switching function should be unnoticed. It should permit either party to break into the conversation naturally without abnormal raising of the voice, e.g. for comments, corrections and confirmations such as "of course", "that's right", and the like. The speech control must also be as non-sensitive as possible to external noise; nor, of course, must it distort the speech.

After intense development work L M Ericsson has produced an electronic control equipment which fulfils these requirements. The DIRIVOX system is built up around this advanced electronics. Since DIRIVOX allows two parties to converse as though they were sitting in the same room, we speak of "natural speech control".

Traffic Facilities

In its standard form DIRIVOX has a number of traffic facilities which make the system simple and convenient to use. Fully dependable privacy, individual name calls, secretary transfer and "courteous" priority are some of these facilities.

The alphabetical symbols on the various keys referred to below relate to fig. 2, which shows the master set in the DIRIVOX system.

Incoming Calls

When switch H is moved upwards, all calls come in automatically (hands-free-accepted calls). A brief tone is heard in the master set and connection is immediately established.

When switch H is moved downwards, a call is notified by repeated tones corresponding to the ringing signals of an ordinary telephone. The same tone is heard at the calling extension and shows that the called extension is switched for privacy. The called extension accepts the call by brief pressure on the answering bar C.

Outgoing Calls

Name calls are made by pressing one of the ten buttons A. Access to a further ten extensions can be obtained by first pressing the preselection bar B followed by the desired button in row A. The names of the persons having these 20 extensions are marked on the labels above and below the digit buttons.

In the larger systems the combinations of extensions to be called "by name" can be "tailored" for most requirements to allow quick contact with members of a working group or with common servicing departments. Every extension can choose two out of up to 32 combinations of ten extensions most suitable for his needs in the 90 line exchange. The extensions to be included in each combination can be chosen at will, as well as the order of sequence between them.

The remaining extensions in large organizations are contacted on ordinary extension numbers. One first presses the digit-call preselection bar C until the yellow lamp J lights and dial tone is returned. The desired number is then keyed with the digit buttons.

Busy Tone

If the called extension is engaged a busy signal is returned, consisting of repeated short tones.

"Courteous" Priority

The type of priority offered by the DIRIVOX system is called "courteous" priority, i.e. if a priority extension calls an engaged number he can warn the conversing parties by means of a discreet tone. To do this he presses his talk-listen bar E. When the parties have finished their conversation the priority caller is automatically connected to the desired extension.

Clearing

Bar D is used to clear a connection. After a hands-free-accepted call the caller alone need clear the connection. After a call to a privacy-connected extension, both extensions must clear the line.

Secretary Transfer

A certain number of extensions can have calls automatically transferred to another number, e.g. a secretary. This is done by operating switch G. Outgoing calls can be made whether the switch is operated or not. In some systems the extension to which calls are transferred can bypass the transfer connection and call the transferring extension.

Manual Speech Control

If the called extension is in a room with high noise level (machine-room or the like), the automatic speech control may in rare cases not operate satisfactorily. In such case the direction of speech can be controlled manually by either party by pressing bar E to talk and releasing it to listen.

If the noise ceases during conversation, automatic control can be restored by the other party momentarily pressing his talk-listen bar E.

Privacy

The yellow lamp J indicates that the extension is switched to the line. During conversation the lamp lights on both extensions. In conjunction with the tones for establishment of the connection, this precludes all risk of eavesdropping.

Temporary Privacy

The extension microphone circuit can be cut-off with button F. A conversation with another person in the room can then not be overheard by the other extension.

Non-loudspeaking Conversation

Handset telephones or Ericofons can be connected to the DIRIVOX system if non-loudspeaking conversation is required. When using the handset or Ericofon, the microphone and loudspeaker of the DIRIVOX master are disconnected.

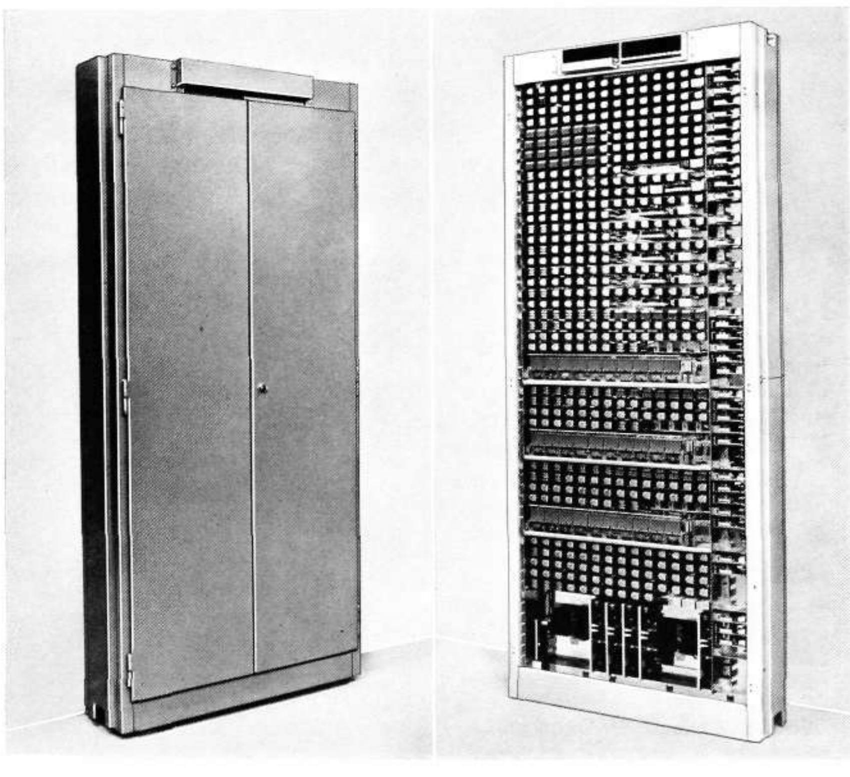

Fig. 3
Exchange AKD 847 with and without doors

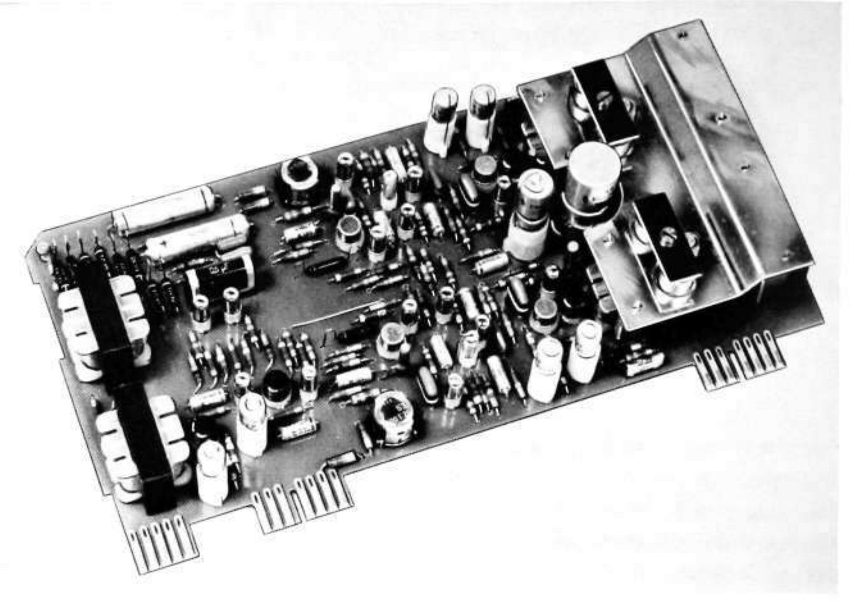

Fig. 4
Connecting-circuit amplifier

Busy Lamp

In a DIRIVOX system one need not wait for busy tone. If all connecting circuits are engaged the red lamp I lights.

Extra Traffic Facilities

An auxiliary equipment enables the DIRIVOX system to be used for paging. Ordinary conversations on the system are not disturbed by paging calls. Special loudspeakers can be used for paging in large rooms, for example, or out-of-doors. Visual and radio paging equipment can also be connected.

Under certain circumstances tie lines can be arranged between different DIRIVOX exchanges.

Exchanges and Systems

The DIRIVOX systems consist of exchanges with built-in amplifiers and speech control circuits, and units for tone signals etc., extension sets and cabling.

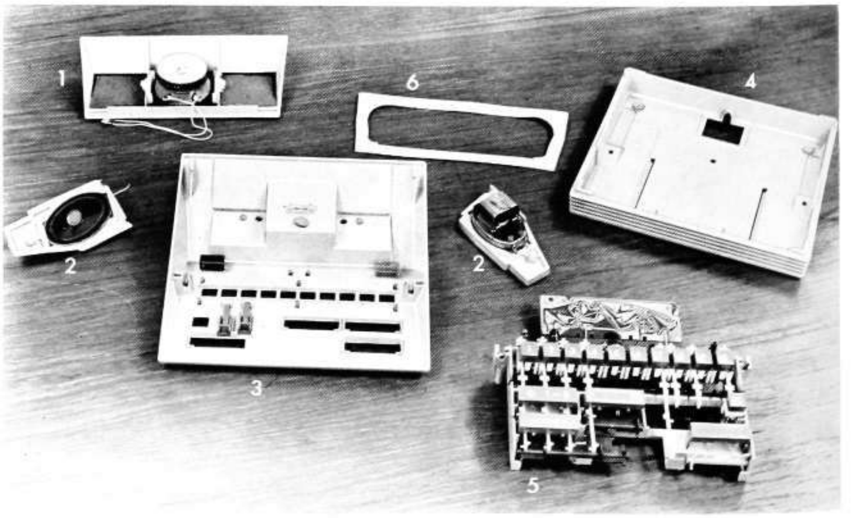

Fig. 5
Parts of DIRIVOX

1 Microphone (with casing)
2 Loudspeaker
3 Upper part
4 Lower part
5 Keyset with microphone amplifier
6 Gasket

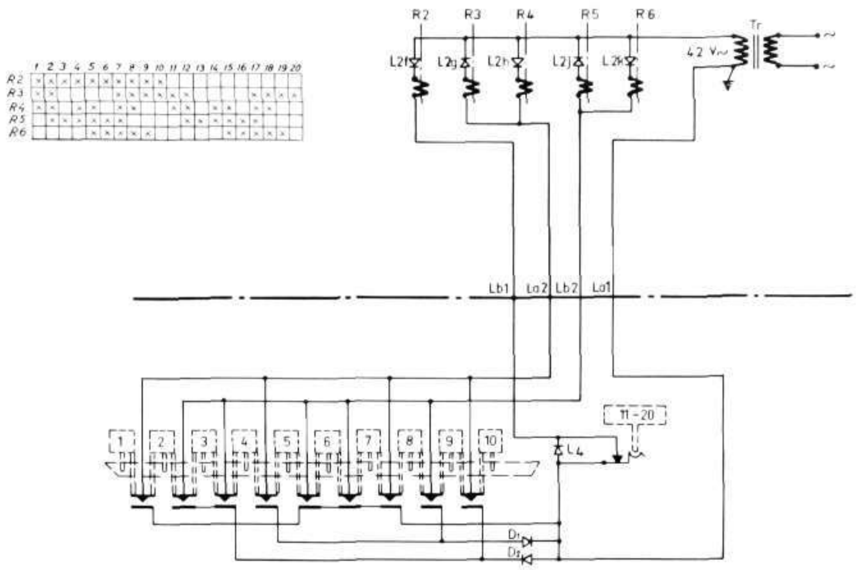

Fig. 6
Circuit diagram of digit receiving relays

Exchanges can be supplied for max. 20, 60 or 90 extensions. As the exchanges operate fairly silently and are of attractive appearance (fig. 3), they can well be placed in office premises.

The electronic equipment consists of a connecting-circuit amplifier (fig. 4), tone generator and voltage stabilizer. The equipment has printed circuits and is fully transistorized.

Extension sets are connected to the exchange on four-wire cables. Sets with secretary transfer facility require a fifth conductor. Ordinary plastic-insulated telephone cable can be used. The maximum length of line with 0.5 mm copper wire is 1000 metres and with 0.7 mm copper wire 2000 metres.

In view of the few moving parts in the extension sets, the simple cabling, and the fact that all automatic equipment is placed centrally in the exchange, the system requires a minimum of maintenance.

Master Set

The master set has a robust, light grey thermoplastic casing. It contains a row of 10 buttons, two loudspeakers and a microphone in a special compartment (fig. 5). A master set connected to a large exchange also has a transistorized microphone amplifier. One model is made without call buttons—for use as subset for incoming calls alone.

Push-button-dialling takes place on a relay-diode circuit. The operating voltage is 42 V AC. During keying this voltage is connected to the line wires and passes via rectifiers to the digit receiving relays (fig. 6). The relays operate in different combinations depending on whether the positive, negative or both half-cycles of the alternating current are used.

Natural Speech Control in the DIRIVOX System

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If a loudspeaking telephone conversation is to be equivalent to a natural conversation, the voice control must be so well designed that the conversing parties normally do not notice the switching of the direction of speech. No effort should be needed to interrupt the speaker, and the system must not distort the spoken word. It is important, too, that the voice control is as insensitive as possible to room acoustics and to noise from fans, typewriters and the like.

After intense development work Telefonaktiebolaget L M Ericsson has produced the advanced electronic equipment required for natural speech control. This article deals with the speech control circuits and with some of the ideas which lie behind them.

The requirements in respect of speech control may be summarized under the following points:

- ☐ Switching from one to the other channel must be extremely rapid and unnoticed by the conversing parties.
- ☐ The turn-on time must be very short. The interval between the moment when the voice reaches the microphone and the moment when one channel of the amplifier works at full gain must be extremely short. Otherwise the first syllable, perhaps a whole word, will be lost.
- ☐ The turn-off time must exceed the reverberation time for the called party's room. Sound reflected from furniture, walls etc. must not switch the direction of speech. The speaker must not hear the echo of his own voice.
- ☐ Switching to the other channel must not occur between syllables or between words in a sentence. On the other hand the turn-off time must not be so long that a quickly alternating conversation is rendered impossible.
- ☐ Either party must be able to interrupt the other quickly and effortlessly.

The DIRIVOX speaking circuits, which use more than 60 transistors and other semiconductors on every conversation, fulfil these requirements. When a DIRIVOX connection has been established, the parties can carry on a hands-free conversation. They need not worry about reversing the direction of speech, this is done by the DIRIVOX electronics.

Speaking Circuits

Every conversation makes use of two separate amplifier channels for the two directions of speech, and of control circuits which keep one channel open and the other closed, dependent on the direction of speech.

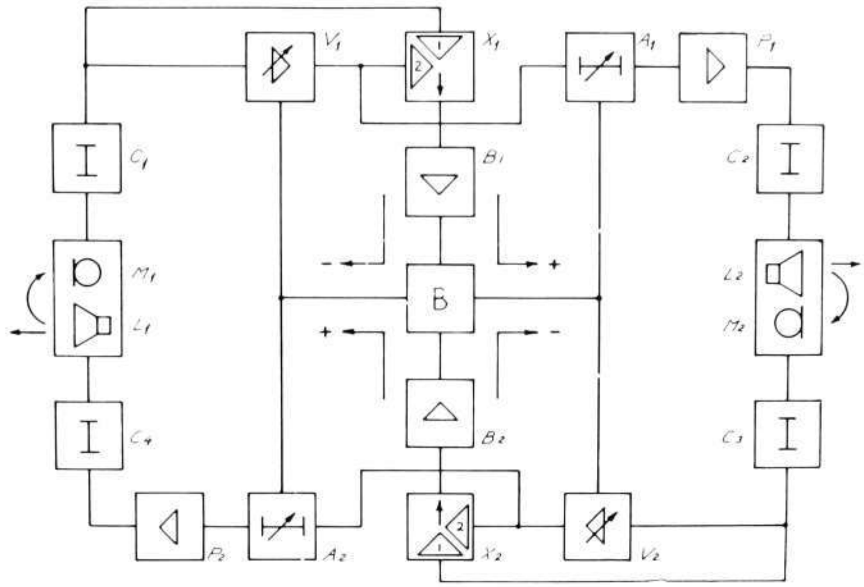

Fig. 1
Block schematic of speech circuits of DIRI-VOX system

V_1, V_2 **Variable gain amplifiers**
A_1, A_2 **Variable attenuators**
C_1, C_4 **Line attenuators**
X_1, X_2 **Mixers**
P_1, P_2 **Power amplifiers**
B **Control bridge**
B_1, B_2 **Channel control amplifiers**
M_1, M_2 **Microphones**
L_1, L_2 **Loudspeakers**

Fig. 1 shows a block schematic of the speech circuits. Each of the two identical speech channels consists of microphone, line attenuator, variable gain amplifier, variable attenuator, power amplifier and loudspeaker.

The controlling circuits consist of mixers *X1–X2*, channel control amplifiers *B1–B2* and the control bridge *B*. The latter controls the various amplifiers and attenuators in the speech channels.

Microphone and loudspeaker are placed in the extension set. The line attenuator *C* is placed on the line between the extension set and the exchange. The other units in fig. 1 are placed in the connecting circuit unit in the exchange.

In order to avoid singing, the ratio between attenuation and gain in the closed loop must not exceed 1. This is achieved through the fact that there is a reciprocal relationship between gain on one channel and attenuation on the other.

A strong coupling can thereby be accepted between loudspeaker and microphone, on an average –60 dB, the maximum in unfavourable cases being –40 dB. This means that the extension set is very insensitive to location.

Since all increases and decreases of the signal level in the entire speech chain are known, the signal in the active channel can be compared in control bridge *B* with that on the suppressed channel. If the control bridge receives from the suppressed channel only the signal deriving from the coupling between loudspeaker and microphone in the receiving extension, it keeps the channel open. A very small additional signal in the suppressed channel, however, through the listener entering the conversation, causes the bridge to switch the direction.

Since the control voltage is extracted both directly from the microphone and after the variable gain amplifier *V*, a low supplementary signal can be made to change the direction of speech. When the speech control has started to function fully, the amplifier *V* in the previously suppressed channel has its gain increased so that the signal to the control bridge increases further. Thus, once the signal has started, it increases with avalanche-like velocity.

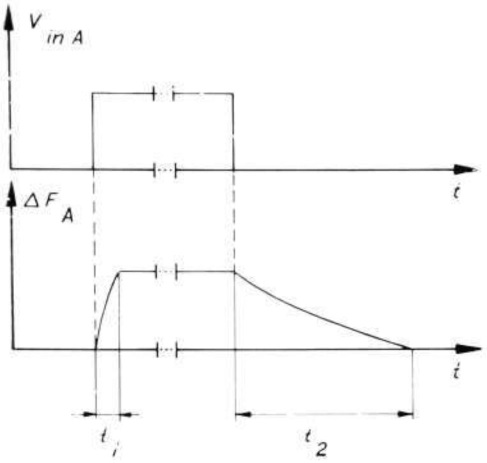

Fig. 2
Change of gain in channel A (ΔF_A) resulting from an input signal ($V_{in\,A}$) as function of time

t_1 Turn-on time
t_2 Turn-off time

The change of gain is achieved through change of impedance in the respective stages. The change of impedance is controlled by the bridge B and reduces the attenuation in the sending channel and the gain in the other channel.

Switching Times

The automatic voice switching does not take place instantaneously but with some delay. The choice of time constants for turn-on, turn-off and channel switching has great significance for the smoothness of speech control.

Figs. 2 and 3 show the signal amplitudes on the speech channel inputs and outputs as function of time. For comparison with the switching times mentioned below, some durations for ordinary human sounds may be indicated. These vary greatly, of course, but, on an average, it may be said that the consonants lie chiefly between 22 and 75 ms and the vowels between 44 and 120 ms. The shortest consonants are *k* (22 ms), *r* (35 ms) and *n* (68 ms). Among the vowels a short *i* has a duration of 50 ms and a long *a* 120 ms.

In the idle condition the gain in both speech channels is so low that no singing can occur.

If a signal enters channel A, the gain is increased in that channel as shown in fig. 2. The time t_1 is the turn-on time. It should be short in order that no syllable shall be lost at the beginning of a word. In the DIRIVOX it is around 8 ms. The time t_2 is the turn-off time which, in the DIRIVOX, is around 150 ms. It should be long enough to preclude any variation in gain in the middle of a word owing to pauses between syllables. The turn-off time should also be so long that the speaker does not hear the echo of his own voice.

Fig. 3 shows what happens if a signal enters channel B at the same moment as the signal ceases in channel A. The time t_3 is the switch-over time. In the DIRIVOX it is about 20 ms, so considerably less than the total turn-off and turn-on time, which permits rapid and natural reversal of the direction of speech without loss of syllables at the beginning of words.

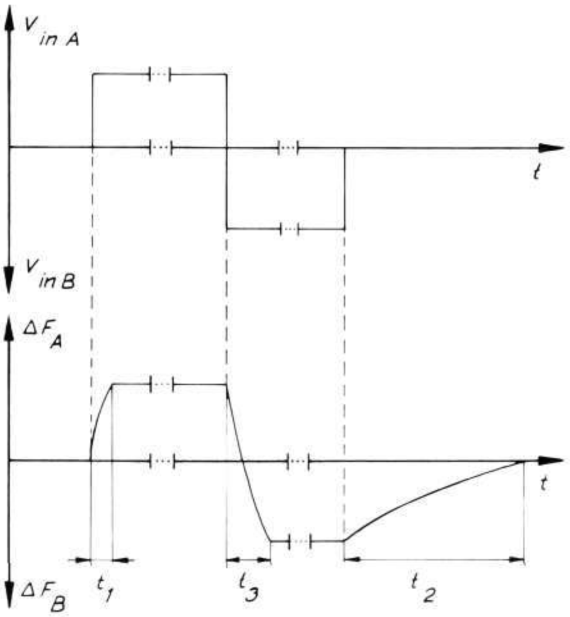

Fig. 3
Changes of gain in channels A and B (ΔF_A and ΔF_B) as a result of two consecutive signals on the two channels, as function of time

t_3 Switch-over time

The switching times are dependent on the sound level and increase with decreasing level. The turn-off and switch-over times are affected by the coupling between loudspeaker and microphone. This can be individually adjusted to the room acoustics and reverberation time by means of a potentiometer built into the extension set.

Frequency Range and Sound Level

The DIRIVOX amplifier has a very sharp low-frequency roll-off. This is aided by the microphone, which has a steeply falling sensitivity below 400–450 Hz. The room echo, which may cause speech to sound as if it came out of a barrel, is thereby avoided. Room echo increases heavily at frequencies below 400 Hz.

The upper cut-off frequency is 5000 Hz. This is not a critical value; a higher cut-off frequency does not appreciably add to intelligibility. By avoiding frequencies above 5000 Hz, however, one avoids interference from fans and the like.

A DIRIVOX circuit transmits the frequency band 400–5000 Hz, which provides very good intelligibility of speech.

The intelligibility for a given frequency range is favourably influenced by an increase of sound level. The DIRIVOX system therefore utilizes a slightly elevated sound level. The channel gain is 80–85 dB, which gives an acoustic gain of 10 dB. The maximum power is 3 W, which ensures satisfactory dynamics.

Insignificant Noise Sensitivity

The variable gain amplifiers *B1* and *B2* (fig. 1) are frequency-corrected. This ensures that the entire system is very little sensitive to room noise, which as a rule lies in the lower frequency range.

The switching of the channels is influenced by the wave fronts caused by speech and is therefore insensitive to continuous noise, even if at a higher level than the speech.

DIRIVOX — Flexible Loudspeaking Communication System with Many Traffic Facilities

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The DIRIVOX systems are built up around exchanges of different types and capacities. This article deals with the exchanges ARD 631 for max. 20 lines and AKD 847 for max. 60 or 90 lines. The same extension instrument is used with both types of exchange. Since the large exchange operates at a higher microphone level, the extension instruments for this exchange are supplied with built-in microphone amplifier. The latter is in the form of a printed circuit card which is easily fitted into the instrument.

Traffic Facilities

The traffic facilities of the two exchanges are listed in the table on page 14.

Common Name Call

Speedy connection with frequently called extensions can be obtained by means of "name calls", by pressing one of ten call buttons. A further ten extensions can be called in this way by pressing first a preselection bar followed by one of the ten individual buttons.

Individual Name Call

Large exchanges can be equipped with relay sets which allow a larger number of name-call groups. This is an advantage in organizations in which there are groups among the staff who work in close cooperation. Each extension has the choice of two combinations of 10 names out of 32 possible in a 90-line exchange.

Digit Calls

Digit calls are used in large exchanges for calling extensions outside the caller's name-call groups. A digit-call preselection bar is pressed, dial tone is returned and the caller keys a two-digit number (10–99). Experience shows that, thanks to the individual name-call groups, only 10 % of all calls need usually be made as digit calls.

Number of Simultaneous Conversations

The number of possible simultaneous conversations depends on the number of connecting circuits. Loudspeaking conversations take a very much shorter time than other kinds of telephone calls. A limited number of connecting circuits, therefore, suffices for a large volume of traffic. If all connecting circuits are engaged, this is marked by the lighting of the red lamp on all unengaged extensions.

Priority with Camp-on-busy Feature

When a priority extension calls an engaged number, busy tone is returned. Momentary depression of the talk-listen button sends a tone signal to the conversing parties. This signal indicates that someone wishes to communicate with one of them. As soon as they have cleared the line, a new connection is established automatically between the priority extension and the called party.

Priority for any given extension is arranged through strapping in the exchange.

Secretary Transfer

Incoming calls can be transferred to another extension, e.g. a secretary, by operating a switch on the extension instrument. The transfer takes place irrespective of whether the call is made as name call or digit call.

If desired, calls to several extensions can be transferred to a single number, e.g. when several persons have the same secretary.

The operation of the transfer switch does not prevent the use of the extension for outgoing calls.

By-passing of Transfer

The extension to which calls are transferred can by-pass the transfer connection, i.e. a secretary can communicate with her boss even if his extension is switched to her line.

Paging

The system can be used for audible, visual or radio paging. A paging call can be made from any extension. The audible signal is sent to selected free extensions without disturbance of engaged extensions. Separate loudspeakers or a separate public address system can be connected if desired. In large exchanges the extensions can be divided into groups to which paging calls can be made in any desired combination.

Tie Lines

DIRIVOX exchanges can be interconnected by means of tie lines. This requires a special unit (*FUR-X*) in one of the exchanges. In the other exchange the tie line terminates on an ordinary extension line. In this way an extension of the exchange which is equipped with *FUR-X* can make calls direct to any of the extensions in the other exchange. No connecting circuit is used in the exchange from which the call is made.

If two lines are used, they may be connected to the same exchange or to two exchanges.

If a two-way circuit is desired, both exchanges must be equipped with *FUR-X*.

Exchange *AKD 847* can be expanded in stages since the components are connected by plug and jack. Each switching unit serves a group of 30 lines. The connecting circuit units, register for digit calls, and name call groups can be installed according to requirements.

Facility	Exchange ARD 631 max. 20 lines	Exchange AKD 847 max. 60 lines	max. 90 lines
Common name calls	For all 20 extensions	For extension nos 10—29	
Individual name calls		8 individual combinations of 10 names each for each 30-line group plus 8 individual groups per exchange	
Digit calls	—	10—69	10—99
Connecting circuits	2	Max. 4*	Max. 5*
Priority	Optional number of extensions	Max. 28 extensions	Max. 42 extensions
Secretary transfer	Standard for 1 extension; extra for additional extensions	Standard for 6 extensions	Standard for 9 extensions
By-passing of transfer		Standard	
Paging (extra relay set)	To all or selected unengaged extensions	To any of 9 selected groups of extensions	
Tie line (extra relay set)	Max. 1	Max. 2**	Max. 2**

* Need not be initially installed to full capacity but can be added as desired.

** Max. 1 if exchange equipped for paging.

Privacy and Tones

The various DIRIVOX exchanges have the same system for privacy and tone signalling.

Privacy

A call is announced by repeated tone signals. The called party takes the call by briefly depressing an answer button. The yellow lamp remains alight during the conversation as a reminder that the microphone is connected. A connection is cleared by briefly depressing the release button.

A simpler method of taking a call is to set the privacy switch on the extension instrument for direct through-connection. A call is then announced by a distinct tone, after which it is put through automatically. The yellow lamp remains alight during the conversation. The connection is cleared by the caller without any action on the part of the called party.

Through these privacy measures an extension user is completely safeguarded against eavesdropping.

Tones

The DIRIVOX exchange is equipped with a generator which delivers the call and busy tones. The generator is fully transistorized and has a volume

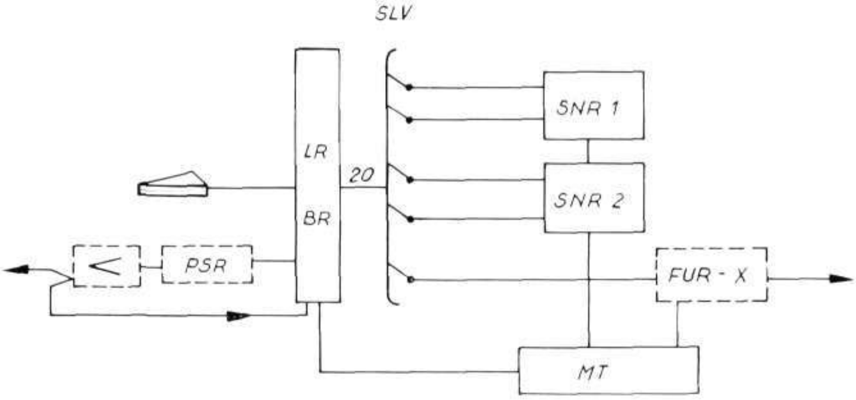


Fig. 1
Trunking diagram for ARD 631

LR	Line relay
BR	Cut-off relay
SLV	Crossbar switch
SNR	Connecting circuit
MT	Marker
FUR-X	Tie line equipment
PSR	Paging relay set

control for adjustment of the signal volume. The frequency of the signals is about 600 Hz. The character of the busy tone is 0.4 second on, 0.4 second off. The calling tone is sent at intervals of 1 second on, 1 second off.

Operation of Exchanges

Exchange ARD 631

This exchange is designed for 20 extensions. Its trunking diagram is shown in fig. 1.

The switching unit is a 6-horizontal crossbar switch with 5 verticals, four of which are used for switching between extension lines and the connecting circuits. The fifth vertical is used for tie lines to other exchanges.

In the following the calling side will be referred to as the *A*-side and the receiving side as the *B*-side.

When an extension makes a call, its line relay (*LR*) operates to identify the *A*-extension and the marker (*MT*) is seized. The line relay connects the extension's line to the marker, which immediately analyses the keyed code. The marker hunts for a free connecting circuit (*SNR*) and connects the *A*-side of the connecting circuit via the crossbar switch to the *A*-extension's line. The cut-off relay (*BR*) then operates and the line relay releases.

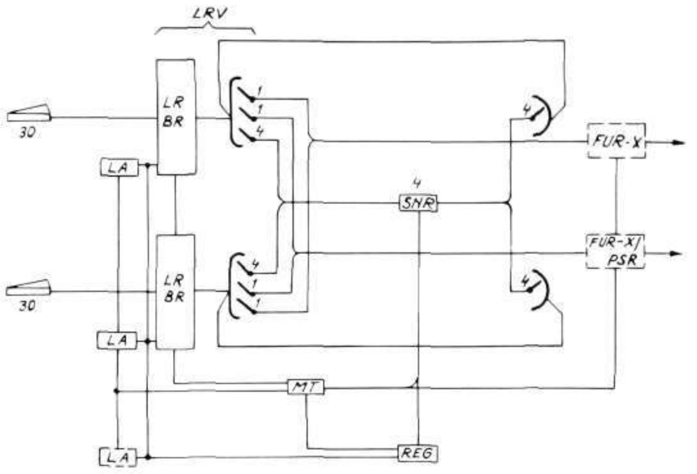
The code information stored in the marker causes the *B*-extension's line relay to operate. The *B*-extension has now been identified and the marker can connect the *B*-side of the switch to the *B*-extension's line. The marker then tests to see whether the *B*-extension is free. If so, the connection is set up. If the *B*-extension is engaged, the connecting circuit unit returns busy tone to the *A*-extension. In both cases the marker releases immediately thereafter.

If a priority extension calls an engaged number, the connecting circuit unit returns busy tone. If the *A*-extension then presses his talk-listen button, the connecting circuit unit induces a discreet tone signal via the crossbar switch on the connection.

The *A*-extension can now wait on the camp-on-busy circuit: a test relay in the connecting circuit unit senses when the *B*-extension becomes free and then puts through the new call.

Fig. 2
Trunking diagram for AKD 847, 60 lines

LRV	Code switch unit
LR	Line relay
BR	Cut-off relay
LA	Relay set for name-call groups
SNR	Connecting circuit
MT	Marker
REG	Register
FUR-X	Tie line equipment
PSR	Paging relay set



Exchange AKD 847

This exchange can be supplied for maximum capacities of 60 and 90 extensions divided into groups of 30. The trunking diagrams for the two exchanges are shown in fig. 2 and 3.

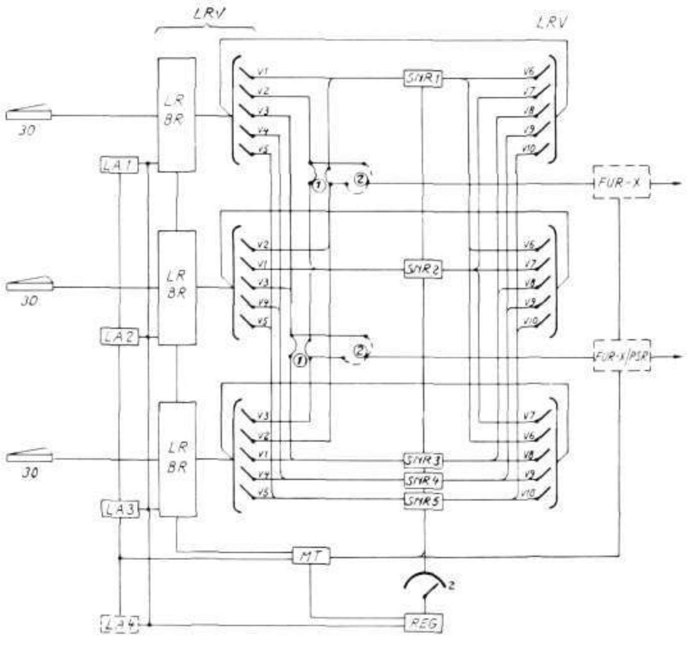
Each 30-line group has a complete switching unit (*LRV*) containing line and cut-off relays (*LR*, *BR*) and code switch with ten verticals (*V1–V10*). Every vertical has 30 multipled outlets.

A connecting circuit (*SNR*) normally has access to two code switch verticals in each 30-line group, one on the *A*- and one on the *B*-side. Five connecting circuits therefore utilize all 30 verticals in the three code switches in order to be accessible to all extensions on the *A*-side and to reach all extensions on the *B*-side.

When a 90-line exchange has a tie line (*FUR-X*) or paging (*PSR*) unit, two code switch verticals in each 30-line group are used for this purpose. They are obtained by grading the verticals of the first three connecting circuits on the *A*-side. The first connecting circuit thus becomes accessible to extensions in the first 30-line group, the second connecting circuit to the second, and the third to the third group. The two remaining connecting circuits are accessible

Fig. 3
Trunking diagram for AKD 847, 90 lines

LRV	Code switch unit
LR	Line relay
BR	Cut-off relay
LA	Relay set for name-call groups
SNR	Connecting circuit
MT	Marker
REG	Register
FUR-X	Tie line equipment
PSR	Paging relay set
①	Strap, to be removed if FUR-X or PSR installed
②	Strap, to be inserted if FUR-X or PSR installed



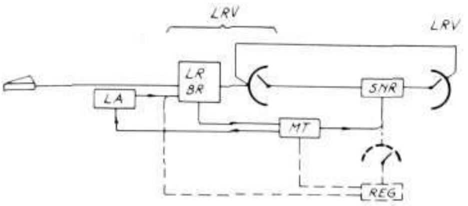


Fig. 4
Simplified trunking diagram for AKD 847, name calls

LRV	Code switch unit
LR	Line relay
BR	Cut-off relay
LA	Relay set for name-call groups
SNR	Connecting circuit
MT	Marker
REG	Register

to all groups. Since the marker (*MT*) is in this case arranged so that the fourth and fifth connecting circuits are allotted a call only when the connecting circuit of the caller's 30-line group is engaged, this grading does not materially affect the traffic capacity of the exchange.

There are two ways of making calls, i.e. name calls or digit (register) calls.

Name calls do not make use of the register (*REG*). The operation of the exchange will be seen from the simplified diagram in fig. 4.

When the button of the wanted extension is pressed, the line relay (*LR*) operates to identify the *A*-extension and the marker (*MT*) is seized. At the same time the relays for the two name-call groups allocated to the *A*-extension operate in the respective *LA* unit. The line relay connects the extension line to the marker, which immediately analyses the keyed code. The information is transmitted to the relay sets for the name-call group in 1 out of 20 possible codes.

The marker selects a free connecting circuit and connects the *A*-side of the code switch to the *A*-extension. The cut-off relay (*BR*) then operates and the line relay releases.

The code information stored in the marker and the *LA* unit, together with the information from one of the two operated group relays in the name-call unit (*LA*), now controls the operation of the wanted *B*-extension's line relay. The *B*-extension is thereby identified and the marker can cause the associated vertical on the *B*-side to operate. The marker ascertains whether the *B*-extension is free and, if so, the connection is completed. If the *B*-extension is engaged, the connecting circuit unit returns busy tone to the *A*-extension. In both cases the marker releases immediately after the busy test.

A register call does not engage any relay set for name-call groups (*LA*). Fig. 5 shows a simplified diagram of the method of operation of the exchange on register calls.

When the *A*-extension makes a register call, he presses the digit-call preselection bar, whereupon line relay and marker operate as described above. In this case the marker does not receive a name-call code but selects a free register (*REG*) and free connecting circuit. The *A*-side of the code switch is connected to the extension line and the register sends dial tone to the extension via the connecting circuit. The marker releases.

The *A*-extension now presses the two buttons representing the *B*-extension's number. When the register has received two digits, it calls and seizes the marker. The register now actuates the line relay of the called extension, whereupon the marker operates the code switch and tests whether the *B*-extension is engaged, in the same way as before. Register and marker then release.

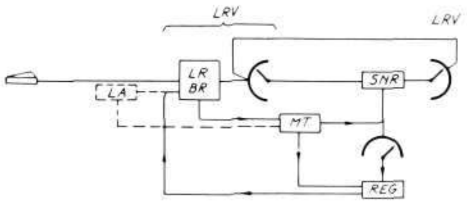


Fig. 5
Simplified trunking for AKD 847, digit calls

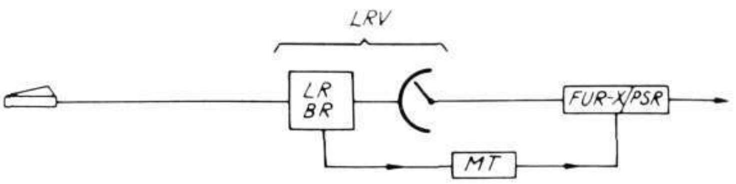
LRV	Code switch unit
LR	Line relay
BR	Cut-off relay
LA	Relay set for name-call groups
SNR	Connecting circuit
MT	Marker
REG	Register

Priority calls are made in the same way as described above, whether name calls or register calls. When the *A*-extension's line relay operates, a class-of-service indication is sent from the line relay via the marker to the connecting circuit. A relay in the connecting circuit stores this information until the busy test has been completed. If the *B*-extension is engaged, the connecting circuit unit returns busy tone.

If the *A*-extension presses the talk-listen button, the connecting circuit unit sends a discreet tone via the line relay to the called party's line. The *A*-extension can now remain on the line. A relay in the connecting circuit unit senses when the called *B*-extension becomes free and then immediately sets up the connection.

Fig. 6
Simplified trunking diagram for AKD 847, call to special service equipment

LRV	Code switch unit
LR	Line relay
BR	Cut-off relay
MT	Marker
FUR-X	Tie line equipment
PSR	Paging relay set



Tie line (*FUR-X*) and paging (*PSR*) calls are initiated as name calls, but no *LA* relay set, connecting circuit or register is used. The trunking diagram is shown in fig. 6.

On depression of the appropriate button for a tie line or paging call, the line relay operates and the marker is seized. The marker analyses the code and selects a tie line or paging unit. If free, the unit's vertical which has access to the called extension is switched to the line. The marker releases and the connection is put through.

A call on a tie line to another exchange seizes an extension line in the latter. The call is thereafter completed in the same way as a call within the calling exchange.

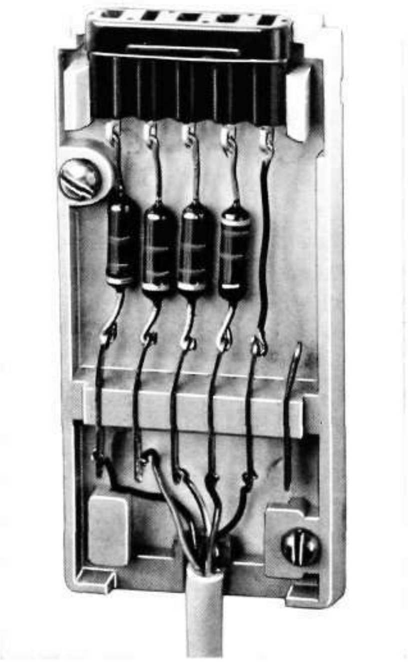


Fig. 7
Wall terminal with compensation resistor

Installation

Every extension is connected to the exchange on 4 wires. Extensions with secretary transfer facility require an extra conductor. Ordinary unscreened, plastic-insulated telephone cable with twisted pairs can be used. The line resistance may be up to 170 Ω, i.e. 85 Ω per conductor. With 0.5 mm copper wire, therefore, the maximal length of line is 1000 m and with 0.7 mm copper wire 2000 m.

The extension set is connected through a flexible plastic cable and 5-point plug to a wall terminal.

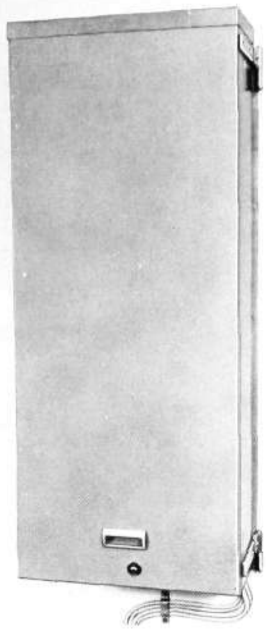
A compensation resistor to compensate the line resistance is soldered into the wall terminal (fig. 7), the compensation thereby being fixed to the line and not to the instrument.

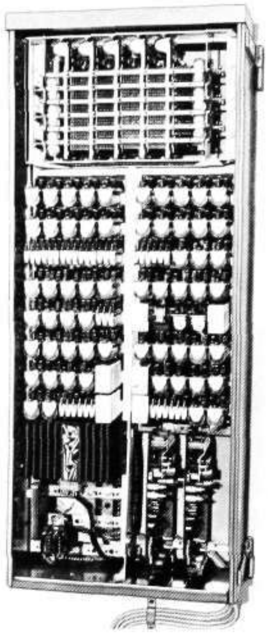
The incoming lines terminate on screw terminal blocks in the exchange.

The larger exchanges (*AKD 847*) have an M.D.F., which on its line side has terminals for 110 lines (fig. 8). By alteration of the jumpering on the M.D.F. an extension user can be moved from one room to another without changing his number or name-call facility. The allocation of special facilities is done in the larger exchanges by means of single-wire straps in the switches and relay sets for name calls.

Fig. 8
M.D.F. for name-call jumpering, AKD 847

Fig. 9
Exchange ARD 631 with and without front panel





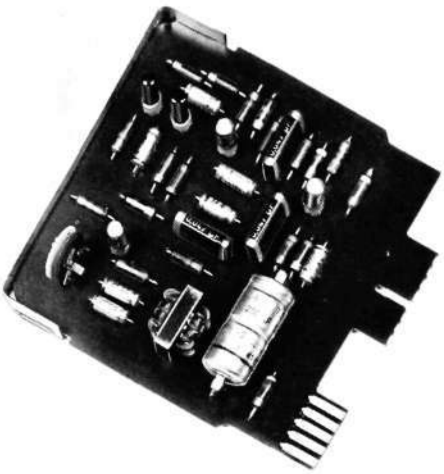


Fig. 10
Tone generator for ARD 631

Design of Exchanges

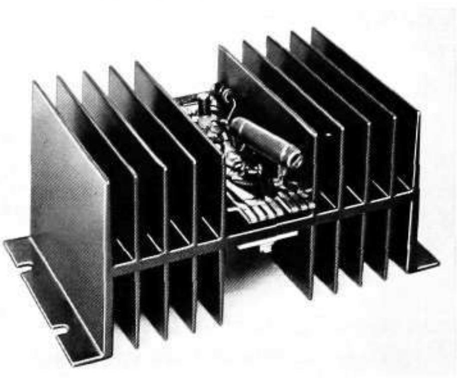
ARD 631 for 20 extensions is enclosed in a wall cabinet (fig. 9). For purposes of installation and maintenance the entire exchange can be swung out so as to provide access to all components both at front and rear.

The electronic equipment consists of tone generator, voltage stabilizer and two connecting circuit amplifiers with speech control circuits (fig. 10, 11 and 12). The connecting circuit amplifiers and tone generator connect to the exchange cabling by plug and jack.

The switching equipment consists of crossbar switches and ordinary telephone relays.

A metal cover protects the exchange against dust and mechanical damage. The cover and bottom frame are enamelled light grey.

Fig. 11
Voltage stabilizer



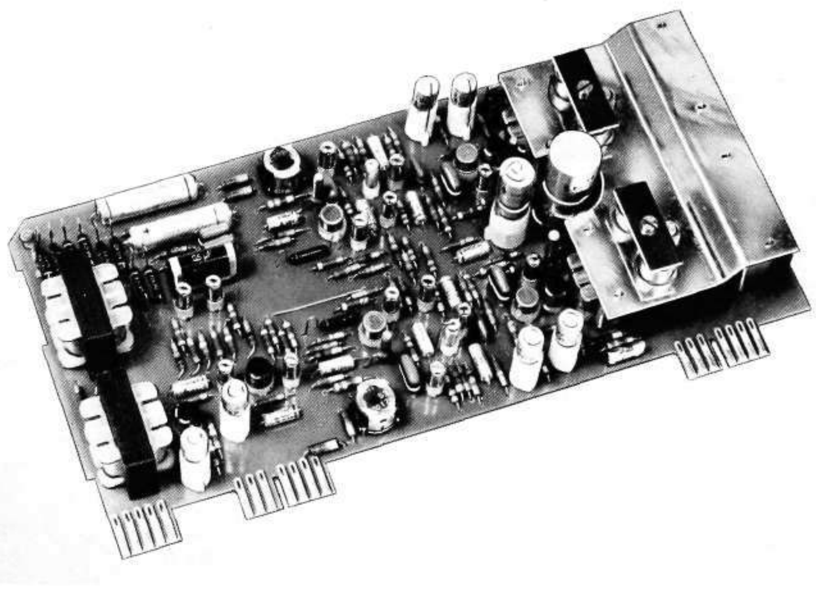


Fig. 12
Connecting circuit amplifier

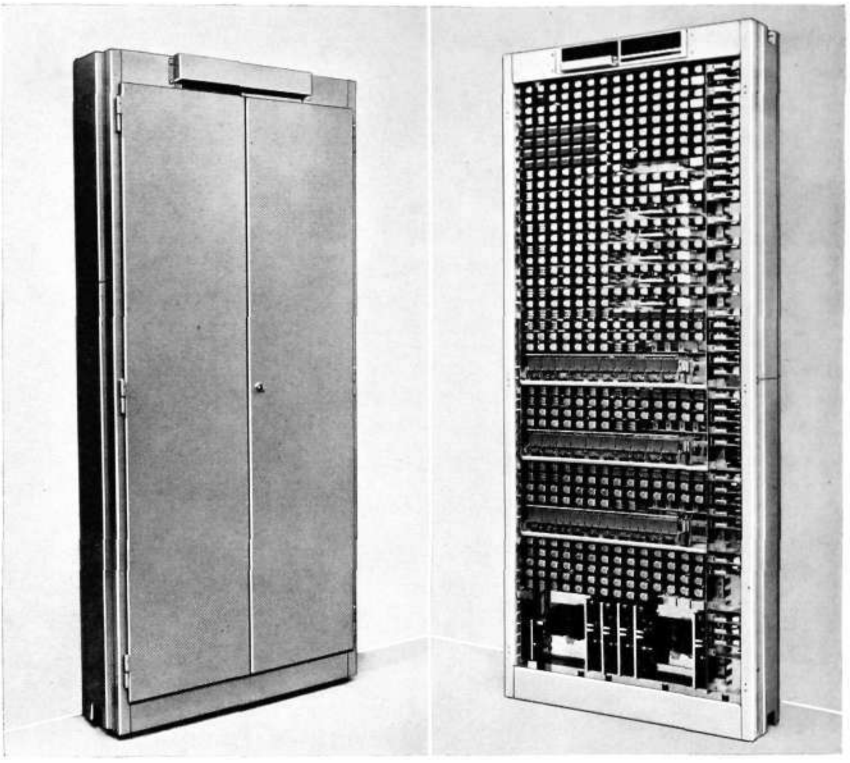


Fig. 13
Exchange AKD 847
(Right) with doors removed

Exchange *AKD 847* is supplied in two sizes, for 60 and 90 lines (fig. 13). The racks are supplied ready cabled for maximum capacity. The switching equipments connect by plug and jack. Installation can thus be completed quickly and testing is very simple. The plug-and-jack arrangement also implies that the exchanges can be easily modified and extended without interruption of service.

Each switch and relay set in the exchange has its individual dust cover.

If the exchange is set up in an office or in a room used for other purposes, it can be supplied with a lockable door. It then has the appearance of a sheet-metal filing cabinet. The doors also provide extra dust protection.

Racks, relay covers etc. are antirust-treated and grey-enamelled. They can therefore be used also in tropical climates.

The electronic equipment is made up roughly of the same units as in the 20-line exchange (fig. 11 and 12). The difference is that the tone generator in *AKD 847* has its own power amplifier (fig. 14).

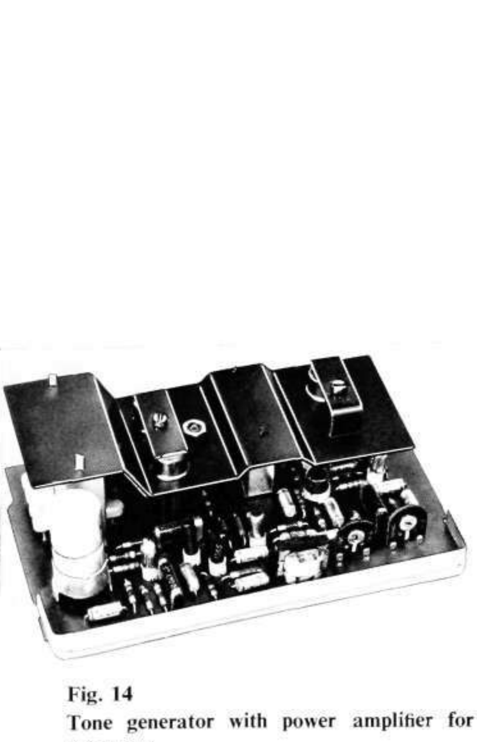


Fig. 14
Tone generator with power amplifier for AKD 847

The relay equipments, on the other hand, are of entirely different type. *AKD 847* is register-controlled. The switching stage consists of code switches operating on the bypath principle.

The dimensions of the exchanges are tabulated below:

Exchange type	Height	Width	Depth
	mm	mm	mm
ARD 631	1000	425	220
AKD 847, 60 lines	1940	1025	250
AKD 847, 90 lines	2400	1025	250

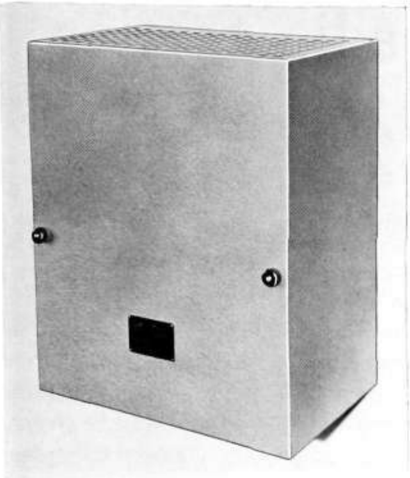


Fig. 15
Battery eliminator

Power Supply

The exchanges are supplied from the commercial network via battery eliminators, *BMN 2430* for the 20-line exchange and *BMN 2431* for the larger exchanges. Both units have the same dimensions: height 360, width 280 and depth 200 mm (fig. 15).

The battery eliminators have tappings for 100 to 240 V (in steps of 10 V), 50–60 Hz. The exchange equipment will tolerate mains voltage variations of up to ± 10 %.

The output voltages are:

	BMN 2430	*BMN 2431*
for relays and switches	48 V DC 3 A	48 V DC 5 A
for electronic equipment	20 V DC 2 A	20 V DC 4.2 A
for pushbutton-dialling	42 V AC 0.5 A	42 V AC 1 A

SRA-TRANSPORT—Mobile Radio Station

H. NORRBY, SVENSKA RADIOAKTIEBOLAGET, STOCKHOLM

UDC 621.396.721
LME 8525

Svenska Radio AB (SRA) has manufactured radio stations for mobile use and their associated stationary equipments for more than 20 years. In this field—as in all other electronics applications—developments in the last few years have been extremely rapid, due to a large extent to the transistor. Transistors have enabled the power consumption of radio stations to be greatly reduced. The increased radio traffic has rendered certain accessory apparatus necessary in some cases. With its Series 300, SRA has sought to meet the demands made by modern developments. The stations in this series have been given the name SRA-TRANSPORT.

SRA-TRANSPORT is used for directing vehicles of different kinds—police, fire brigade, hauliers' and road maintenance vehicles, etc. This type of station is made for a maximum of six radio channels in three frequency bands, 30—41, 70—87.5 and 100—108 MHz, and in all three cases in two models, one for 25 and one for 50 kHz channel spacing. Owing to the serious shortage of frequencies the Swedish Board of Telecommunications has ruled that, after a transitional period, radio traffic of this kind on the aforementioned frequency bands may be effected only with apparatus for the smaller channel spacing, and specifications have been issued for such equipments. SRA-TRANSPORT naturally fulfils the specifications, and the 80 MHz model for 25 kHz channel spacing has been put through type tests by the Radio Division of the Board of Telecommunications. It has also been type-tested according to the standards of the Swedish Army for shock stability (50 g acceleration).

The designations of the three models in the aforementioned frequency ranges and of narrow-band type are *CN-301*, *CN-302* and *CN-303*. In the broad-band type the letter *N* (narrow band) is replaced by *B* (broad band).

The normal method of operation is simplex, i.e. two communicating stations must transmit alternately. A duplex model (simultaneous transmission) is also available. This is designated by a *D*, e.g. *CN-302 D*. The station can be transferred from one vehicle to another with different battery voltages—6, 12 or 24 V—without any circuit modification.

A complete standard radio station consists of

- main unit containing transmitter, receiver and DC converter
- control unit with built-in loudspeaker
- microphone or handset with holder
- aerial for roof- or side-mounting
- fuse box and standby relay, cables and terminals

An entire system of accessories has been developed for SRA-TRANSPORT, providing for widely varying requirements and permitting the station to be used in the most efficient possible manner. The station can, for instance, be supplied with an automatic *channel changer* for simultaneous watch on two radio channels, a *squelch relay unit* and a *tone transmitter* and *tone receiver*

Fig. 1
Main unit

for selective calling. It can also be used as fixed station if equipped with a *mains power unit*. For the latter case there are two systems of operation, one for extended local control via a multiwire cable and one for remote control over a distance up to ten kilometres on a two-wire telephone line. The local control station is designated *F/CN(B)-300* and the remote-control station *F/CN(B)-300 R*, *F* signifying "fixed" and *R* "remote control".

For remote control a panel containing line relays is placed in the mains power unit. This *line terminal panel* can also contain a *voice-operated T/R switching unit* which permits connection of the station for simplex operation as well to the telephone network.

The control unit for the mains-connected stations is used also for SRA's larger radio stations, types *F-40* and *F-100*.

Main Unit

The main unit (fig. 1 and 2) consists of two sections. One comprises the transmitter driver and output stages ; these contain the only two valves in the station. The other section contains the transistorized units. The two sections are joined into a unit separated by a thermally insulating air gap. The life of the transistors and other components is thereby increased. The transistorized section is in turn divided into four subunits: transmitter modulator and low-power stages, receiver RF and oscillator stages, receiver IF and AF stages, and the DC converter. The latter has effective aluminium heat sinks in which the transistors are mounted. The three former subunits are mounted on printed circuit cards in low frames. The latter are secured by captive screws on bars running along the inner sides of the main frame and can be easily removed for inspection. The main unit is mounted on a baseplate screwed to the vehicle and fixed to it by two snap-on catches.

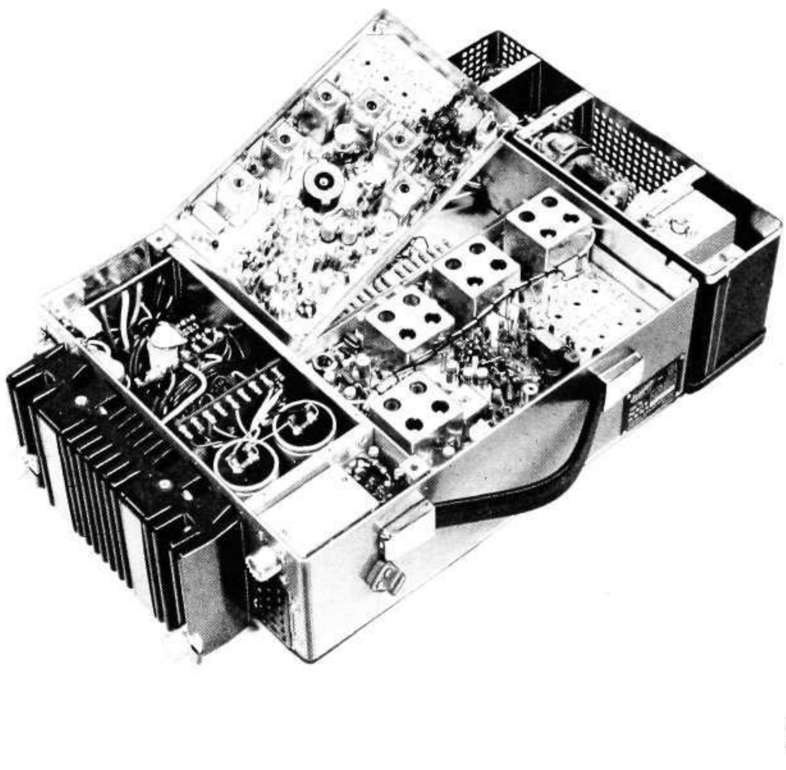


Fig. 2
Main unit with cover removed. (From left) DC converter, modulator and low-power stages of transmitter (raised), RF amplifier and first oscillator of receiver. (Far right) Transmitter power unit with driver and output stage

The operation of the transmitter and receiver will be seen in broad outline from the block schematics in fig. 3 and 4.

Transmitter

On the printed circuit card carrying the modulator and low-power stages there is first the oscillator. This is switchable between six crystals. Switching is done with diodes instead of relays, which for this purpose are rather unreliable. The voltage from the oscillator is amplified in one stage and then taken to the phase modulator, which is of diode type. As appears from the block schematic, in the narrow-band case only one modulator is used and in the broad-band case two modulators in cascade. After the modulation there follow a number of frequency- and deviation-multiplier stages. The crystal frequency is multiplied only twelve times, which means that spurious radiation from the transmitter is kept to a very low level.

The circuit card delivers 10—15 mW at the transmitter frequency and this power is taken to the power amplifier.

The AF amplifier of the transmitter includes a speech clipper for prevention of overmodulation and a low-pass filter which cuts-off speech frequencies above 3000 Hz.

Receiver

The receiver is a fully transistorized double superheterodyne. Its RF unit contains two stages with six tuned circuits, the crystal-controlled first oscillator with doubler stage and the first mixer. Switching of the crystals is done as in the transmitter with diodes. The subsequent IF unit comprises, first, four circuits tuned to 8.8 MHz. This first intermediate frequency and the signal from the second oscillator are taken to the second mixer, which is followed by 5+5 circuits with an intermediate amplifier stage. These circuits are tuned to the second intermediate frequency of 455 kHz. Thereafter follow a number of limiter stages and the discriminator which, via an emitter-follower, feeds the AF unit. This contains two amplifier stages and a push-pull output stage which delivers about 2 W at 1000 Hz and max. frequency deviation.

The AF unit also contains a squelch circuit. It consists of two amplifier stages and a noise detector, the output voltage from which controls a keying stage which cuts off the AF amplifier in the absence of a carrier signal.

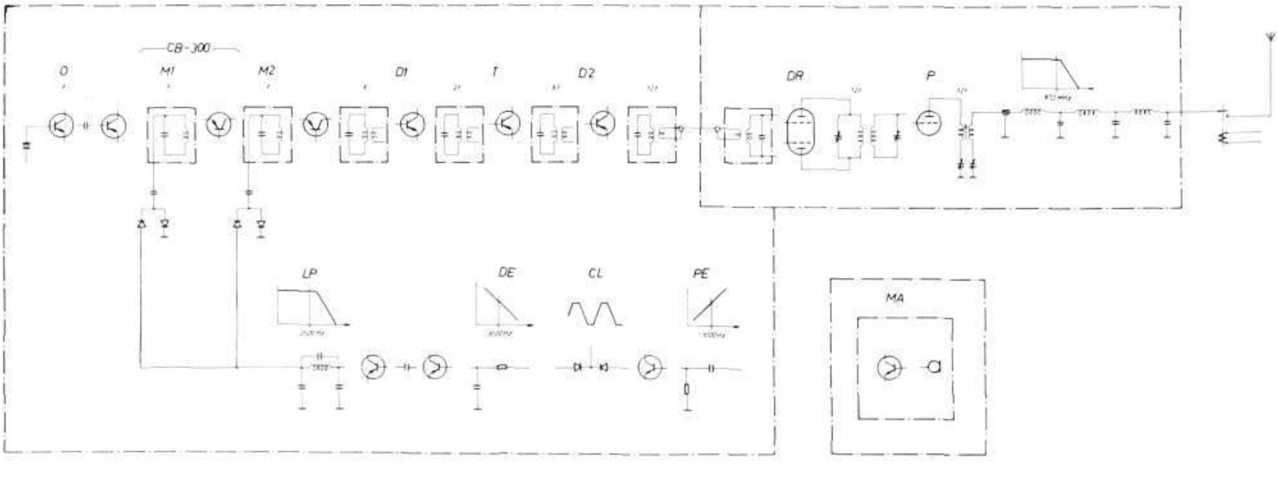


Fig. 3
Block schematic of transmitter

O	Oscillator
M1, M2	Modulators
D1, D2	Doubler stages
T	Tripler stage
DR	Driver stage
P	Output stage
PE	Pre-emphasis network
DE	De-emphasis network
CL	Speech-clipper
LP	Low-pass filter
MA	Microphone with built-in amplifier

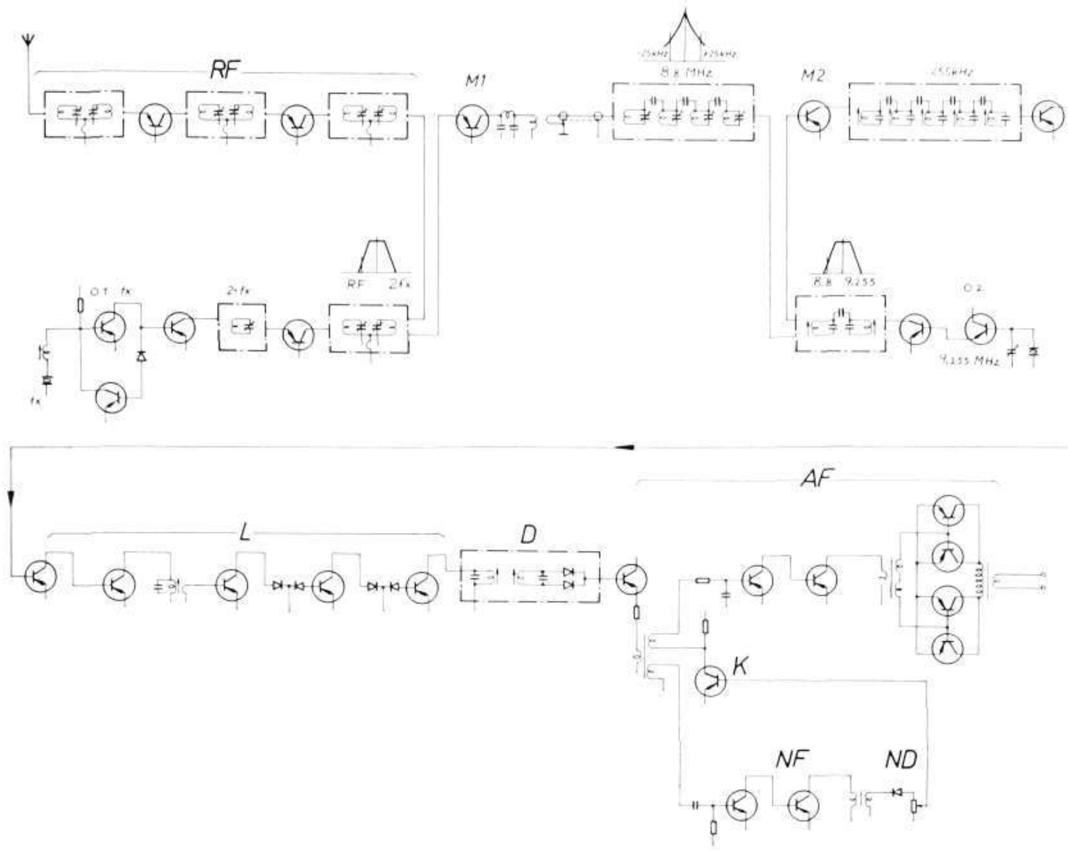


Fig. 4
Block schematic of receiver

RF	RF amplifer
M1, M2	First and second mixers
O1, O2	First and second oscillators
L	Limiter
D	Discriminator
AF	AF amplifier
NF	Noise amplifier
ND	Noise detector
K	Keying stage

DC Converter

The converter contains two push-pull oscillators with the windings on a common transformer core. The oscillators are thereby very rigidly coupled to one another, the output voltage being in phase. The connections for 6 V and 12 V differ in the number of turns in the collector circuits and in the difference of bias point (the change being made in the battery plug). At 24 V battery voltage the two oscillators work from a DC point of view in series but from an AC point of view in parallel. The oscillator frequency is 3000—5000 Hz depending on the load. At this high frequency the transformer core could be made small despite the relatively large power output. In this case the core consists of a ferrite toroid. The AC voltage arising in the primary winding of the transformer is transformed to the desired values on the secondary side, rectified and smoothed. The DC converter delivers the following voltages:

- + 450 V and + 225 V to the transmitter output stage,
- – 18 V, stabilized, to the transmitter modulator and low-power stages and to the receiver,
- – 15 V to the receiver output stage and
- 6.3 V to the filaments of the transmitter valves. This voltage is obtained from a separate winding of the transformer.

The relays station are fed from – 15 V and from the rectifier prior to the – 18 V stabilizer.

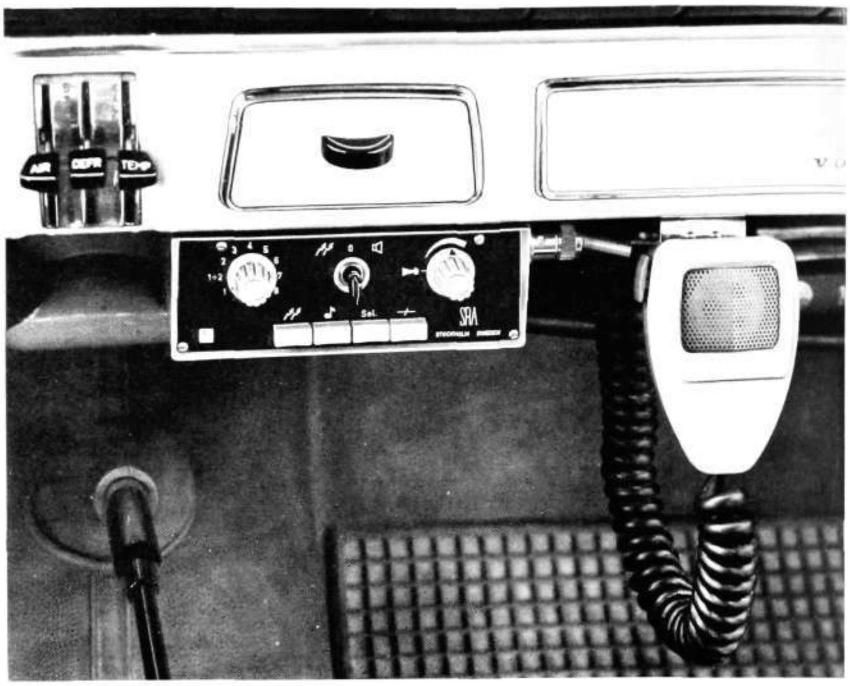


Fig. 5
Control unit with microphone mounted in passenger car

Control Unit

The control unit (fig. 5) is built in a frame of grey impact-resistant plastic with top and bottom sections of sheet steel pressings. The loudspeaker is mounted on one of them. Top and bottom can be interchanged, so that the loudspeaker can be directed in the most favourable manner according to the position of the control unit.

The control unit has space for a tone transmitter and tone receiver for selective calling (see below). The front panel carries the following controls:

- Main switch. This has three positions. In the centre position, marked 0, the station is shut-down; in the right hand position, marked ◁, only the receiver is in operation. This position is used when an especially low current consumption is important, e.g. when no charge goes to the battery. In the third position, marked //, heater voltage is supplied to the transmitter valves, i.e. standby operation of transmitter.
- Channel selector
- Stepwise volume control
- Switch on right: squelch "on" and "off"
- Switch on left: setting of tone code
- Green lamp, indicates station "on"
- Red lamp, indicates that a selective call has been received
- Row of keys with following functions:

  // = sending key

  ♪ = tone transmission

  Sel. = connection of tone receiver for selective call

  —/— = restoring after selective call

As already mentioned, the station can be supplied either with a microphone (fig. 5) or a handset, in both cases with dynamic microphone inset and built-in transistor amplifier. The transmitter is operated with the microphone key.

Accessories

Automatic Channel Changer

As switching of the crystals is done purely electronically with diodes, automatic watching on two channels simultaneously is possible. The switching is achieved through the fact that an astable multivibrator earths the leads to the crystal-switching diodes in the receiver alternately and so shifts between two channels. When a carrier signal arrives on one of the channels, the multivibrator is locked in the position corresponding to that channel. This takes place through the fact that the voltage from the squelch circuit, which in the presence of a carrier signal deblocks the low-frequency amplifier, controls the multivibrator as well.

The automatic channel changer is made up on a small printed wiring unit mounted on the RF and oscillator card of the receiver. If the station has an automatic channel changer, therefore, it can only be equipped with crystals for four channels.

The channel selector on the control unit must be set to position 1+2 for simultaneous watch on two channels. When the call is to be answered, however, i.e. for operation of the transmitter, the channel selector must always be set to the desired position.

Squelch Relay Unit

The squelch circuit of the receiver opens and blocks the AF unit electronically in the presence and absence, respectively, of a carrier signal. Often, however, it is desirable to extend the function of the squelch circuit to provide at the same time a contact closure, e.g. for starting an alarm device, lighting of lamps etc. The squelch relay unit provides precisely this extended function and, like the channel changer, is controlled by the detected voltage from the noise amplifier.

The unit contains three transistors and one relay and is placed in the main frame near the socket for the control cable.

Mains Power Unit

This is carried on a base of pressed sheet steel similar to the bottom section of the main unit and, apart from its height, has the same dimensions as the transistorized part of the main unit.

The unit delivers −24 V DC, which is fed to the station via the battery plug, connected for 24 V. The DC converter thus operates when the station is connected to the mains. This has the practical advantage that, without special arrangements, any vehicle station whatsoever can be used as stationary equipment, an important point from the servicing point of view. The power unit contains a mains transformer, rectifier, choke and smoothing capacitor. The choke is of "swinging choke" type to maintain the output voltage as far as possible constant despite the large difference between sending and receiving current output.

Control Unit and Operation of Mains-Connected Station

Extended local control takes place, in the same way as when the station is installed in a vehicle, on a multiwire cable (max. 75 m), but the control unit is of different design. It naturally has the same facilities, but in this case is equipped entirely with push-buttons instead of knobs.

The control unit is enclosed in a plastic casing of console type. The tone transmitter and tone receiver can be built into the control unit. Fig. 6 shows the model with rows of buttons for sending of tone code (see Selective Calling page 30). The other buttons have the following functions:

ON = switching-on of control unit

◁ = volume control (two buttons)

SEL = connection of selective call receiver

1+2 = simultaneous watch on two channels

f_1—f_4 = channels 1—4

↗ = transmission

⊣ = restore after selective call

Yellow lamp indicating that the control unit is switched on

Red lamp indicating receipt of a selective call

The control unit has a built-in dynamic microphone and a microphone amplifier. For checking of uniform modulation when speaking, a level instrument of the same type as used in most tape recorders is fitted on the panel between the two lamps.

In some cases, however, for example in noisy premises, it may be inadvisable to use the built-in microphone. In such case an Ericofon can be connected to the control unit. The Ericofon has a dynamic microphone and a sending key and its bottom terminal is used in such a way that, when the Ericofon is raised, the built-in microphone is disconnected.

The *remote control unit* is of exactly the same appearance and has the same controls as the local control unit but contains, in addition, a line transformer and a line amplifier both for microphone and loudspeaker; also a rectifier unit which supplies the various amplifiers and relays. The control unit is connected to the mains via a transformer which delivers 2×17 V AC to the rectifier. The transformer is placed in a ventilated casing for wall mounting.

Fig. 6
Control unit for mains-connected station

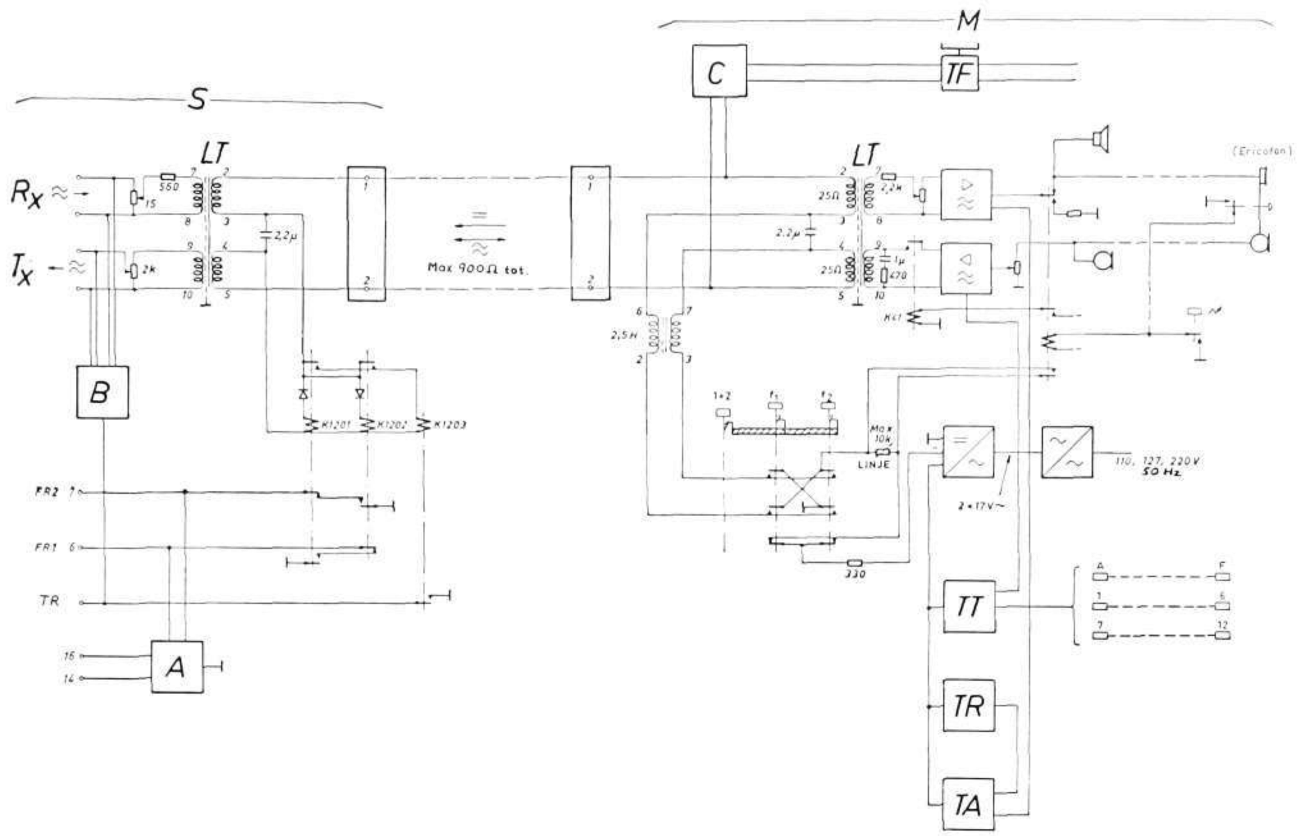


Fig. 7
The remote control system. *S* indicates the apparatus at the station position and *M* at the control position

LT	Line transformer
K1201-K1203	Control relays
$1+2, f_1, f_2$	Channel keys
↗	Transmission key
A	Automatic channel selector
B	Voice-operated T/R switching unit
C	Line terminal box
TF	Intermediate telephone set
TT	Tone transmitter
TR	Tone receiver
TA	Tone amplifier
R_x	Receiver output
T_x	Transmitter output

The part of the remote control equipment belonging to the station position, the *line terminal panel*, is, as already mentioned, placed in the mains power unit. The panel contains three telephone relays, two of which connect the desired radio channel and the third controls the transmitter ; also a line transformer, level setting device, microphone socket and traffic switch. For remote control the latter must be set to "TRAFIK" position. In "TEL" position telephone communication is possible with the control unit via the line, which may be of value for servicing purposes. In the other two positions of the switch, *FR1* and *FR2*, the station is entirely controlled from the line terminal panel.

In the standard equipment the remote control system allows two radio channels. The principle is shown in fig. 7. When the remote control unit is switched on, DC is fed to the line via the potentiometer, *LINJE*, which is accessible on the underside of the control unit. The polarity depends on which of the buttons, f_1 or f_2, is pressed. The potentiometer must be set so that *K 1201* or *K 1202* (depending on the polarity) operates with some margin to spare. The setting will of course depend on the line resistance. *K 1201* connects channel 1 and *K 1202* channel 2. When the sending key is pressed, the potentiometer is short-circuited and the full line voltage, 36 V, is supplied. *K 1203* then operates and starts the transmitter.

If key 1+2 is pressed, no direct current flows on the line; for the station with automatic channel changer this means that simultaneous watch is obtained on channels 1 and 2. In this position transmission is prevented.

Zero level on the line, i.e. about 0.8 V AF, is set from the radio receiver at the station position and from the microphone amplifier on the control unit. The modulation of the transmitter and the volume of the loudspeaker will depend on the length of line and must be set accordingly.

Voice-operated T/R Switching Unit

The line terminal panel can be equipped with a unit for voice operation of the transmitter. This, as noted, is used especially when the radio station in simplex operation is to be connected to a telephone network. The voice-operated unit has two inputs. The speech voltages from the line enter one input and, after amplification and rectification, start the transmitter via a relay circuit. The other input is connected to the radio receiver output and, if speech power comes from the latter, the relay set becomes inoperative and the transmitter cannot be started. On the control side the line is connected to the telephone network via an intermediate telephone set and line terminal box.

Selective Calling

As the name indicates, selective calling implies that calls are picked up only by a specific station. The method is becoming increasingly common and is adopted for several reasons, in most cases to reduce the irritation sometimes felt when personnel have to listen to a number of calls and conversations which do not concern them. SRA's selective calling system works with audio frequencies in the speech band. The 18 frequencies are divided into two groups, six with the alphabetical notations *A—F* and 12 with digits *0—11*. Each tone code consists of two audio frequencies, an alphabetical frequency and a numerical frequency, and these are sent simultaneously. The method provides a great safeguard against false calls and allows a total of 72 combinations.

Apart from the controls referred to in conjunction with the control units, the apparatus consists of a two-tone transmitter and a two-tone receiver (fig. 8). These are transistorized and made up on printed circuit cards for placing in the control units, whether stationary or mobile.

A tone transmitter contains two *LC* oscillators, one for the alphabetical frequency and one for the numerical. The various audio frequencies are obtained from different tappings on the coil. The selection of tapping is done in the stationary control unit with keys *A—F* and *0—11*. The alphabetical keys release one another, while the numerical keys are non-locking. Code *B9*, for example, is sent by pressing first key *B*, which remains locked when the pressure is released, and then key *9*, whereupon a carrier signal modulated with tones *B* and *9* is transmitted as long as key *9* is held depressed.

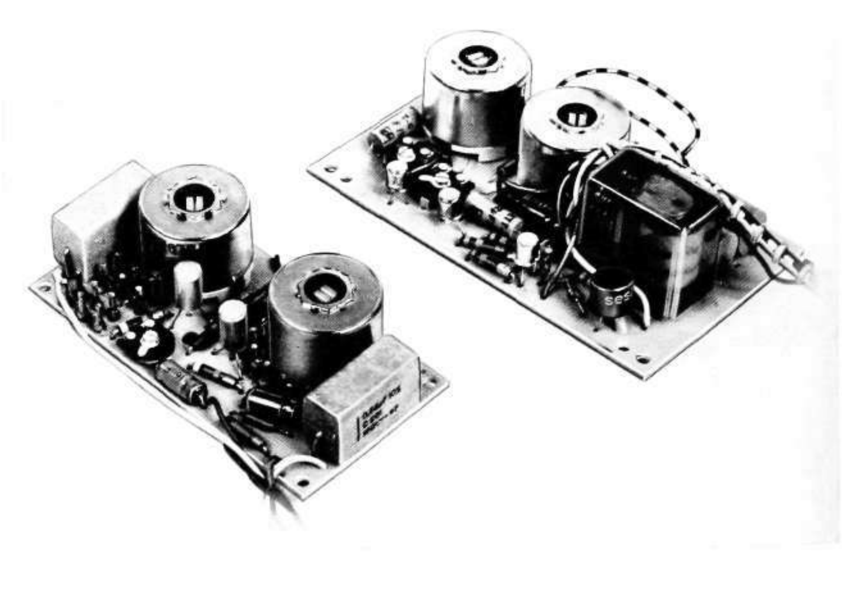


Fig. 8
Printed circuit card with tone transmitter (left) and tone receiver

In the vehicle control unit the alphabetical frequency is preset and can be changed only by resoldering. Thus in this case only a numerical frequency can be selected, i.e. one can have 12 combinations. The digit is selected with the switch on the left and is visible in the small square window at the bottom left of the panel. The carrier signal and the desired tone code are sent with the key marked ♪.

The tone receiver contains two series tuned-circuits in parallel, and the desired combination of tones is obtained by connecting the tuning capacitors to certain terminals on the coils. The audio frequencies from the two circuits are rectified and control their respective transistors. These transistors are in series and, only when there is a control current on both, do they actuate a relay via a thyristor. If key SEL on the control unit is depressed, the loudspeaker is bypassed. It is connected by the relay in the tone receiver only after reception of the correct combination of tones. This is indicated also by the lighting of the red lamp. At the end of conversation the restore key —/— is pressed, whereupon the lamp goes out and the loudspeaker is disconnected again.

The mobile control unit has a position on the volume control marked with the symbol ⌐⇒ . This implies that an external alarm device such as a hooter can be connected. Alarm is issued as long as the numerical key on the sending control unit is kept depressed.

Technical Data

The data below relate to the 80 MHz model. The same data, however, apply to the 40 and 100 MHz models with the exception of the maximum frequency spacing between channels, which in the 40 MHz band is 400 kHz and in the 100 MHz band 600 kHz. The output on the 100 MHz band, moreover, is maximized in Sweden to 3 W, but the Board of Telecommunications often allows 15 W.

Type of station	CN-302, CB-302
Frequency range	70—87.5 MHz
Number of channels	1—6
Max. channel spacing	550 kHz
Min. channel spacing	25 kHz (50 kHz for CB-302)
Frequency stability (ambient temperature $-25°$ to $+45°$ C)	Better than $\pm 20 \times 10^{-6}$ ($\pm$ 0.002 %)
Modulation	FM (phase)
Transmitter	
Power output	25 W $\pm$ 1 dB*
Frequency multiplication	12 times
Max. deviation	$\pm$ 5 kHz ($\pm$ 15 kHz for CB-302) at the 1000 Hz modulating frequency
AF characteristic	300—2500 Hz rising by 6 dB per octave
Spurious radiation	-85 dB

* At 6.3 V battery voltage 20 W $\pm$1 dB.

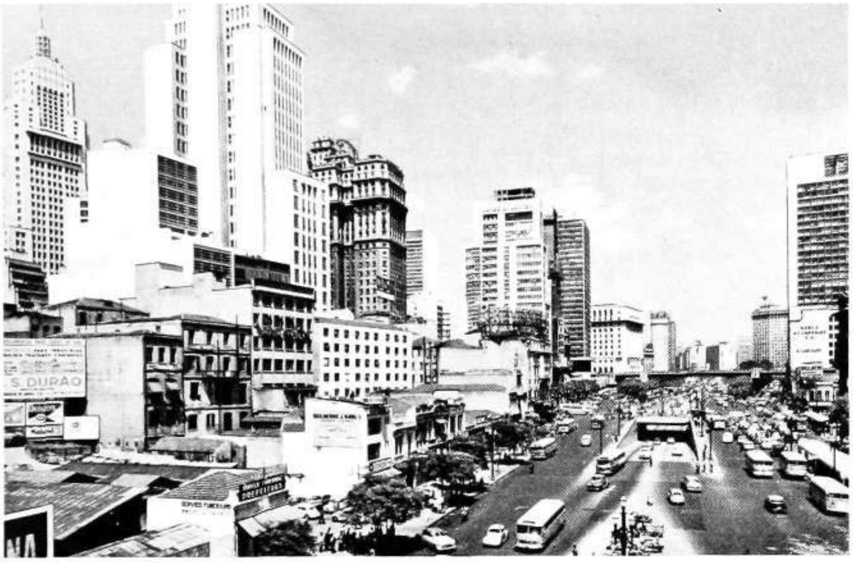
Receiver	
Sensitivity (measured by EIA method)	Better than 0.5 μV
Selectivity	
Two-signal	Better than 80 dB
Three-signal	Better than 70 dB
AF output ± 1 dB	2 W at ± 5 kHz (± 15 kHz for CB-302) deviation and 1000 Hz modulating frequency
AF characteristic	300—3000 Hz falling by 6 dB/octave
Sensitivity to spurious signals	− 80 dB
Transistors	
Transmitter	3-AC126, 2-AF118, 5-AF124, 1-QQE 03/12 (valve), 1-6146 (valve)
Receiver	4-AF102, 7-AF125, 7-AC126, 2-AF118, 2-AF124, 4-AC128
DC converter	4-2N277
Power supply	6, 12 or 24 V DC 110—240 V, 50 Hz with mains power unit

Power consumption	Receiving	Standby	Transmit
6.3 V DC	1.5 A	4.3 A	18.8 A
12.6 V DC	0.8 A	2.2 A	9.3 A
25.2 V DC	0.4 A	1.1 A	4.8 A
Mains connection 220 V	0.3 A	0.4 A	0.9 A

Dimensions and weights	Width	Height	Depth	Weight
	mm	mm	mm	mm
Main unit + base plate	250	100	400	10.7
Control unit with loudspeaker ..	170	60	179	1.3
Mains power unit	250	140	300	14.2

Ericsson NEWS *from All Quarters of the World*

Multimillion Order from Brazil



Anhangabau Avenue, São Paulo

L M Ericsson's Brazilian subsidiary, Ericsson do Brasil (EDB), has received a very large order for telephone equipment for the city of São Paulo. The contract was gained in hard competition with American, British and German manufacturers and exceeds 100 millon kronor in value.

The contract comprises 13 automatic telephone exchanges of crossbar type for altogether 85,500 lines. It was signed with Companhia Telefônica Brasileira, Brazil's largest telephone operating company, which has nearly one million subscribers in the most important industrial and commercial parts of the country.

The project covers the first stage in a plan for expansion of the São Paulo telephone network, where telephones are in very great demand. The bulk of the equipment will be manufactured at L M Ericsson's factory at São José dos Campos in Brazil.

L M Ericsson has been established in Brazil through subsidiaries since 1934 and has had a factory there since 1955. The factory was designed by the internationally known architect, Oscar Niemeyer, among whose other creations are the Presidential Palace and public buildings in the new capital, Brasilia. L M Ericsson has supplied and has on order from Brazil automatic exchanges and other telephone equipment for 380,000 lines in more than 300 localities from Belém on the Amazon in the north to Pelotas near the Uruguay frontier in the south.

São Paulo is one of the most rapidly growing cities in the world. It is the largest industrial centre in Latin America and, with its roughly 6 million inhabitants, is South America's largest city.

From the signing of the São Paulo contract. (Sitting from left) Sr. Geraldo Nóbrega, EDB, Mr. Ragnar Hellberg, EDB, Sr. Carlos Reis Filho, Companhia Telefônica Brasileira, and Sr. José Meiches, Secretary of Public Works in São Paulo.

Continued Automatization of Norwegian Railways

The first ARD 331 exchange was delivered at the end of last year to the Norwegian State Railways (NSB). It was installed at Oslo East and at the cut-over 1200 local lines from the earlier OS exchange and from a manual exchange used for Oslo West were transferred to the new exchange. The new exchange is connected to the public telephone network via 40 two-way exchange line circuits. Via trunk circuits it is also connected to NSB's exchanges at Trondheim, Bergen, Drammen and several other stations throughout Norway. The exchange has some 20 selective calling circuits and also a number of code ringing lines. There are five manual operators.

The installation was excellently carried out by L M Ericsson's Norwegian subsidiary, A/S Elektrisk Bureau.

Director General Håkan Sterky (left) receives a gift from Dr. Marcus Wallenberg, Chairman of the Board of L M Ericsson, and Mr. Sven T. Åberg, its former President.

Last autumn L M Ericsson was visited by Sr. Alberto Mamán, head of the Planning Department OPD (Oficina de Planificación y Desarrollo de Telecomunicaciones) of CANTV (Compañía Anónima Nacional de Teléfonos de Venezuela) in connection with an earlier contract for 29 ARM exchanges.

(Standing, from left) Messrs. R. Rinnan and G. Vikberg, LME, Sr. S. Grimaldi, CEV, Mr. T. Lindstedt, LME, Mr. van der Dys, CEV, and Mr. T. Andersson, LME, (Sitting) Srs. R. Diaz, J. Pagez, and A. Mamán, CANTV, Mr. A. Stein, LME, Mr. N. Kauser, CANTV, and Mr. G. Fernstedt, LME.

Retirement of Director General Håkan Sterky

On his retirement from the Director Generalship of the Swedish Telecommunications Administration at the end of last year, Mr. Håkan Sterky received many tokens of respect at a farewell ceremony arranged in his honour. Some thirty representatives from a number of companies and from the management and officials of the Board of Telecommunications were in attendance.

Dr. Marcus Wallenberg, Chairman of the Board of L M Ericsson, presented 25,000 kronor to the fund for scholarships granted to members of the staff of the Administration, which had been founded by Director General Sterky. From the Board of Telecommunications Mr. Sterky received, among other gifts, a transistor radio which is remarkable insofar as it can receive two programmes on the same wavelength. The Administration had published a book surveying the activities of the Administration during the last 25 years, a de luxe edition of which was presented to Mr. Sterky.

32 ARF Exchanges to El Salvador

In 1964 a contract was signed between L M Ericsson and Administración Nacional de Telecomunicaciones of El Salvador in Central America, representing the first stage in the reorganization of the country's telephone system. It comprised 26,000 lines, with ARF exchanges at the capital, San Salvador, and at Santa Ana and San Miguel, all of which are now under installation.

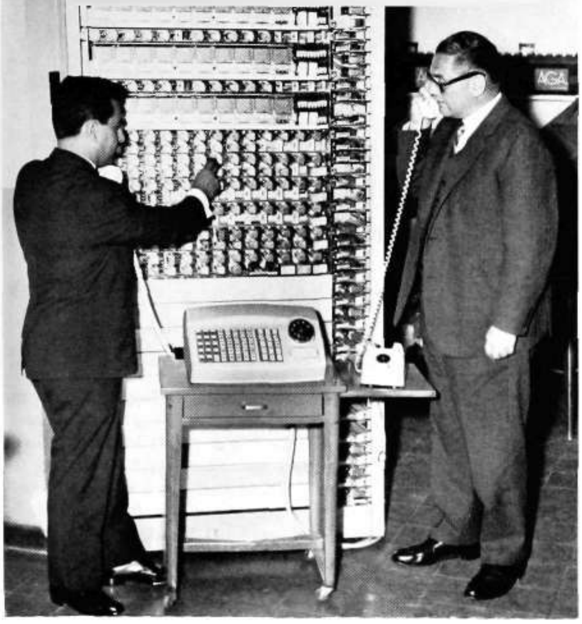
On December 10, 1965, a new contract was signed for the installation of a further 32 ARF exchanges totalling 7,600 lines in rural areas. Since these exchanges will be connected to the automatic trunk network on modern radio links, the contract also includes the delivery and enlargement of a number of ARM exchanges. El Salvador will then have an extremely modern telephone network. The contract is worth about $8^1/_2$ million kronor and is being financed by the World Bank.

New Credit Agreement with Ecuador

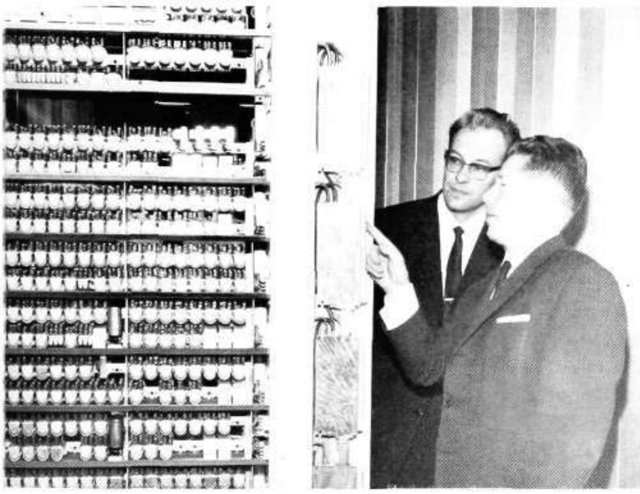
Through its subsidiary in Ecuador, L M Ericsson has signed two new credit agreements with the Telephone Administrations of Quito and Guayaquil. The contracts amount to 10 million dollars and cover the total requirements of telephone equipment of the administrations up to 1974. The credit agreements extend those signed in 1962, which totalled 6.8 million dollars.

The new credit agreements are guaranteed by the state of Ecuador and will form part of the 10-year financing plan for Ecuador. This plan was drawn up in cooperation with the Interamerican Development Bank, and comprises some forty projects, among which the construction of the telephone systems at Quito and Guayaquil.

From the signing of the El Salvador contract. (From left) Dr. Margarito Gonzales Guerrero, Head of the State Telephone Administration, Col. Mario Guerrero, Mr. Ragnar Ling, L M Ericsson, and Dr. Alvaro Gonzales Lara.



L M Ericsson's new P.A.B.X. type AKD 741, based on the code switch, has now been introduced in Colombia, the first installation being at the main offices of the Royal Bank of Canada at Bogotá. The picture above shows the President of the Bank, Mr. Winston Kendall Moyle, and (left) the Technical Director of L M Ericsson's subsidiary company in Colombia, Sr. Alvaro Cifuentes, who recently held a special course at Lima, Peru, on this type of P.A.B.X. for Ericsson technicians in South America.



Finland's first code switch exchange was opened at the end of last year when the Tampere Telephone Administration put into operation 2000 of the contracted initial capacity of 4000 lines. This exchange, of system AKF 10, is an extension of the Tampere local exchange and is housed in a separate bunker. In his opening address the chairman of the board, Bank Director T. Hietala, emphasized the excellent commercial relations with L M Ericsson extending back to the twenties. The Managing Director of the Tampere Administration, K.V. Onnela, spoke of the rapid subscriber growth, which in the last nine months had amounted to 7 per cent. Mr. Onnela (right) is seen discussing a detail with his chief engineer, Mr. Rainer Letho.

During a recent trip to Venezuela Mr. Björn Lundvall, President of L M Ericsson, was received in audience by the Venezuelan President, Raúl Leoni. (From left) Mr. Nils Kjellander, President of Compañia Anónima Ericsson, Caracas, Mr. Lundvall and President Leoni.

November 10, 1965, was the tenth anniversary of the inauguration of the Ericsson do Brasil (EDB) factory at São José dos Campos. To celebrate the occasion a number of prominent visitors had been invited to view the plant. Among the 40 or so persons who arrived direct from Rio in a plane chartered by EDB were General Dirceu Coutinho, head of Emprêsa Brasileira de Telecomunicações (EMBRATEL), and Captain Euclides Quandt de Oliveira, head of Conselho Nacional de Telecomunicações (CONTEL). Also General Elysio Dale Coutinho from the Communications Department of the Ministry of Defence and several representatives of Companhia Telefônica Brasileira (CTB) of Rio and São Paulo, headed by its director, General Landry Salles. The EDB Works Manager, Mr. Robert Brunn, demonstrated the firm's products and mentioned that the present production capacity is 80,000 telephones and 60,000 crossbar lines per annum.

In the picture above from the tour of the factory are seen, in the centre, the Director of CTB, General Landry Salles, the chairman of EDB, Marshal Nelson de Mello, and Captain Euclides Quandt de Oliveira.

Several papers were read by Ericsson engineers at the Second International Telecommunication Congress at Madrid in November in 1965. An exhibition had been arranged in conjunction with the congress and was visited by the Minister of Industry, Sr. López Bravo (photograph above, right). He is seen greeting Dr. Christian Jacobæus, Technical Director of L M Ericsson. Between them (from right) General Rafael Mª Cavanillas Prósper, chairman of Cía Española Ericsson, and Mr. Sven Oscar Englund, president of the same company. (Below) An interior from L M Ericsson's section of the exhibition.

(Above) Some photographs from visits to the exhibition room and factory at Midsommarkransen. (From left to right) Mr. Kwee Swan Tie, Research and Planning Director of the Indonesian PTT, is studying a crossbar switch demonstrated by Mr. Ernst Bergholm, L M Ericsson. Visitors from Madagascar are shown old and new telephones; (from left) M. Henri Rasolondraibe, Commercial Attaché at the Embassy in London, M.Eugène Lechat, Minister of Communications, his Permanent Secretary, M. Jean Ralaivas, M. Georg Ramparany, Commercial Counsellora t the Paris Embassy, and Mr. Erik Lundqvist, L M Ericsson. A group from the UN course on Trade Promotion were shown round the factory. Here they are seen inspecting the soldering of relay sets.

The flagship of the Nigerian Navy, the frigate N.N.S. Nigeria, was delivered a few months ago from a yard in Holland. This 2000-ton frigate, which is designed for use against submarines and air attack, has a P.A.B.X. for 40 internal and 5 external lines. The telephone equipment was supplied from L M Ericsson's factory at Rijen, Holland.

Ericsson Technics

Ericsson Technics No. 2, 1965, was issued at the year end, so completing the 21st annual volume of the journal. No. 1, 1965, was reported in Ericsson Review No. 1, 1965. No. 2 contains three papers.

The first is "Planning of Junction Network in a Multi-exchange Area. II. Extensions of the Principles and Applications" by Y. Rapp. This is a continuation of the paper published in No. 2, 1964, on the general plan for a multi-exchange area. This new paper develops the principle of simultaneous optimization of the number of junctions and of the transmission plan.

The second paper, by A. Törby, is entitled "Detectability of Signal in Noise when Using Range Gated MTI Radar". The author studies two alternatives for a coherent NTI system with range gating. In one system the signal-to-noise ratio in a range channel is determined principally by the limitation of bandwidth prior to the non-linear detection. In the other system the signal-to-noise ratio in a range channel is dependent on the frequency of the doppler shift.

The last paper, "A Class of Stochastic Processes Applicable to the Control of Service Quality in Telephone Systems" is the thesis presented by G. Lind for the Filosofie Licentiat Degree in mathematical statistics at the University of Stockholm. The auther builds up a mathematical model in the form of a class of stochastic control processes designed to describe how technical faults arise, are supervised and repaired in telephone systems. The paper is intended to provide a basis for assessing how the statistical quality control of telephone plant should be organized.

FATME's new factory at Rome was opened recently, the ceremony being attended by a large group of representatives of government and industry. The opening address was held by Sr. Marchesi. Sr. Baggiani presented a brief retrospect and mentioned that the total floor area of the factory is close on 700,000 sq.ft., which allows space for some 3000 employees. The Minister of Industry, Sr. Lami Starnuti, and the Mayor of Rome, Sr. Petrucci, also spoke. Cardinal Dante blessed the factory in the customary manner, after which the visitors were shown round the premises. In the photograph below are seen in the front row (from right) Monsignor Pietro Galavotti, Mr. Arvid Olsson, Mr. Björn Lundvall, General Bucchi, Senator Latini, Senator Pennavaria, General Perrone and Cardinal Dante.

UDC 621.395.24
LME 8372

BERGQUIST, Å.: *DIRIVOX—L M Ericsson's Loudspeaking Communication System with Natural Speech Control.* Ericsson Rev. *43*(1966): 1, pp. 2—7.

Advanced electronics for automatic speech control, numerous standard traffic facilities and individual name calls are some of the advantages offered by L M Ericsson's new DIRIVOX loudspeaking communication system.

DIRIVOX is the outcome of an intense development project aimed at a flexible loudspeaking system with at least as good voice reproduction as in a lowspeaking system, but much more convenient to use. The goal has been to offer loudspeaking communication of so high a class that it constitutes a real alternative to natural conversation.

UDC 621.395.24
LME 8372

MELLQVIST, L.: *Natural Speech Control in the DIRIVOX System.* Ericsson Rev. *43*(1966): 1, pp. 8—11.

If a loudspeaking telephone conversation is to be equivalent to a natural conversation, the voice control must be so well designed that the conversing parties normally do not notice the switching of the direction of speech. No effort should be needed to interrupt the speaker, and the system must not distort the spoken word. It is important, too, that the voice control is as insensitive as possible to room acoustics and to noise from fans, typewriters and the like.

After intense development work Telefonaktiebolaget L M Ericsson has produced the advanced electronic equipment required for *natural speech control*. This article deals with the speech control circuits and with some of the ideas which lie behind them.

UDC 621.395.24
LME 8372

KÜHN, W.: *DIRIVOX—Flexible Loudspeaking Communication System with Many Traffic Facilities.* Ericsson Rev. *43*(1966): 1, pp. 12—21.

The DIRIVOX systems are built up around exchanges of different types and capacities. This article deals with the exchanges ARD 631 for max. 20 lines and AKD 847 for max. 60 or 90 lines. The same extension instrument is used with both types of exchange. Since the large exchange operates at a higher microphone level, the extension instruments for this exchange are supplied with built-in microphone amplifier. The latter is in the form of a printed circuit card which is easily fitted into the instrument.

UDC 621.396.721
LME 8525

NORRBY, H.: *SRA-TRANSPORT—Mobile Radio Station.* Ericsson Rev. *43*(1966): 1, pp. 22—32.

Svenska Radio AB (SRA) has manufactured radio stations for mobile use and their associated stationary equipments for more than 20 years. In this field—as in all other electronics applications—developments in the last few years have been extremely rapid, due to a large extent to the transistor. Transistors have enabled the power consumption of radio stations to be greatly reduced. The increased radio traffic has rendered certain accessory apparatus necessary in some cases. With its Series 300, SRA has sought to meet the demands made by modern developments. The stations in this series have been given the name SRA-TRANSPORT.

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On cover: Reporting from input station for automatic data collection.

Automatic Data Collection in a Swedish Iron and Steel Works

OLLE LANTZ, STOCKHOLM

UDC 669.1.013.5
681.3
LME 872

L M Ericsson has designed an automatic data collection system HDC 800. The system is based on components of the very highest reliability, which have been thoroughly tested in telephony.

In the past two years an installation has been in use within a Swedish iron and steel works comprising data collection for steel plant – cogging mill, i. e. for the production of steel billets and slabs. The system includes a special signalling plant for direction of the flow of materials through pit furnaces.

The data collection system comprises the collection of primary data from furnace units in the steel plant, casting and stripper positions, ingot stock, pit furnace shop and cogging mill with two cooling beds (Fig. 1).

The direct planning of the production within this section is done by a foreman at a central position at the pit furnaces. The foreman's job is to obtain optimal production in the cogging mill. This is conditional on the best possible use being made of the available pit furnaces for the material supplied from the steelworks.

From centralographs the planning foreman receives a flow chart of the process in the steel plant. Times and results of casting and stripping of ingots are recorded. The centralograms constitute the planning foreman's instrument

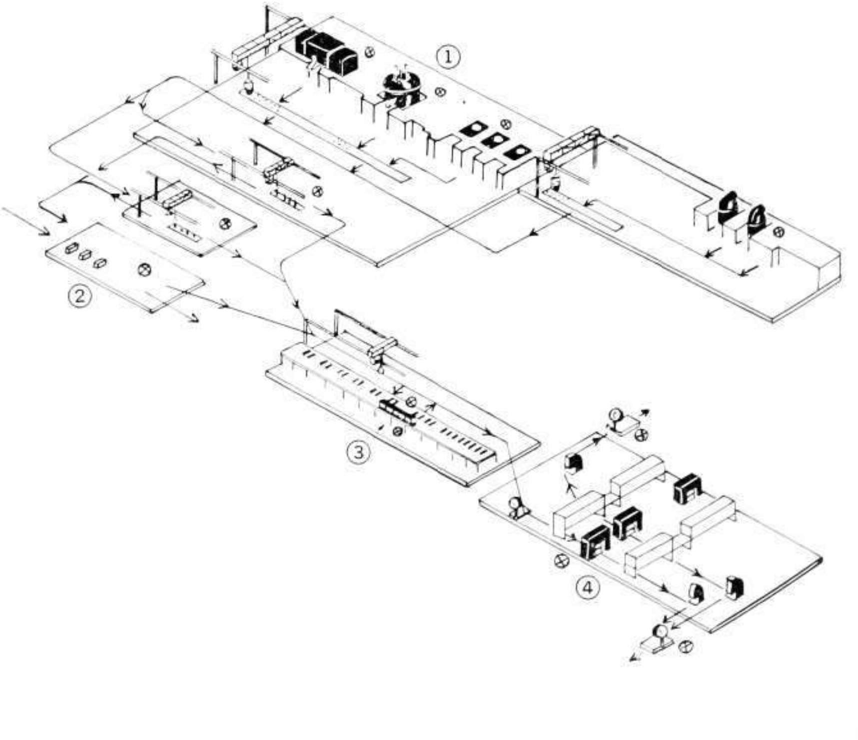


Fig. 1
Flow chart
① Steel plant
② Ingot stock
③ Pit furnace shop
④ Cogging mill
⊗ Input stations

for directing the flow of materials. A simultaneous check of the flow eliminates the risk of using the wrong material, a point of the very greatest importance in a high-grade steel works.

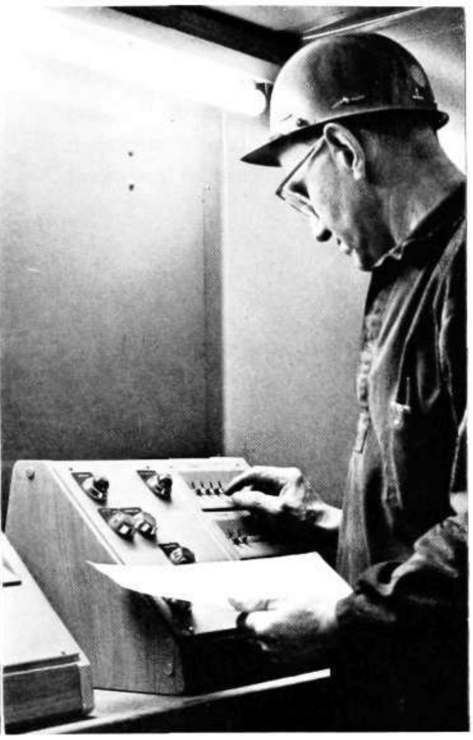


Fig. 2
Reporting point in steel plant

Within the pit furnace shop orders for lowering and withdrawal of ingots are given via the special signalling system. Signals are used to check the heating and soaking times, so guaranteeing correct treatment of the ingots. Confusion between materials in the pit furnaces is eliminated through the fact that a direct order is issued concerning each ingot. The signalling system is also connected to the data collection system.

From the cogging mill automatic reports are given of productive time, down-time and the result of rolling.

From the feed-in stations in the steel plant data are reported of the time when a charge starts, and of the result of casting and stripping in the form of number of ingots of each type. The times of each phase of production are recorded automatically, also on a Centralograph.

From the ingots stock, reports are given of the ingoing and outgoing quantity of material per charge, again in the form of number of ingots of each type.

When work is ordered in the pit furnace shop a report is automatically sent to the *HDC* system of how the ingots from a charge are distributed in the various pit furnaces, particulars of heating times, soaking times, hot-holding times and empty times of each pit furnace.

From the pit furnace control station, reports are given of how the ingots from the charge are allocated among different billet production orders. At the same feed station the time taken up by each production order in the cogging mill is reported, and which crew the report refers to. Data of productive time or down-time are controlled by machine contacts in the rolling mill.

During down-times in the cogging mill the controller indicates the cause, and in the event of rejects during rolling he also reports the quantity and cause.

Fig. 3
Control panel in pit furnace shop

The result of the billet production is reported in the form of number, type and total weight of billets per production order from the cooling beds.

The output device consists of a tape punch. Via punched cards the data processing centre produces the necessary data for checking that instructions have been followed, as well as a result report for following-up prognoses and projects.

The automatic data collection provides chiefly

- information concerning production, flow of materials, and production planning
- reports required between the steel plant, pit furnaces and rolling mill
- orders for jobs at pit furnaces and cogging mill with simultaneous collection of the desired information
- automatic collection of the necessary variable primary data.

An effective flow of information within the billet production sector should provide the management with rapid and reliable data for the making of decisions, and at a lower administrative cost than by conventional methods. The system should simplify the decision process and function in such a way that the departments concerned within the company are warned in advance of situations which require action.

Examples of information furnished for the production chain up to the rolled billets are:

- ☐ *Steel plant*
  Reports showing the result of production are presented for the various furnace units in the steel plant and provide information concerning times of handling and transport from the casting positions up to lowering into the pit furnaces.

- ☐ *Pit furnaces*
  Reports of down-times and repair times, and occupation times with breakdown by heating and soaking times specified per furnace and for the entire furnace capacity.

- ☐ *Rolling mill*
  Reports for the works management and planning departement are quickly compiled on a 24-hour basis. The production result is supplemented by data of operating and down-times and by output reports for each particular order per grade and charge.

- ☐ *Ingot stock*
  Reports on the present stock and its alterations are sent to the works management and planning departement.

- ☐ *Reports required* for the accounting of wages, materials and costs are distributed to the relevant departments within the company.

The goal in constructing the flow of information has been to obtain a better control over quality, quantity and costs. To reach this goal a production ordering and planning system was required, combined with automatic data collection. After a thorough investigation of the conditions a *HDC 800* system was installed.

Fig. 4
Reporting point in rolling mill

This system widens the bottleneck in a comparatively complicated production chain. The quality of the information obtained has been considerably raised through the automatic data collection.

Automatic data collection has reduced the personnel required for reporting work and has increased production. It has also provided an objective basis for planning and direction of the flow of materials and has resulted in a higher utilization of the pit furnaces.

A cautious estimate shows that with a mere 3 per cent rise of production the installation pays for itself in two years. The first year's experience reveals that the rise of production has been more than 3 per cent.

In addition to these directly calculable savings, a better basis is obtained for planning and a better grip on the control of quality, quantity and costs.

An Experimental 24-Channel System with Pulse Code Modulation

G EINARSSON, TELEFONAKTIEBOLAGET L M ERICSSON, STOCKHOLM

UDC 621.395.454
621.376.56
LME 8436

This article presents an account of an experimental transmission system with pulse code modulation developed at Telefonaktiebolaget L M Ericsson. The system has 24 speech channels and is mainly intended for unloaded cables with repeaters connected at the loading points.

The article describes the operation of the system and its electrical and mechanical structure. Technical data and some experience from a field test in cooperation with the Swedish Telecommunications Administration are presented.

Investigations of the possibility of transmitting several telegraph or telephone messages on the same pair of wires started as early as the mid-19th century. The discovery of the electron tube and the development of filter technique during the first decades of the 20th century permitted the design of frequency-division systems. In these systems the speech voltage is modulated on a carrier wave and every channel has its specific frequency position during the transmission. The carrier systems came into practical use on a large scale during the thirties and are today the basis of all long-distance telephony.

Another type of multiplex transmission is obtained if, instead of separating the channels in frequency, one employs time-division. These systems employ some form of pulse modulation, and pulse code modulation (PCM) is one of the many alternatives. The idea of using PCM for telephony was conceived at the end of the thirties, but only since the advent of modern semiconductor components has it been possible to design economically competitive systems. Today PCM is used as short-haul system in the United States, Japan and Italy, and a great interest is being shown in this type of system all over the world.

This article describes an experimental PCM system for 24 channels for use on unloaded pair cables. The system was designed in cooperation between L M Ericsson's Research and Long Distance Divisions.

Principles

The general principles of a time multiplex system with PCM are shown in fig. 1. The incoming speech voltages are sampled periodically and the sample

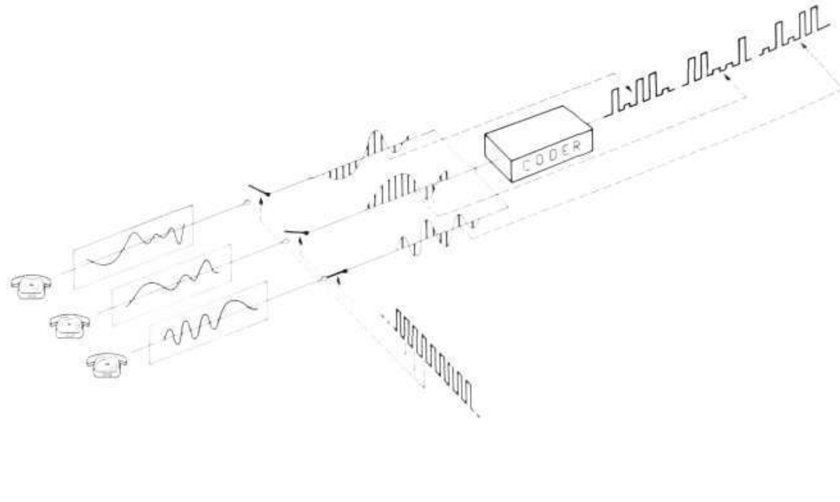


Fig. 1
Pulse code modulation

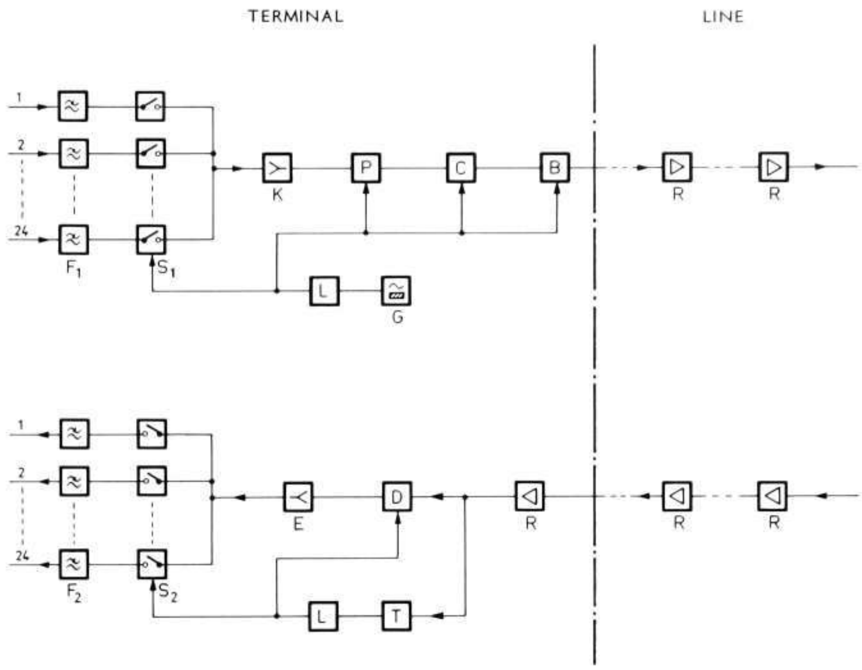


Fig. 2
Block schematic of 24-channel PCM system
F_1 Channel filter on sender side
S_1 Sampling gate
K Compressor
P Pulse stretcher
C Encoder
B Bipolar converter
G Clock pulse generator
L Logic circuits
R Repeater
T Clock pulse circuit
D Decoder
S_2 Distribution gates
F_2 Channel filter on receiver side

values are converted to binary form with the aid of an encoder which, for every sample value, delivers a group of on-off pulses. These groups of pulses are transmitted in serial form on the line, which usually contains repeaters. On the receiver side the procedure is reversed: groups of binary pulses are converted in a decoder to sample values from which the speech signal can then be reconstructed.

A more detailed picture of the procedure may be obtained by studying the simplified block diagram in fig. 2. On the sender side the signals first pass through a bandpass filter with the pass band 300–3400 Hz. After the sampling gates there follows an instantaneous compressor and thereafter a pulse stretcher and encoder. Compression and expansion of the signals improve the volume range of the system in a manner which will be described below. The pulse stretcher is necessary in order to give the encoder sufficient time to carry out the analogue-digital conversion, whereas the compressor requires short pulses in order to have time to be restored between them. Before the pulses from the encoder are sent on the line, the polarity of each alternate pulse is reversed, so obtaining a bipolar pulse train. This reduces the frequency range of the line signals and prevents the occurrence of a DC voltage component.

The sampling gates, encoder and other units must be extremely accurately synchronized in time. On the sender side, as appears from fig. 2, there is a crystal oscillator which controls a logic network, which in turn coordinates the various functions. The sampling frequency is 8000 Hz and the code used has 7 binary digits per sample. An eighth binary digit is needed for signalling and synchronization, which means that the frequency of the crystal oscillator is $24 \times 8000 \times (7 + 1) = 1536$ kHz. This is also the pulse frequency on the line.

The transmission on the line is effected via repeaters at the loading points, which implies a repeater spacing of 1400–1800 m. The repeaters detect and regenerate the bipolar pulse train along the line, and therefore the incoming pulse train on the receiver side has in principle exactly the same appearance as on the sender side.

As appears from fig. 2, the received pulse train first passes through a decoder which converts the groups of binary pulses into amplitude-modulated pulses. After an expander, which restores the amplitude relations, the pulses are

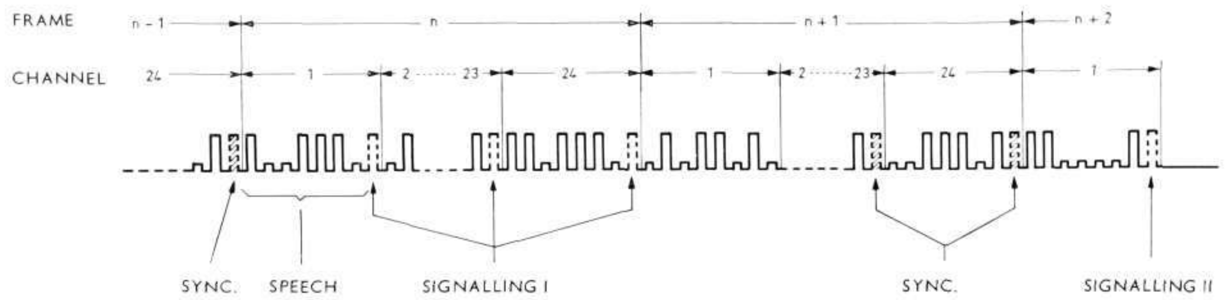


Fig. 3
Pulse train after encoder

divided among the various channels by means of distribution gates. The speech signals are obtained after passage through a bandpass filter of essentially the same type as on the sender side. For coordination of the various functions there is a clock pulse circuit which extracts from the incoming pulse train the fundamental frequency 1536 kHz. The subsequent synchronization takes place via a logic network in the same way as in the sender.

The pulse train after its passage through the encoder is shown in fig. 3. All 24 channels are sampled within one frame, corresponding in time to 125 μs and containing 192 pulse positions. Of the 8 pulses in a channel, as already mentioned, 7 are used for speech and 1 for signalling and synchronization. The division between the two latter functions is effected by using alternate frames for signalling and synchronization. The system contains two independent signal channels produced, as appears from fig. 3, by allocating alternate frames to signalling channel I and signalling channel II.

As already mentioned, the system contains a compressor and an expander in order to improve the volume range, and some brief discussion of questions associated therewith may be advisable. Since the encoder converts the analogue signal value to the nearest 7-digit binary number, a quantizing error arises. This implies that the speech signals on the receiver side do not exactly correspond to those on the sender side, and the consequent distortion is called quantizing distortion. For the same reason signals with high amplitude will be liable to be clipped since the encoder cannot indicate higher amplitudes than correspond to the binary number 2^7, and this phenomenon is called overload distortion.

In contradistinction to overload distortion, quantizing distortion is more troublesome the lower the signal level, since the relative errors are then greater. The two types of distortion result in the fact that a PCM system

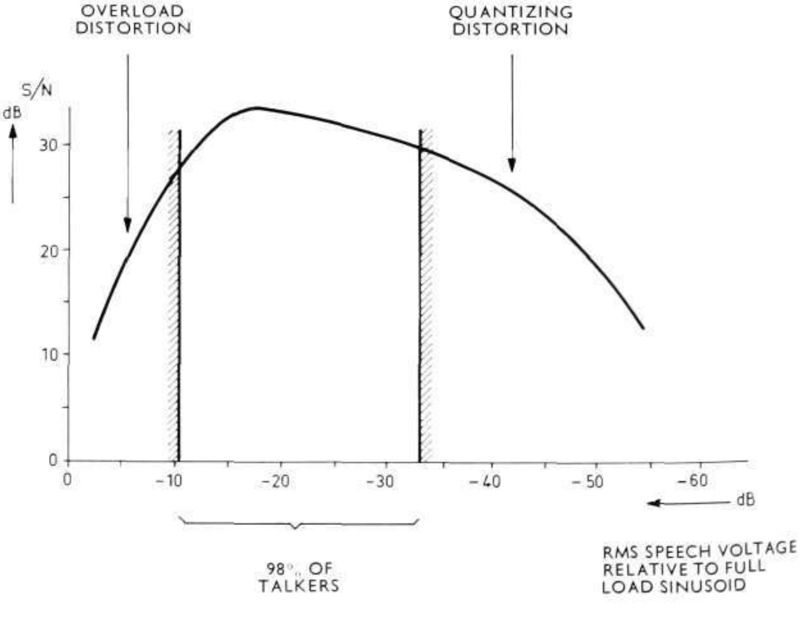


Fig. 4
Quantizing and overload distortion; theoretical curve

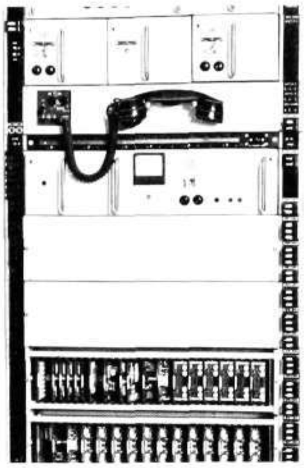


Fig. 5
Terminal equipment for 24-channel PCM system

has a limited volume range, i.e. a range of levels within which the signal must lie in order not to be exposed to undue quantizing distortion on one side or undue clipping on the other. By selecting a compression curve of a suitable shape, the volume range can be greatly increased compared with linear quantization. This is effected by using smaller quantization steps for low signal levels than for higher, so producing a roughly similar relative quantizing error over the entire amplitude range.

Fig. 4 shows, for a logarithmic compressor, a theoretical curve of distortion expressed as signal-to-noise ratio in dB as function of the level of the speech voltage. The diagram also shows the interval within which 98 per cent of the subscribers may be expected to lie under normal conditions.

Terminal Equipment

The mechanical structure of the terminal equipment of the experimental PCM system is shown in fig. 5. On a bay 670 mm wide × 1940 mm high have been placed the sender and receiver equipment for 24 channels with the associated power supply and supervisory units. The units are made up on printed circuit cards placed on shelves, each of which accommodates max. 30 cards. An example of the mechanical structure of the units is shown in fig. 6, a frequency divider belonging to the logic networks and the compressor. The circuits are made up exclusively of silicon semiconductors, and a bay contains about 500 transistors and 900 diodes.

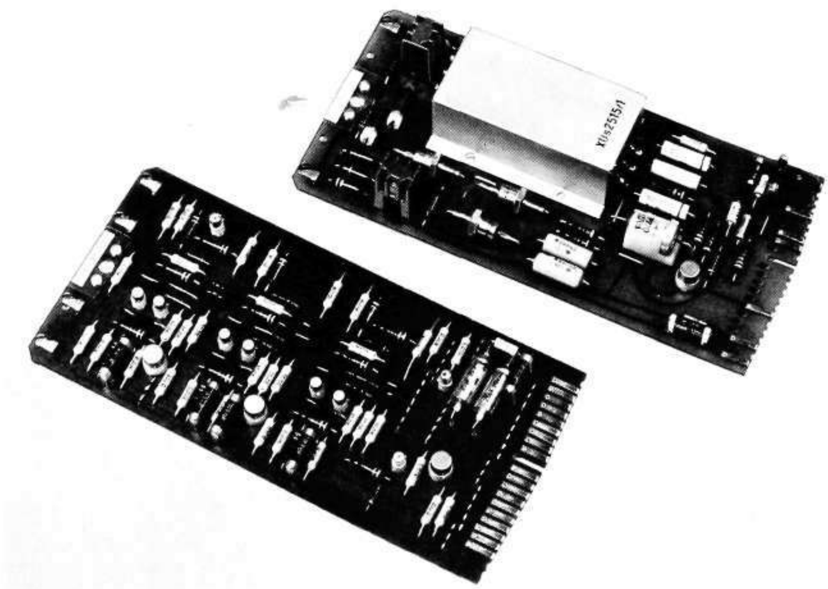


Fig. 6
Example of units in terminal equipment

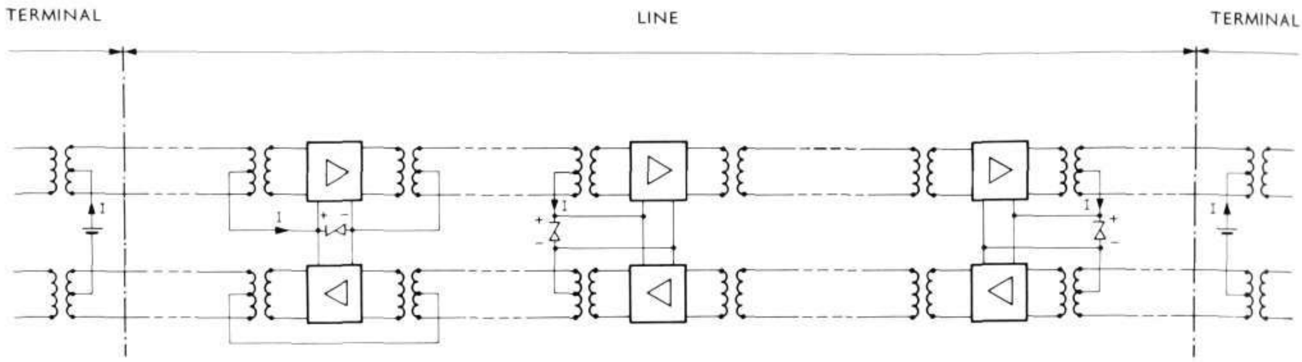


Fig. 7
Block schematic of line equipment

Line Equipment

The repeaters along the line are supplied with DC on the phantom circuit as shown in fig. 7. Two repeaters are supplied from a common voltage stabilizing network.

If the terminals are far apart, the line is supplied from both terminals as shown in fig. 7. The maximum distance between power-supplying terminals is determined by the gauge of the conductors and the maximum permissible voltage. For normal cases it is around 30–40 km.

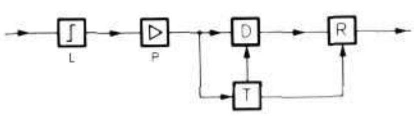


Fig. 8
Block schematic of repeater
- *L* Line building-out network
- *P* Amplifier
- *D* Detector
- *T* Synchronization
- *R* Regeneration

A block schematic of the repeater is shown in fig. 8. It contains a simple line building-out network followed by an amplifier with suitable pulse-forming properties. A synchronizing signal is derived from the incoming pulse train and controls the detection circuit and the pulse circuit which produces the regenerated signal. The procedure is shown in fig. 9, which shows how serious disturbances can give rise to erroneous pulses in the outgoing signal. Such errors are rare, however; in practical tests with the equipment the error rate was of an order of 10^{-8} for a chain of 20 repeaters. So low a figure implies that the digital errors do not affect the quality of transmission in the system.

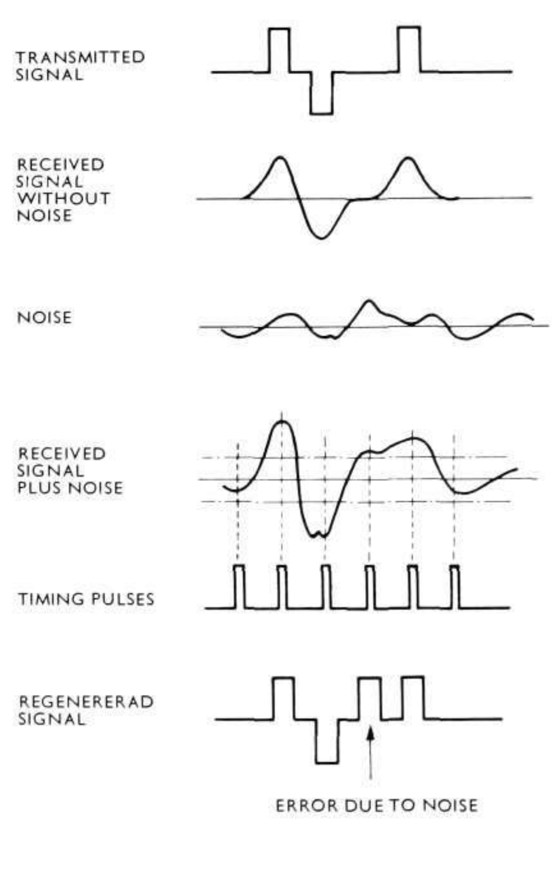


Fig. 9
Function of repeater

Fig. 10
Repeater unit

Four one-way repeaters are placed in the same mechanical unit, as shown in fig. 10. The unit is watertight and mechanically sturdy and can be placed directly on a shelf in a cable manhole as shown in fig. 11. The connection to the pair cable is effected in a gastight C.T. box connected to the main cable by a branched joint. Fig. 12 shows the arrangement, with the protective cover of the C.T. box removed.

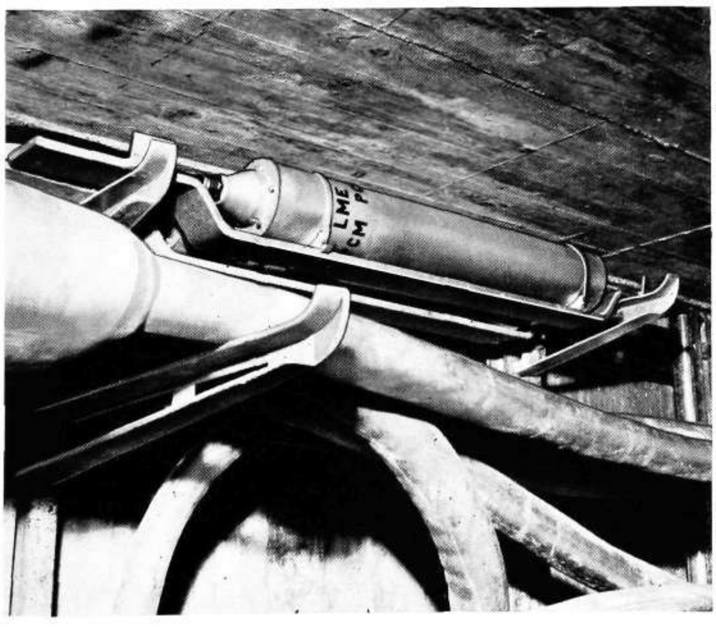
Use of PCM

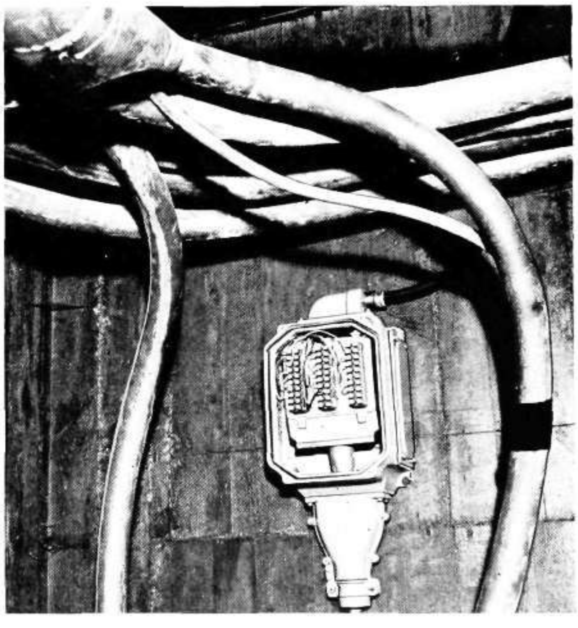
The experimental system described has successfully passed through field tests carried out in cooperation with the Swedish Telecommunications Administration. From the technical data it is evident that the system provides a fully acceptable quality of transmission for speech. Tests have shown that it can also be used for data transmission.

A PCM system has a number of characteristics which distinguish it from a carrier system. The signals are transmitted in digital form and the equipment works to a large extent on a digital basis, i.e. in the same way as a computer.

Fig. 11
Repeater unit in cable manhole

Fig. 12
C. T. box for repeater





The rapid development of digital technique, both in respect of components and circuits, offers hopes that a PCM system could be slightly cheaper than a corresponding carrier system. An advantage of PCM is that no balancing of the cables is necessary and that cables of widely differing dimensions can be employed.

The introduction of PCM, however, may lead to problems and consequent extra costs when working with existing carrier systems. This applies particularly to the possibility of setting-up through-connections, i.e. replacement of groups of channels, between the two types of system.

PCM has been mainly used hitherto for links in local networks, but other possibilities are conceivable in the future. One example is integrated systems in which the transmission and switching processes in a telephone network are combined into one unit. This is made possible by the fact that modern telephone exchanges are starting to use digital techniques, which makes them particularly adaptable to PCM.

Technical Data

Number of channels	24
Frequency band per channel	0.3–3.4 kHz
Nominal levels at 4-wire point	
sending side	−7 dBr
receiving side	+4 dBr
Impedance at 4-wire point	600 ohms balanced
Frequency response	as per CCITT Rec. G. 232 (1964)
Sampling frequency per channel	8000 Hz
Number of binary digits per sample	7
Compressor characteristic	logarithmic
Crosstalk between channels	
subsequent channel	better than 65 dB
other channels	better than 70 dB
Noise on silent channel	less than −65 dBmOp
Volume range	32 db
Quantizing distortion within volume range	better than 25 dB
Number of signal channels per speech channel	2
Signalling distortion	max. 4 ms
Power supply of bay	
voltage	220 V AC
power	240 W

MAGICALL — Automatic Dialler

H. EKSTRÖM & P. NYLÉN, TELEFONAKTIEBOLAGET L M ERICSSON, STOCKHOLM

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MAGICALL, the automatic dialler, is a valuable aid to persons who make large numbers of telephone calls daily. It can be connected to an ordinary telephone set. It memorizes a large quantity of telephone numbers, and with it a call is put through to the desired subscriber by pressing a single button without needing to use the telephone dial. MAGICALL was developed by an American company, DASA Corp., and will be sold by L M Ericsson in many parts of the world. This article presents an account of the dialler and its mode of operation.

MAGICALL is a modern accessory equipment for telephone sets and was developed primarily as an aid to business subscribers. It offers numerous advantages to business executives, their secretaries and office staff. In the first place one avoids the troublesome procedure of searching through the telephone directory for a number and dialling it. MAGICALL also sets up calls more quickly. After a number has been recorded in MAGICALL the corresponding dial pulses are transmitted at the highest speed allowed by the exchange equipment, so that a call is put through more quickly than when a subscriber dials a number. And thirdly—a very important point—MAGICALL cannot dial a wrong number.

The increased number of telephones in all countries and the increasing trend towards subscriber-dialled trunk calls have resulted in complicated area codes and telephone numbers. The situation has reached the point where numbers are practically impossible to remember and are very difficult to dial correctly. This is no problem for the MAGICALL equipment, which can dial calls anywhere in the world, however complicated the number.

Fig. 1
The complete MAGICALL assembly. (Left) Dial-in unit and power unit, (centre) dialler.

Another advantage of MAGICALL is of interest to telephone administrations. Since calls are put through more quickly and the number of wrongly dialled calls is reduced, the switching path is occupied for a shorter time on the setting-up of connections. In other words, the extensive use of MAGICALL will increase the capacity of a telephone network.

Construction and Operation

MAGICALL is an electronic dialler in which telephone numbers (with area codes) are recorded on magnetic tape by a dial-in unit, which plugs into the rear of the dialler. The complete MAGICALL assembly consists of the dialler, tape cartridge, dial-in unit and power unit. The complete equipment is shown in Fig. 1.

The magnetic tape, one side of which is formed as a subscriber list, is enclosed in a cartridge which can be easily removed by the subscriber and replaced by a cartridge containing other numbers. The standard cartridge has space for 400 listings; a special cartridge is available for 1000 listings. The alphabetical subscriber's list is visible through a window on the front of the dialler. Subscribers' names and telephone numbers can be written on the list in pencil or typed.

Flexible cords run between the telephone set (any normal telephone set), the dialler and power unit, the latter being connected to an AC wall terminal (Fig. 2). On the front of the dialler are push-buttons for recording of numbers and placing of calls.

The MAGICALL can be connected both to loudspeaking and ordinary telephone sets and can be used with all public and private telephone systems.

Plugging-in of the dial-in unit automatically converts the dialler for recording of telephone numbers (Fig. 3). Numbers are automatically erased when a new number is recorded in the position of an earlier number.

For recording of a subscriber's number an electric motor drives the tape quickly across the alphabet at the bottom of the window and stops it opposite the desired alphabetical group. A red vertical index line on the tape makes it easy to locate the tape directly on the desired letter. A shutter on the front of the dialler is then raised and lays bare the subscriber's list. Name and

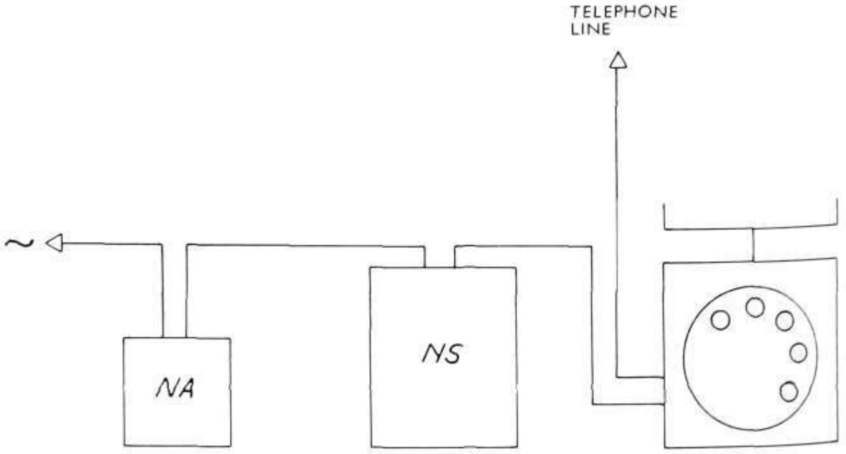

Fig. 2
MAGICALL equipment, block schematic
NA power unit
NS dialler

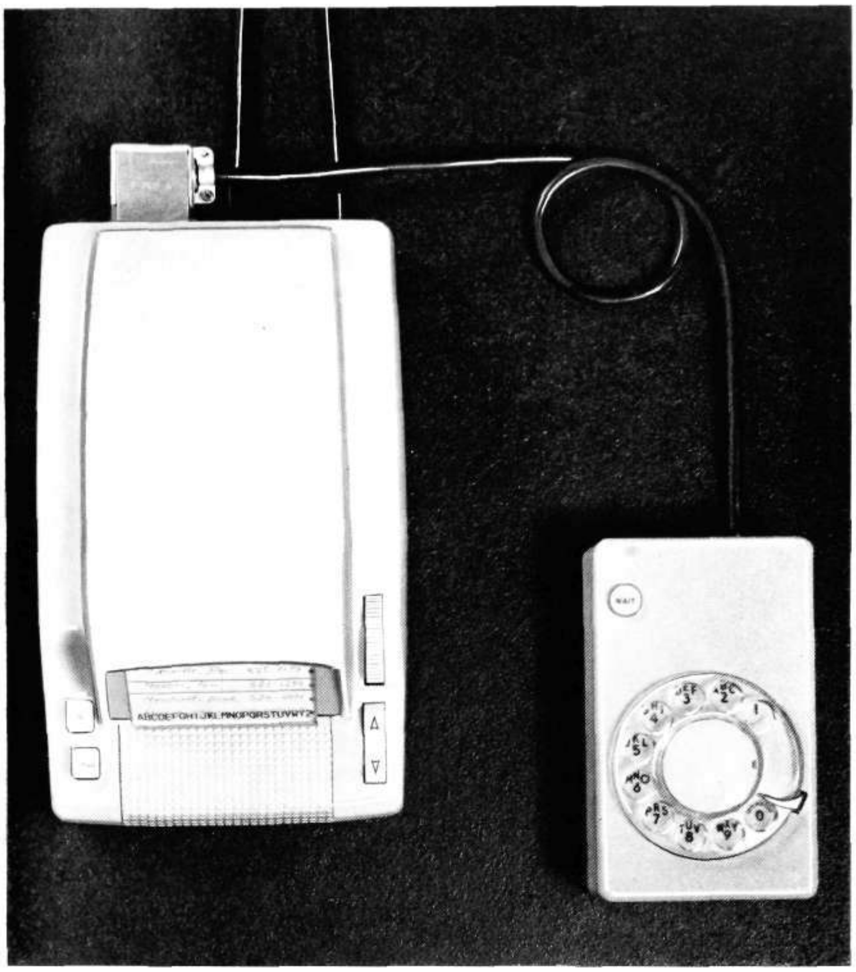

Fig. 3
Dial-in unit connected to dialler

telephone number can now be easily entered in pencil. One then places the name between the guide-lines on the window, presses the call button and dials the number on the dial-in unit. If the subscriber's list is to be typed, the entire cartridge can be removed and the tape placed round the typewriter roller.

To place a call, the subscriber's number is found by quick-winding of the tape to the desired alphabetical group in the same way as for recording a number. When the wanted name or telephone number appears in the window, the subscriber raises his handset, waits for dial tone and presses the call button. A magnetic head then scans the dial pulses on the tape and transmits them at a frequency of 10 pulses per second. The call is put through automatically in a shorter time than when dialling a number in the ordinary way.

Operation

The digital information is stored in MAGICALL on a magnetic tape. All information is recorded and played back by a magnetic head which is driven by a synchronized motor at a constant speed across the tape. The tape is contained in a replaceable cartridge and moves in its longitudinal direction. The movement is controlled by an electric motor, and changes of the direction of movement are effected mechanically. There is also a selector wheel for moving the magnetic tape by hand. MAGICALL is operated with the call button and start button. These two controls have the same electrical function, namely to start the head motor. The only difference is that, on depression of the call button, a catch is released and the magnetic head is allowed to start from its normal starting position. On depression of the start button the magnetic head starts its movement across the tape from the point at which it happens to be at the moment. For recording there is an adapter containing, among other items, an ordinary dial. The return movement of the dial is controlled by a synchronized motor, and the dial therefore has a more exact pulsing frequency than an ordinary governor type dial. The dial of the adapter has a make/break ratio of 1 : 1. The length of the pulse, however, is not a decisive factor, since it is only the fore edge of the pulse that is used for triggering.

The electronics of MAGICALL consist of an amplifier and of a motor and pulsing unit. The function of the amplifier is to scan the recorded digital information and, after amplification and conversion into well defined pulses, to transmit them to the motor and pulsing unit. The function of the motor and pulsing unit is to scan the pulses from the amplifier and to ensure that the movement of the magnetic head across the tape and the pulsing on the subscriber's line are in accordance with the recorded digital information. For recording of a subscriber's number the adapter is connected to the telephone set. A 3 mA direct current then flows through the magnetic head and the tape is magnetized (see fig. 4).

On depression of the call button the head motor starts and a lamp lights on the adapter to indicate that the motor is running. The magnetic head starts to move across the tape. After 1.4 second an electronic timer in the motor and pulsing unit causes the motor to stop. The lamp on the adapter goes out, so indicating that the apparatus is ready for recording of a subscriber's number. The procedure requires some recording discipline, however, and ensures that every recorded item of information is included in the playback irrespective of mechanical and electronic functional tolerances.

When a digit is now dialled on the adapter dial, the head motor is started by a contact in the dial and the lamp relights. During the return movement of the dial its pulsing contacts open alternately and the direct current through the magnetic head changes direction, with the result that the tape is alternately magnetized in the two directions. At the same time, in step with the pulsing, a change of state takes place on the amplifier input, which results in a train

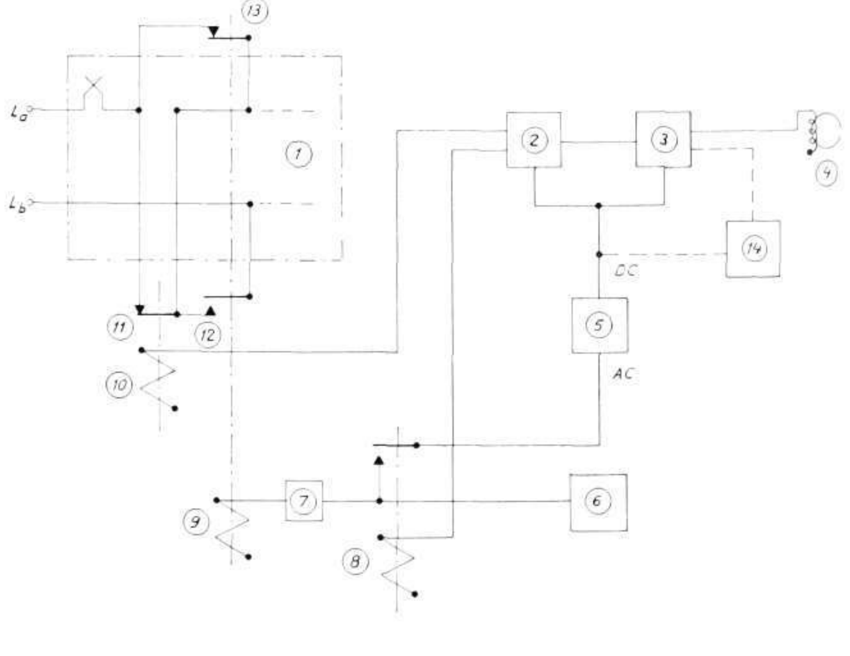

Fig. 4
Circuit diagram
① Telephone set
② Motor and pulsing unit
③ Amplifier
④ Magnetic head
⑤ Power unit
⑥ Head motor
⑦ Rectifier
⑧ Motor relay
⑨ Shunt and safety relay
⑩ Pulsing relay
⑪ Pulsing contact
⑫ Shunt contact
⑬ Safety contact
⑭ Adapter

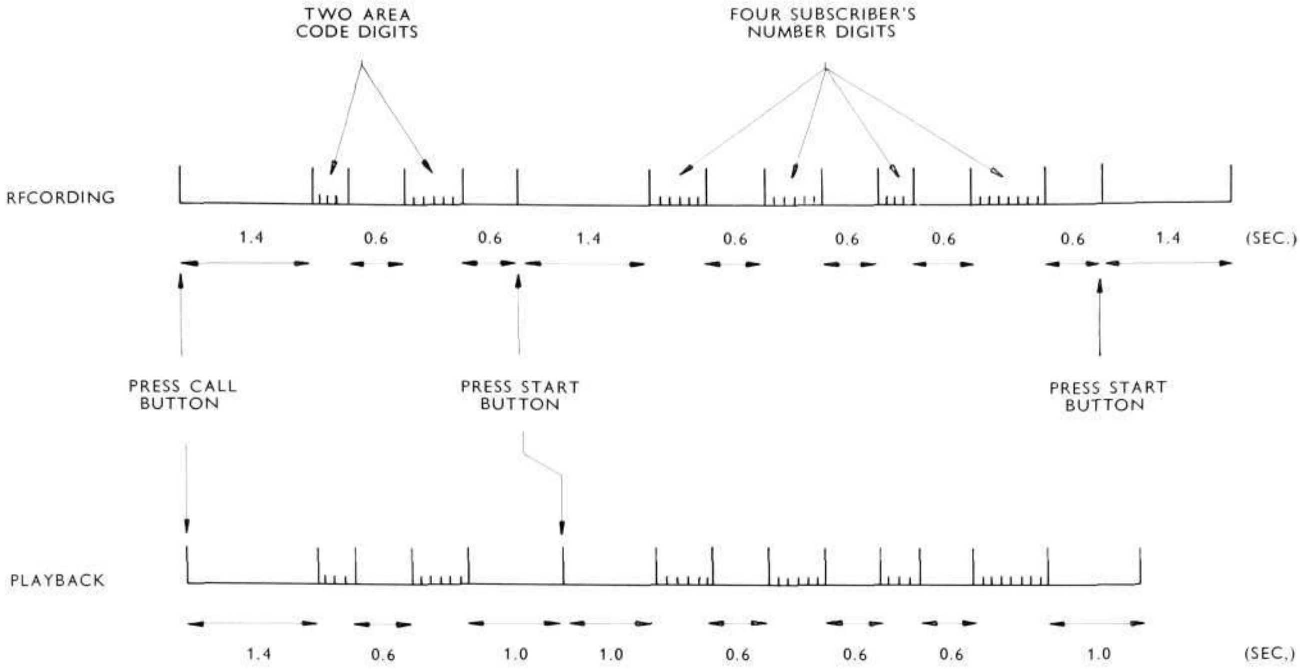

Fig. 5
Time diagram

of pulses on its output. Each of these pulses controls flip-flops and timers in the motor and pulsing unit. When the dial has returned to normal, the contact which kept the motor running during pulsing opens. The motor is kept running for a further 0.6 second by the electronic timer. The motor then stops in response to a pulse from the timer and the lamp on the adapter goes out. The apparatus is now ready for recording of a new digit.

If the information to be recorded consists of several independent groups such as area codes and subscriber number, the following procedure is used. The call button is pressed and the first group (the area code) is recorded as already described. When the lamp on the adapter goes out after the last digit and the head motor has thus stopped, the start button is pressed. The motor then restarts and the lamp of the adapter lights. The motor runs for a further 1.4 second and is then stopped by a pulse from the timer. The lamp goes out, so indicating that the next group (the subscriber's number) can be recorded (see fig. 5).

For playback the adapter is disconnected, whereupon the direct current through the magnetic head disappears. The amplifier is now ready to receive information from the tape.

When a recorded subscriber's number is to be played back, the call button is pressed, the head motor starts and moves the magnetic head across the tape. If no information is encountered within 3.5 seconds, the motor is stopped by a pulse from the timer. Otherwise the following events take place. During the recording the tape was alternately magnetized in the two directions. These alterations in the direction of magnetization are recognized by the magnetic head as a train of pulses. Each single pulse is amplified in the amplifier and taken to the pulsing flip-flop in the motor and pulsing unit, which then breaks the current to the pulsing relay.

The pulsing contacts open and cut off the line current on the subscriber's line. The break time is controlled by an electronic timer and, after 61 ms, the latter delivers a pulse which restores the flip-flop. The pulsing relay then operates and closes the pulsing contacts and restores the line current on the subscriber's line. The break time can be set with a potentiometer for different

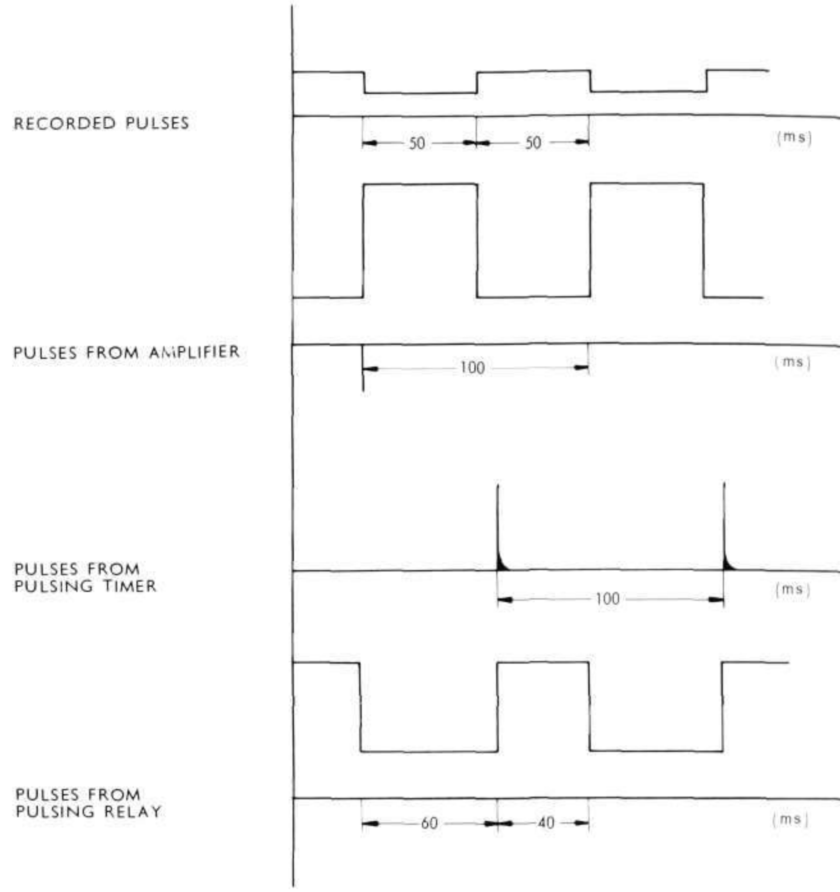

Fig. 6
Pulse forms

break/make ratios. The equipment is normally delivered for a 60/40 ratio. Every pulse to the flip-flop is recorded by the motor timer which senses the time between the pulses. The process is repeated for each individual pulse from the amplifier. After the last pulse in the item of information the timer recognizes the longer interval and stops the motor after 1 second.

If the information to be played back consists of several groups such as area codes and subscriber's number, the procedure is as follows. The call button is pressed and the first group is played back. After the motor has stopped and the line tone indicates that the first group of information has been delivered, the start button is pressed. The head motor then starts again and the magnetic head scans the tape for the next group (the subscriber's number) (Figs. 5 and 6).

The MAGICALL equipment is so arranged schematically that, if a fault occurs on any circuit, the equipment is immediately disconnected from the line so that no false pulses can be transmitted.

Clutch, gear and push-buttons are made of Delrin, which has a low friction coefficient and is highly reliable. The MAGICALL equipment is mechanically and electrically robust in order to prevent damage during transport, and all electronic components are of high quality. Fig. 7 shows the compact structure of the dialler.

The MAGICALL equipment is supplied in a light grey shade. It has a low, elegant shape and takes up no more space on a desk than a telephone set.

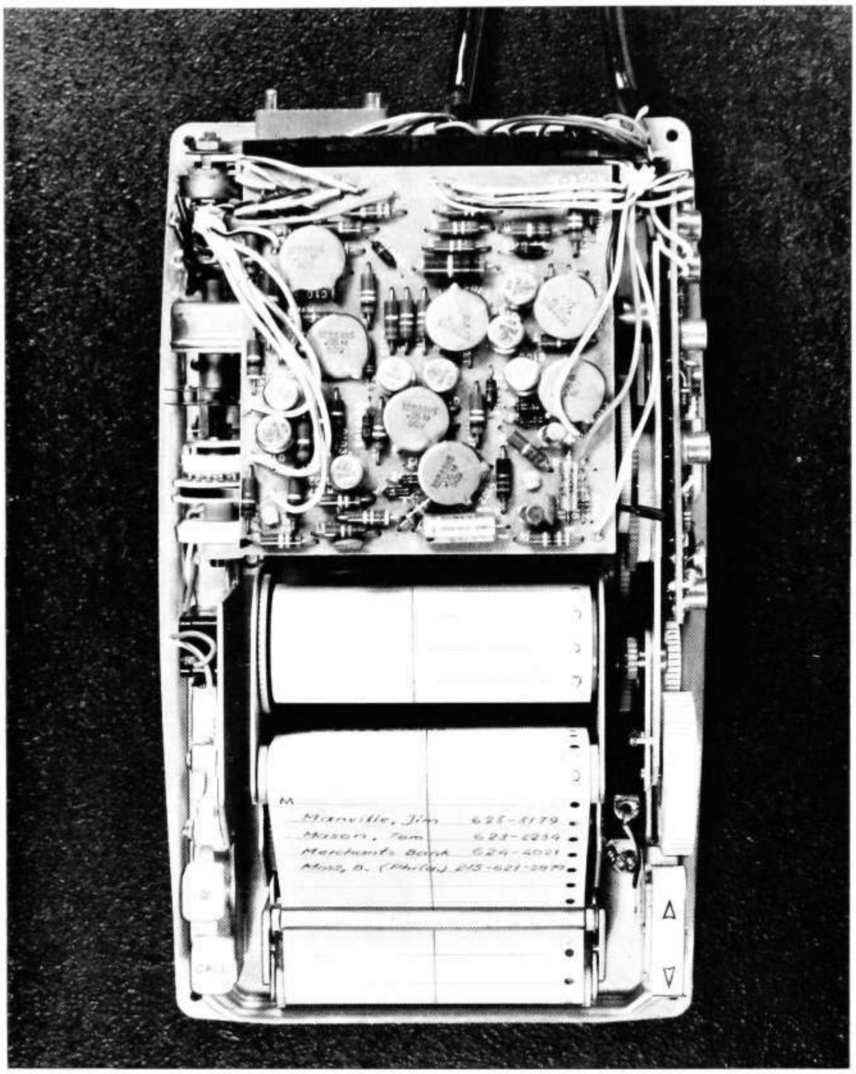

Fig. 7
Dialler with cover removed

Main Features of MAGICALL

1. Rapid setting-up of calls.
2. Simple plug-in connection.
3. Power supply from battery eliminator.
4. Quick finding of a telephone number.
5. Can be connected to different types of dial telephones
6. Time-saving.
7. Simple operation.
8. Efficient and reliable.
9. Adequate number capacity.
10. Adequate digital capacity for subscriber-dialled trunk calls.

Centralization Trends in Exchange Maintenance

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The rapid increase in telephone density, the automatization of international as well as national trunk traffic, the introduction of new traffic facilities, and the demand from subscribers for still higher quality of service—all these facts make it necessary to concentrate attention on maintenance to a greater degree than before. Consequently the telephone administrations are forced to choose a telephone system which both requires the least possible maintenance and has inherent facilities for far-reaching rationalization of maintenance. This article shows how L M Ericsson's crossbar exchanges satisfy these requirements and suggests means of rationalization.

Before discussing the centralization trend, L M Ericsson's basic maintenance philosophy will be briefly reviewed.

Fundamental Principles

Maintenance Economy

In principle switching equipment maintenance consists of:

1. Service supervision (indication of whether a fault exists)
2. Repair (when a fault has occurred)
3. Preventive maintenance (lubrication, periodical cleaning of relay contacts, etc.)

L M Ericsson's crossbar equipment requires no preventive maintenance, in itself a very important rationalization measure. In these exchanges, in other words, the maintenance work consists of supervision and the repair of faults.

Supervision, i.e. measures to ascertain whether faults exist, should be performed as continuously as possible in a telephone exchange. The costs of supervision are proportional to the size of the plant and may be very great if the supervision is carried out manually.

Fault repairs may be divided into two phases, analysis of the fault-indicating information (fault tracing) and the repair proper.

The costs of fault tracing are proportional to the fault incidence, i.e. to the number of faults to be repaired per annum. Fault tracing can be rationalized to a great extent through the use of fault indicators.

The factors which have a decisive influence on the maintenance of a telephone exchange without preventive maintenance are, in other words:

a) The degree of automatization of the supervision;

b) The fault incidence for the exchange, i.e. the number of faults to be repaired per annum in order to attain a desired quality of service.

The extent to which supervision should be automatized is a techno-economical question and depends largely on the telephone exchange system to be supervised. As a general rule it may be said that "common control" systems of all types can be easily provided with fully automatic supervision.

The supervision of L M Ericsson's crossbar exchanges is in practice fully automatized and requires an insignificant amount of manual work. The general rule for these exchanges, therefore, is that maintenance effort and, consequently, maintenance costs, are practically proportional to the incidence of faults in the equipment. This fault incidence is under normal circumstances low—operational statistics from various markets point to the fact that an L M Ericsson crossbar switch becomes defective, on an average, once every 40th to 50th year, and that the corresponding figure for L M Ericsson relays is once every 400th to 500th year.

Maintenance Philosophy

The equipments and methods we use to-day are based largely on the maintenance philosophy which evolved in the late fifties in collaboration between manufacturer and administrations and which may be denoted as controlled corrective maintenance. This is characterized by the following requirements:

- ☐ That the equipments should to the greatest possible extent be isolated in separate rooms, which are visited only in connection with a job to be done. The environmental factor is of the greatest importance in maintenance rationalization, because unsuitable premises may well multiply the fault incidence and thus cause an increase in maintenance costs. The importance of the principle of the "isolated room" for telecommunication equipment can hardly be sufficiently stressed.[1]
- ☐ That periodical maintenance and marginal tests should be adopted only in exceptional cases and only when found necessary in practice. Before the introduction of such routines, furthermore, one should investigate whether the cause of the fault can be eliminated by alteration of a circuit or component.
- ☐ The operation of the equipment should be supervised as continuously as possible and the operational result should be the controlling factor in the maintenance effort.
- ☐ The supervisory equipments should be designed to check the operation of the exchange from the subscriber's point of view. The switching equipments should be regarded as carriers of functions, not carriers of technical data. No action should be taken on account of a solitary disturbance, but only when a predetermined failure rate has been reached.

These general principles have resulted in the following main groups of equipments for supervision of the various L M Ericsson systems.

Main Types of Test and Supervisory Methods

Continuous Supervision of Common Control Units

Markers, code receivers, registers, etc., are continuously supervised by means of built-in circuits. In case of an unsuccessful connection an impulse is sent to a service alarm unit (*DL*), in principle consisting of a memory which checks the *frequency* of unsuccessful connections. If this frequency tends to be too high, an alarm is issued. In system *ARM* a centralograph—in other systems (*ARF* and *ARK*) counters or lamp panels—are used for the subsequent detailed tracing of the fault, see fig. 1.

ARM →	*DL* →	Centralograph
ARK →	*DL* →	Lamp panel (portable)
ARF →	*DL* →	Counters Lamp panel

Fig. 1
Supervision of common control units

Supervision by Means of Test Traffic

Supervision by means of generated test traffic has proved exceptionally useful and constitutes the cornerstone in our supervisory system. The method is used for quality control as well as for fault tracing. The primary aid for this purpose is the traffic route tester with accessories, which is used to set-up test calls between "automatic subscribers" at strategic points in the telephone network. The programming of the test traffic is done with care in order to cover every type of traffic and all subscriber groups at as frequent intervals as possible. The testing procedure is generally based on modern statistical sampling methods, usually sequential analysis.

Service Observation

Observation of subscriber-generated traffic is an essential complement to the supervision exercised by the traffic route tester. One or more of the normal registers in the exchange, equipped for supervision of the connections tested, are used for this purpose. The register records unsuccessful connections and permits the operator to follow the connections from a supervisory desk. In local exchanges checks can be made of the calling subscriber's line and dialling. This technique is applied to local as well as trunk exchanges.

Test of Individual Units

When the supervisory equipments indicate a fault in an exchange, or in a unit or group of units, the fault must be located. For this purpose a large number of testers have been developed for detailed fault tracing. They are usually designed for connection directly to the unit to be tested, and the subsequent testing operation is performed fully automatically. Typical examples of this type of equipments are the *SL-GV* tester for *ARF* and the exchange tester for *ARM*.

Supervision of Traffic Volume

In order to supervise the traffic quality, equipments are available for measurement of congestion, occupation and traffic volume. Congestion is continuously supervised. A complete traffic measurement is performed on an indication from the congestion meters or periodically on a fixed time schedule. Erlang measurements on individual subscriber lines (*PBX*) can be carried out with a special instrument.

Maintenance of Local Exchanges in City Network

General Principles

The maintenance philosophy for local exchanges has in recent yeras shown an increasing trend towards centralized maintenance. Fifteen to twenty years ago the switchroom was the normal habitat for the maintenance staff. In the mid-fifties the thesis was introduced that maintenance staff should not be in the switchroom more than absolutely necessary. On this account L M Ericsson's crossbar exchanges were often equipped for central service control (*CDK*). This implied the concentration of all supervisory equipment to a control room in the same building as the switchrooms and usually in direct communication with them. The control room was intended as the normal place for the maintenance staff, and from it the exchanges were supervised and a certain amount of fault tracing could be done. The control room also serves as the sole entrance to the switchroom, thus forming a desirable air-lock.

During recent years a tendency has been noticeable to push centralization still further, viz. especially in large cities to form a centrally situated switching maintenance office common to all exchanges in the district. The idea is that all or as many exchanges as possible should be unattended and that their maintenance should be carried out by patrols under the control of the maintenance office. The intention is that only very large exchanges of 10,000–15,000 lines or more should be attended.

Technique and organization are closely interwoven, and changes in maintenance technique are often reflected in the maintenance organization. The traditional form of maintenance organization in a city is that each exchange has its chief, responsible for his exchange. This is an excellent system in single-exchange areas but may have disadvantages in multi-exchange areas. The "entirety" of the area may be neglected and the interest concentrated on the individual exchange. In actual fact, from the subscriber point of view a multi-exchange area constitutes a single switching machine and the service is judged on the total result. The maintenance should then be organized on the same principle – that the multi-exchange area as a whole is the unit, the individual plant being of minor importance and to be treated as an integral part and not as an independent administrative unit.

This conception, of regarding the multi-exchange area as a techno-administrative unit, has several advantages. The limited resources can be directed towards those parts of the area which are in most urgent need of them for the moment. The result is a more uniform service to subscribers and avoidance of time lags when an individual exchange is temporarily overloaded with work. And last but not least—the same control is exercised over every type of traffic within the area. There is a tendency in individual exchange operation to concentrate on the local traffic and to neglect the junction traffic. An individual route or a special type of traffic (e.g. special services or trunk junction lines) tends to be overlooked in an exchange-bound organization because the responsibility is divided between several exchanges.

The outside plant maintenance in the majority of large cities has in fact for a long time been organized on the centralization principle, and there is no doubt that this is an important reason why better service has been available at a lower cost in this sphere. There are many things to be said in favour of applying this principle also to city exchanges, with *centralized supervision and centralized control of the repair organization.*

The extent to which centralization can be taken depends to a great extent on the character of the exchanges. In older types of system which have limited facilities for built-in checking circuits and require regular routine tests of individual units, and in which there are a great number of faults to repair, there is less possibility of centralized maintenance. Here one must presumably be content to supervise the functional quality by means of test traffic and centralized handling of subscribers' complaints.

Modern common control systems, on the other hand, such as L M Ericsson's *ARF* system with its great facilities for built-in, fully automatic service supervision and its low fault incidence, are extremely suitable for centralized supervision and fault repair. Such a centralized maintenance system implies in principle that:

- there is in the area a switching maintenance office to which information about faults, congestion, subscribers' complaints, etc., flow in, and which then evaluates the information and orders action to be taken. This maintenance office can be situated either in conjunction with an exchange or in suitable office premises.
- all exchanges except the largest (above 10,000–15,000 lines) are unattended.
- all repair work is carried out by patrols of one or two men under the control of the maintenance office.
- equipment for fault location and repair is carried out by the patrol, if portable, and otherwise kept permanently at the respective exchanges.
- each exchange is provided with a control panel on which the input and output units of the supervisory equipment for the exchange are concentrated. At large exchanges this panel should be situated in a separate control room.

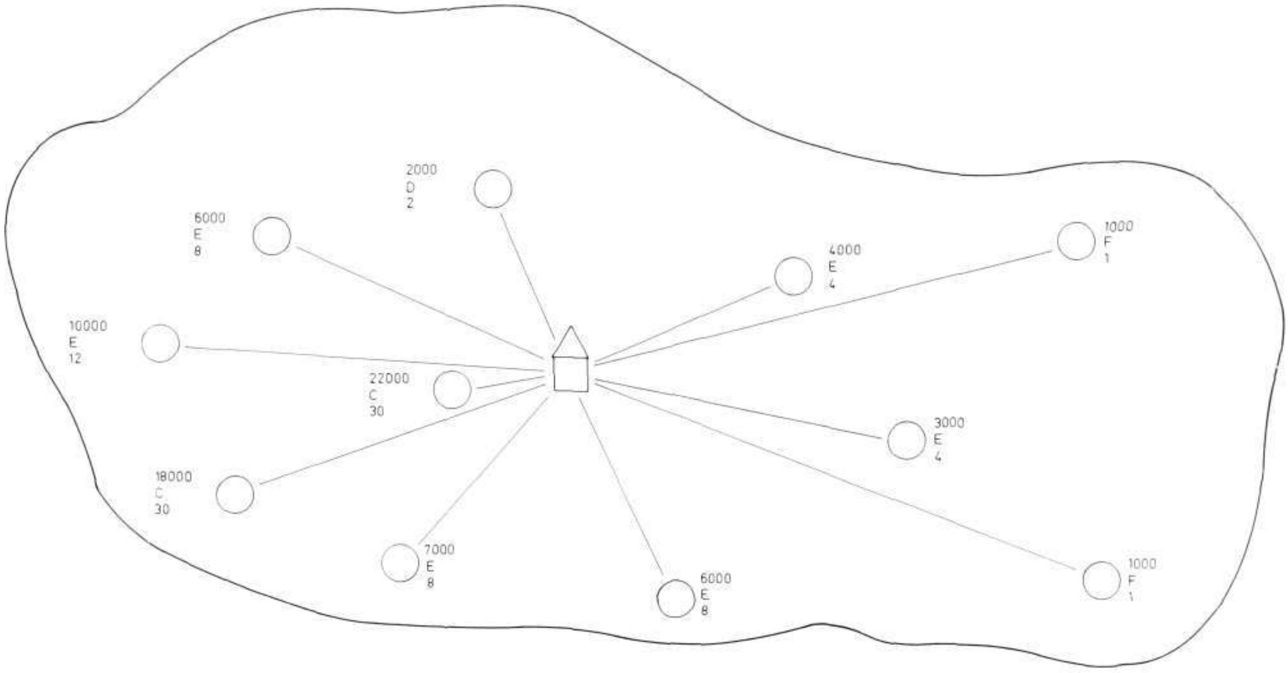


Fig. 2

Example of city network, T-town, with automatic ARF exchanges

Switching maintenance office, fig. 3 B
Outside plant maintenance office, fig. 3 A

7000 = number of subscribers
E = maintenance equipment in fig. 3 E
8 = approximate number of faults per month

- all statistics and all paper work is concentrated to the maintenance office. The fault repairmen (the patrols) con consequently be utilized for repair work to the full extent. Not only is their time then effectively spent, but they also become specialists, as they are always kept in top trim through their qualified work.
- by means of traffic route testers under the control of the maintenance office continuous test traffic is generated according to predetermined programs. Thus a continuous check is kept on unsuccessful calls, i.e. a measure of the functional quality of the equipments. The test subscribers are positioned at different exchanges and are programmed to call each other in such a way that the result presents a true picture of the service from the subscriber's point of view. The result is read at the maintenance office.
- as a complement to the results from the traffic route tester, the traffic generated by subscribers is also supervised. This is done by means of one or more observation lamp panels (*OBR*) which can be connected to control registers at the desired exchanges within the area.

Maintenance of the Exchanges in T-town

To concretize the picture, Fig. 2 shows an example of a medium-sized city network in T-town, embracing 80,000 subscribers on 11 exchanges. The supervision is carried out from a centrally situated maintenance office. The figure shows the size of each of the 11 exchanges, the expected fault rate per month and suitable supervisory equipment according to the typical cases shown in fig. 3. Suitable switching maintenance office equipments will be seen in fig. 3A, and equipments for outside plant maintenance offices in fig. 3B.

Practical experience and operational statistics from *ARF* exchanges in different parts of the world indicate 10–20 repaired faults per year and 1 000 lines, and at the same time a *very high functional quality*, i.e. all faults have been repaired. This implies that in a centrally situated *ARF* exchange of 5 000 lines 1–2 faults are repaired per week and in a 10,000-line *ARF* exchange 1 fault every second or third day. If these figures are applied in our example, the result is an average of about 7 faults per day for the whole area.

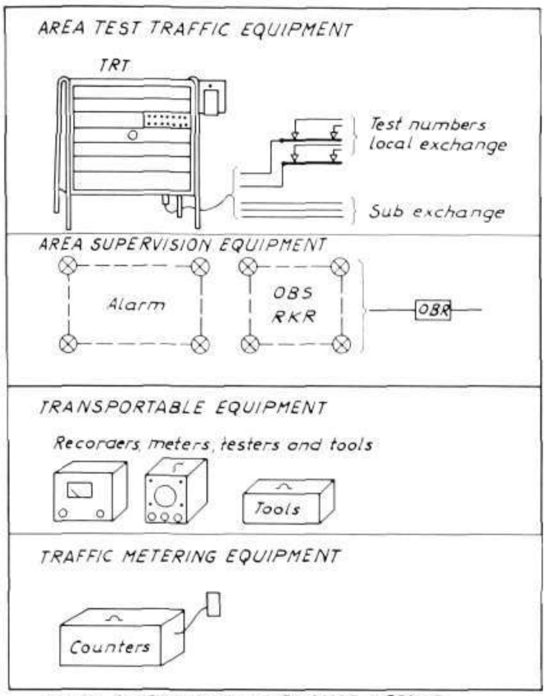


Fig. 3A SWITCHING MAINTENANCE OFFICE

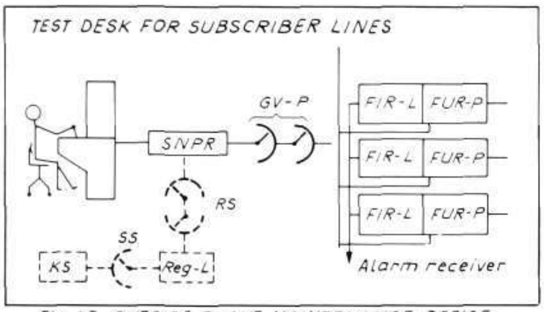


Fig. 3B OUTSIDE PLANT MAINTENANCE OFFICE

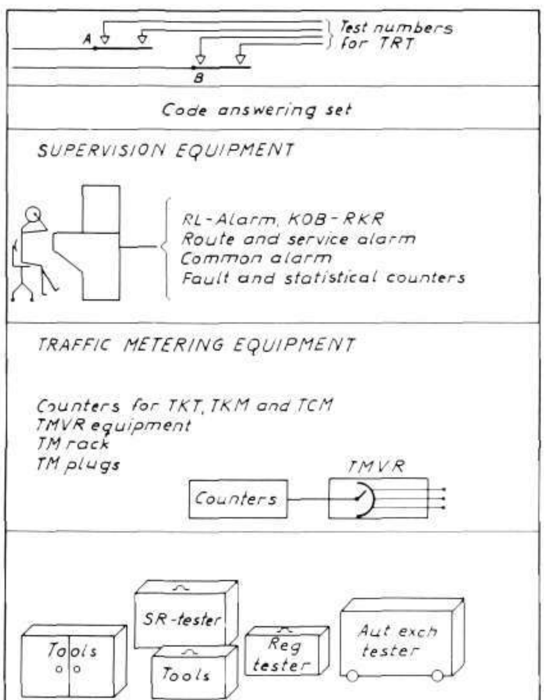


Fig 3C EXCHANGE FOR > 10000 SUBSCRIBERS

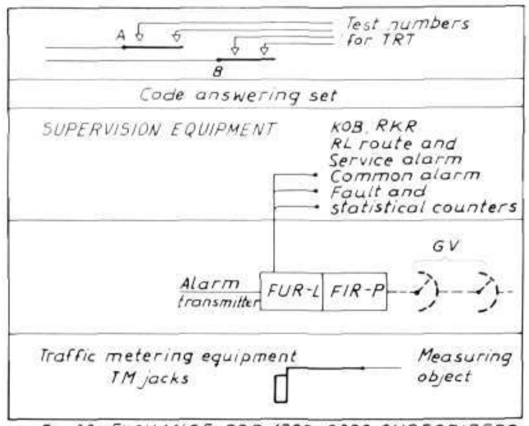


Fig 3D EXCHANGE FOR 1000-2000 SUBSCRIBERS

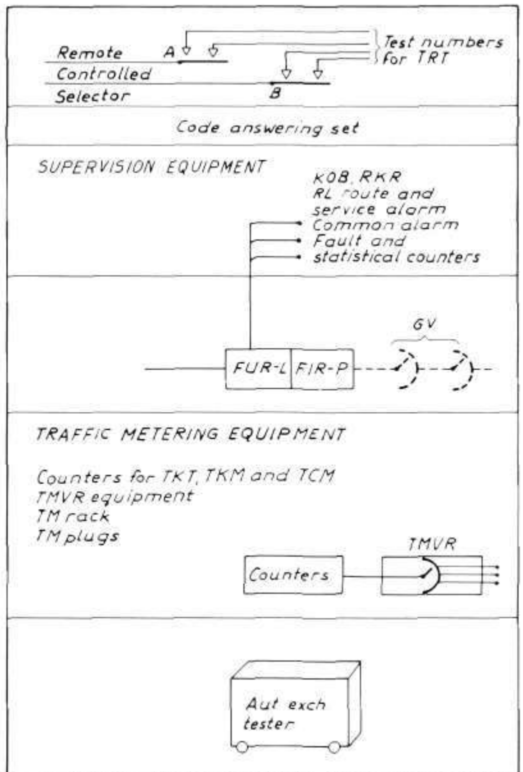


Fig 3E EXCHANGE FOR 2000-10000 SUBSCRIBERS

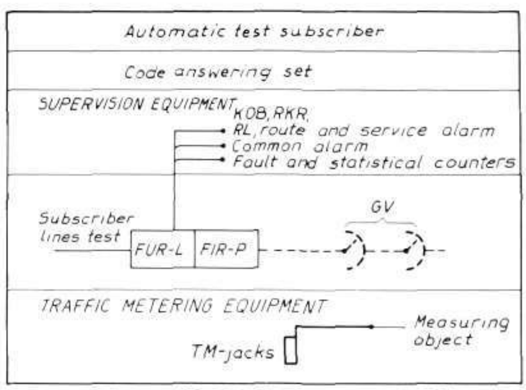


Fig 3F EXCHANGE FOR ≦ 1000 SUBSCRIBERS

Fig 3
Different types of maintenance equipment in T-town

In addition to this there are alterations on *PABX* and junction lines, periodic maintenance of batteries and signalling machines, and reading of congestion and traffic meters. The extent of re-grading, *PBX* alterations, etc., is entirely dependent on the growth rate in the area. If on a major scale, this work should be carried out by specialized staff, preferably from the Plant Construction Department.

In this example permanent repairmen are probably placed at exchanges *A* and *B*. In exchanges of this size two repairmen should be occupied on fault tracing, and thus two men are stationed at exchange *A* and two at exchange *B*. The number of faults to be repaired per day for the remaining area is 3, which should be possible for two 2-man motorized patrols. The maintenance office also requires one man.

Maintenance of Rural Exchanges

General Principles

The basic philosophy concerning maintenance of our rural exchanges *ARK* is identical to that for city exchanges; supervision should be automatized and supervisory information should be transmitted to a central maintenance office. Besides the normal alarm system the exchanges are equipped with service alarm for continuous supervision of the function of the common control units. The network as a whole is supervised by the traffic route tester, which continuously generates test calls between automatic test subscribers distributed throughout the area. The supervision of correct charging is performed at the *ARK* and small *ARM* exchanges by the traffic route tester, and at the larger *ARM* exchanges by special tariff testers. Disregarding batteries and signalling machines no periodic inspections are necessary, the supervision being performed entirely by the equipment mentioned above.

Maintenance of Rural Networks

To present the aforementioned principles in concrete shape, Fig. 4 shows an example of an automatized rural network with fully automatic supervision. The network consists of *ARK* exchanges and a few *ARM*. Fig. 5 shows the testing and supervisory equipment, which in this case is kept at each exchange. The maintenance office is presumed to be situated at exchange 1, and the switching maintenance is attended to by motorized patrols specialized in this work. As routine tests and periodic inspections are used only to a small extent, the quantity of maintenance work is dependent almost exclusively on the number of faults to be repaired.

As the transit equipments constitute a considerable part of the entire equipment, the operational statistics are here based on the number of single-sided racks. The empirical figure for *ARK* exchanges is about 1 fault per single-sided rack and year. In this case, as for *ARF*, the figure applies to districts where the functional quality of the exchanges has been established, i.e. all faults have been repaired. In the rural network shown in Fig. 2, some 500–600 faults per annum would consequently have to be repaired, i.e. 2–3 faults per day. The number of staff required depends to a great extent on local conditions, but two men at exchange 10, also attending to the maintenance office, seems reasonable. There remain 2–3 faults per day in the remaining district, which should be managed by two one-man motorized patrols. A certain share of general jobs, such as minor *PBX* and junction line alterations, should be attended to by this staff.

To facilitate the directing of outside plant repairmen in the rural network, the district has been provided with equipment for remote-controlled measurement of subscriber lines. L M Ericsson are developing two types of remote-controlled line measurement systems for the *ARK* exchanges. In one system the measuring device is located at the group centre and requires physical junctions to the terminal exchange, in the other the measuring device is located at the terminal exchange and entirely independent of the type of junction line.

Fig. 4

Example of fully automati zed rulal network

- ⊠ ARM 20
- □ ARM 50
- ● ARK 523
- ○ ARK 521
- ⊗ ARK 511

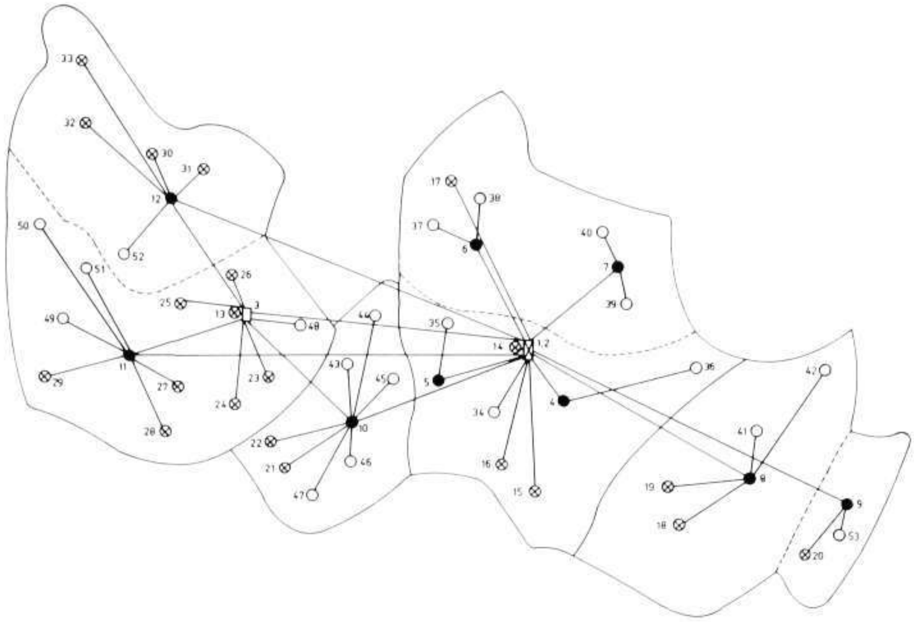


Fig. 5

Testing and supervisory equipments in fig. 4

Exchange	Lines	Racks
1 Maintenance centre		
2 ARK 201	1200	132
3 ARK 503	400	25
4 ARK 523	196	13
5 ARK 523	196	13
6 ARK 523	196	13
7 ARK 523	192	11
8 ARK 523	790	33
9 ARK 523	120	15
10 ARK 523	495	30
11 ARK 523	300	23
12 ARK 523	400	22
13 ARK 521	1000	17
14 ARK 521	450	18
15 ARK 521	292	8
16 ARK 521	100	3
17 ARK 521	96	4
18 ARK 521	100	3
19 ARK 521	100	3
20 ARK 521	130	4
21 ARK 521	100	3
22 ARK 521	100	3
23 ARK 521	100	4
24 ARK 521	200	5
25 ARK 521	100	3
26 ARK 521	100	3
27 ARK 521	100	3
28 ARK 521	100	3
29 ARK 521	100	3
30 ARK 521	130	2
31 ARK 521	100	2
32 ARK 521	130	4
33 ARK 521	200	3
34 ARK 511	60	2
35 ARK 511	60	2
36 ARK 511	60	2
37 ARK 511	60	2
38 ARK 511	60	3
39 ARK 511	30	2
40 ARK 511	60	2
41 ARK 511	60	2
42 ARK 511	30	2
43 ARK 511	60	3
44 ARK 511	30	3
45 ARK 511	30	2
46 ARK 511	60	2
47 ARK 511	30	2
48 ARK 511	60	2
49 ARK 511	60	2
50 ARK 511	30	2
51 ARK 511	100	4
52 ARK 511	60	2
53 ARK 511	40	3

Total number	1–5	6–10	11–15	16–20	21–25	26–30	31–35	36–40	41–45	46–50	51–53
1 Traffic route tester	1										
2 Automatic exchange tester	1 1										
2 Tariff tester	1 1										
2 Centralograph equipment	1 1										
3 Manual or automatic exchange tester (transportable)	2		1								
1 Traffic control desk	1										
1 Traffic control panel	1										
Statistical counters	**50										
17 Service alarm	10 7										
55 Route alarm units	42 13										
1 Traffic metering equipment	1										
2 " " " transportable	2										
47 Automatic test subscriber		1 1 1 1 1	1 1 1 1	1 1 1 1 1	1 1 1 1 1	1 1 1 1 1	1 1 1 1 1	1 1 1 1 1	1 1 1 1 1	1 1 1 1 1	1 1 1
6 Code answering sets		1 1	1 1 1 1								
38 FUR-LT (9 alarms) (Alarm)				1 1 1 1 1	1 1 1 1 1	1 1 1 1 1	1 1 1 1 1	1 1 1 1 1	1 1 1 1 1	1 1 1 1 1	1 1 1
23 FUR-LT (29 alarms) (Alarm)	3 1 1	2 2 3 2 3	3 2 1								
38 FIR-LT (9 alarms) (Alarm)				1 1 1 1 1	1 1 1 1 1	1 1 1 1 1	1 1 1 1 1	1 1 1 1 1	1 1 1 1 1	1 1 1 1 1	1 1 1
23 FIR-LT (29 alarms) (Alarm)	3 1 1	2 2 3 2 3	3 2 1								
1 PR-A (Remote measurement of subscriber lines)	1										
11 PR-B (Remote measurement of subscriber lines)	1 1	1 1 1 1 1	1 1 1 1								
11 FIR-P (Remote measurement of subscriber lines)	1 1	1 1 1 1 1	1 1 1 1								
39 FUR-P (Remote measurement of subscriber lines)	1 1	3 2 3 2 7	6 5 5 4								
4 FIR-P spec. (Remote measurement of subscriber lines)	4										
60 FIR-P terminal exchange			3	1 1 2 2 2	2 2 2 3 2	2 2 2 2 2	2 2 3 1 1	1 1 1 1 1	1 1 1 1 1	1 1 1 1 1	2 1 1
50 Service alarm for ARK	1 1	1 1 1 1 1	1 1 1 1 1	1 1 1 1 1	1 1 1 1 1	1 1 1 1 1	1 1 1 1 1	1 1 1 1 1	1 1 1 1 1	1 1 1 1 1	1 1 1
3 Fault indicator (portable)	2		1								
1 Control register	1										
TKT resistance jacks	* *										
1 Oscillomink (per district)	1										
1 Multirecorder	1										
2 Time meter	1 1										
2 Impulse generator	1 1										
2 Telefonograph	2										
4 Vacuum tube voltmeter	2 1		1								
3 Impulse recorder	2		1								
1 Tool cabinet	1										
1 Tool box			1								
2 Tool case	2										
15 Occupation indicators	10 5										
3 Allotter for test calls	2		1								
3 Counter box (portable)	2		1								

* 1 plug per GDB rack.

** 1 counter for each outgoing route and destination, 1 counter per VM, 2 counters per 5 VM, 1 counter per M, 2 counters per 5 M, 3 counters per 10 reg., 1 counter per RS, 1 counter per SS, 1 counter per KS, 20 counters, which can be zeroed, for traffic supervision and fault tracing, 80 counters, which can be zeroed, for traffic metering.

Maintenance of Transit Exchanges ARM

ARM in Rural Networks

The strategy for transit exchange maintenance is partly dependent on the field of application. Transit exchanges in the rural network are included in the traffic route tester program, which covers switching equipment as well as lines. This, in conjunction with the service alarm, usually provides for complete supervision of the exchange. For fault tracing and repair centralographs are used for the common control units (*M*, *VM*, etc.) and exchange testers for lines and individual units. The supervision of congestion is performed by reading the counters at the respective exchanges.

ARM in the LD Network

The question of operation and maintenance of *ARM* exchanges when used in national and international *LD* networks has several aspects. In the first place the equipment at the exchanges must be supervised and faults repaired. It is, however, also desirable that the supervisory equipments provide information about weaknesses in the lines connected to the exchanges or in the *LD* network as a whole.

The maintenance philosophy which has been outlined above in connection with city and rural networks is to a great extent based on supervision of the network as a whole by means of programmed test traffic from subscriber to subscriber. In the *LD* network, with its extensive geographical spread and more complicated administration, the principle of individual supervision of each part of the network is applied to a greater extent, i.e. each exchange and each group of trunks is separately supervised. It is consequently essential to verify by means of the traffic route tester that the maintenance of the different parts of the network has been successful and to check the total result by means of test traffic between automatic subscribers spread throughout the country. This is performed by traffic route testers, and by this means the *LD* network is supervised also from the subscriber-customer's point of view.

As in the case of *ARM* in the rural network, service alarm and centralograph continuously supervise the common control units (*VM*, *M*, *TB*, *REG*, etc.) and selector stages. The trunks are supervised as regards transmission as well as switching function by means of the automatic transmission measuring equipment[2] (*ATME*). This equipment is punched-card-controlled and utilizes the normal selector stages as access selectors. It tests the trunk circuits individually, setting-up calls in accordance with predetermined programs. The result is presented on punched cards and for international circuits is recorded at both line terminals.

If *ATME* is not used, the circuit supervision is performed by periodical checks with exchange testers working automatically with test numbers in a suitable local exchange.

Testing of the operation of local exchanges in relation to the *ARM* exchange is performed by means of test traffic set up by the traffic route tester from different exchanges to a " test route " in the *ARM*. Supervision of the operation from *ARM* local exchanges is performed from the *ARM* exchanges by means of terminal control registers and exchange testers.

Equipment in which charging takes place is regularly tested by special tariff testers.

The primary purpose of the *ARM* control register is to indicate abnormal fault or congestion rates at certain destinations or on certain routes. The register also serves as source of engineering and traffic statistics for the appraisement of the *LD* network as a whole. The result is presented either on punched cards or on counters. An operator can, via a visual display connected to the control register, observe the connections handled by the control register.

The supervision of congestion is performed by congestion meters, one per route, and by regular traffic measurements.

The maintenance office for *ARM* exchanges in the *LD* network should be at the *ARM* exchange and be in charge both of the switching and transmission equipments. A large part of the *ARM* exchange information concerns the lines, and much duplication of labour can be avoided by a single organization for directing of the maintenance work at switching centres and repeater stations. To the *LD* maintenance office are sent alarms and all fault reports in connection with *LD* traffic. Input and output units for the supervisory equipment in the exchange are located in the maintenance office, from which *ATME* is also controlled.

As in the case of rural and city networks, it is essential to regard the *LD* network as a single switching machine from the maintenance and operational points of view from the start and to include the capitalized value of the maintenance cost. *LD* centres controlling the *LD* maintenance offices should therefore be arranged at a few places within the *LD* network. The *LD* centres should be responsible for the technical and traffic supervision of the *LD* network both on a short-term and long-term basis.

Economic Aspects

The extent to which centralization can be taken varies with local circumstances. It is our belief, however, that the general principle can be applied all over the world. Automatic and centralized supervision leads to a more rational utilization of staff, and above all better operational results and a better survey of the results.

In the case of new plant, it is natural to plan for economic maintenance from the start and to include the capitalized value of the maintenance cost when estimating the cost of planned plant.

In the case of existing plant the possibility of rationalizing maintenance should be constantly kept in mind, especially if there is a possibility of obtaining better functioning exchanges as a "by-product". In this connection rationalization usually involves investments in buildings, maintenance equipments and staff training. These investments will be profitable and justified so long as they are below the capitalized value of the maintenance cost saved. The saving of one man costing 6,000 US $ per annum over a period of 25 years warrants an investment of the order of 65,000 US $ (see Fig. 6).

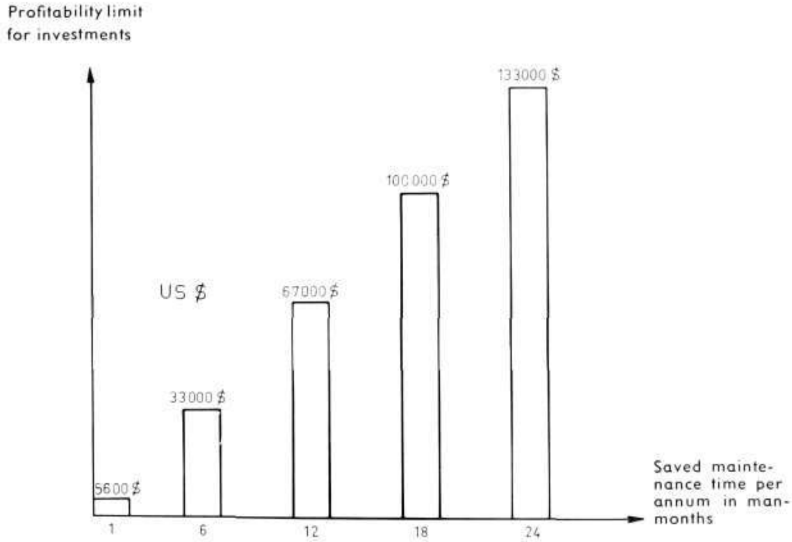


Fig. 6

Profitability limit for investments in relation to saved maintenance time. Account has not been taken of wage increases. At an annual wage increase of 3% the profitability limit rises by about 40%

Annual interest 7.5%
Maintenance cost per man-hour: 3 US $
Service life: 25 years

Future Trends

Future developments will probably accentuate the trend towards centralization. The data technique will make it possible to transmit a large amount of information and to process it at high speed in electronic computers. Technical and traffic information will be data-processed together with fault reports and indicate the probable sources of faults.

The possibility of sending information from the maintenance office to the exchanges facilitates remote-controlled tests and remote-controlled blocking of faulty units, and "storage" of faults for more rational use of the time of the repair staff. Perhaps the greatest advantage in this connection will be the substantially increased facilities for supervision of traffic volume and congestion, which will permit effective centralized supervision of the complicated and expensive national and international networks.

References

1. RAMEL, S. *et al. Manual for Telephone Buildings.* Stockholm: Telefonaktiebolaget L MEricsson 1965. Looseleaf.
2. CARLSTRÖM, P.: *Automatic Transmission Measuring Equipment for Telephone Circuits. 1. Equipment Description.* Ericsson Rev. *40*(1963): 2, pp. 62-68.

LM Ericsson Exchanges Cut into Service 1965

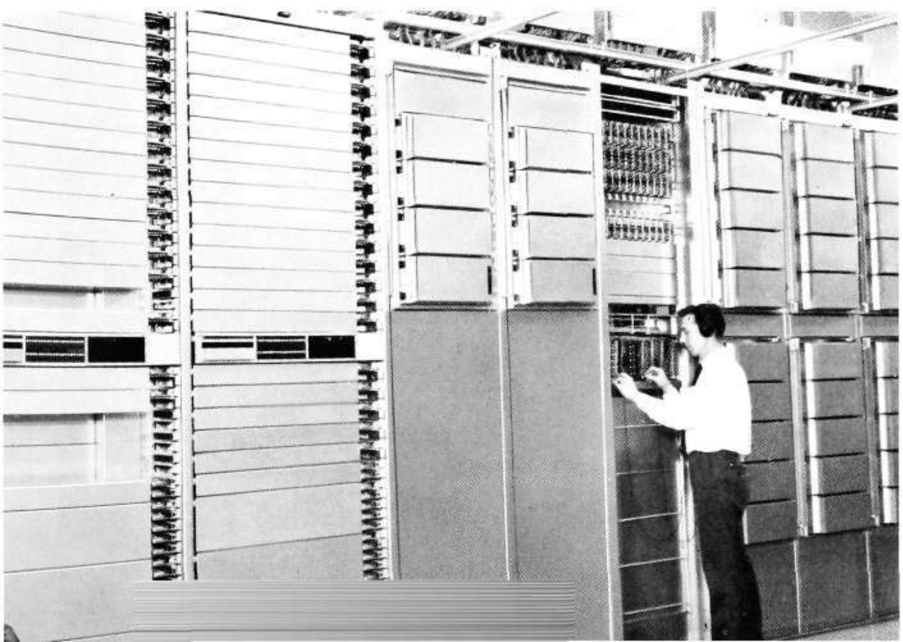
1965—a new record year for L M Ericsson Crossbar Systems. More than 650,000 lines of crossbar systems ARF and ARK installed in 1965.

In the following tables is shown the number of new telephone exchange lines installed in each country during 1965, including extensions of existing exchanges. The figures represent only *public exchanges* and include also equipment manufactured on L M Ericsson licence. Such manufacture on licence is indicated for each country in question by an asterisk.

CITY EXCHANGES

Public automatic telephone exchanges with 500-line, crossbar- or code switches.	500-line selectors Number of lines incl. extensions	Crossbar or code switches Number of lines incl. extensions
Argentine		3,000
Australia		145,000*
New South Wales 61,200		
Queensland 9,800		
South Australia 15,400		
Tasmania 6,600		
West Australia 10,400		
Victoria 41,600		
Bolivia	100	
Brazil	2,000	6,500
Burma		1,000
Chad[2]		200
Colombia	14,200	19,400
Dahomey[1]		800
Denmark		50,600
Ecuador	500	
Ethiopia	1,500	1,800
Finland	2,200	27,600
France[1]		102,880*
Gabon[1]		200
Iceland		900
Ireland		10,400
Italy	39,700	60,800
Ivory Coast		400
Lebanon	10,000	3,400
Liberia		3,000
Mexico	20,500	15,000
Netherlands		12,000
Netherlands West Indies	600	
Niger[2]		200
Norway	5,000	3,800
Panama	5,500	
Sweden	83,500	16,000
Thailand		9,000
Tunisia		6,000
Turkey	12,000	
UAR (Egypt)		42,900
USA[2]		25,750
Venezuela	400	
Yugoslavia		19,000*
Total	**197,700**	**587,530**

[1] System CP 400, delivered by Société Francaise des Téléphones Ericsson, Colombes, or their licensees.
[2] System NX-1, delivered by North Electric Co., Galion, Ohio.

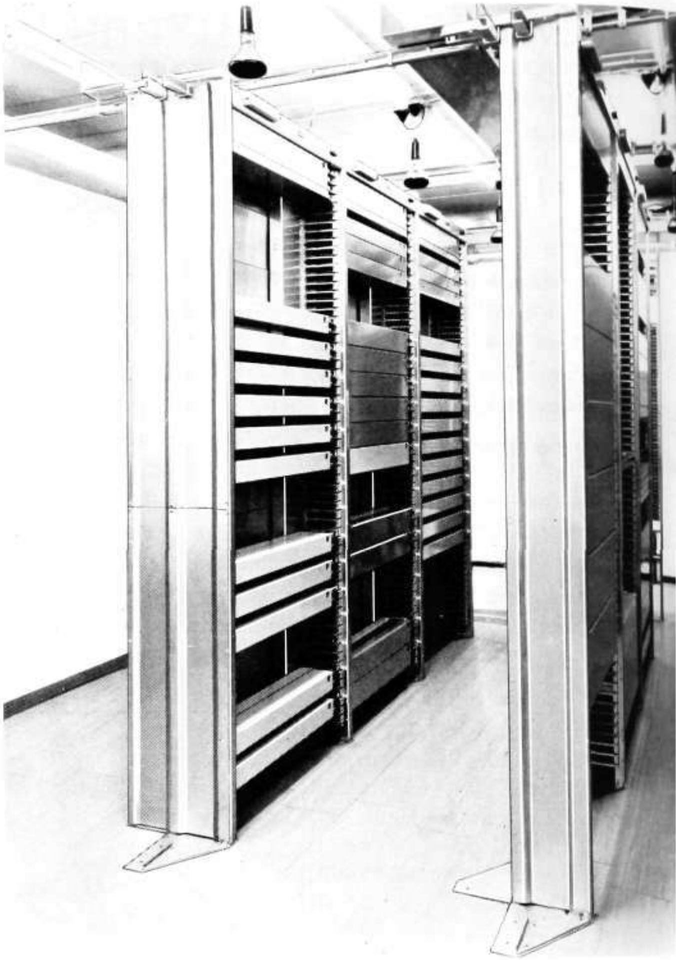


In 1965 public automatic exchanges of a total capacity of approx. 587,000 lines were installed of L M Ericsson Crossbar Systems for city exchanges. In 1960 the corresponding figure was 90,000 lines only, illustrating the rapid advance of L M Ericsson crossbar technique.
The photo shows a group of 1000 lines of system ARF in the new exchange at Brönderslev, Denmark.

RURAL EXCHANGES

Public automatic rural exchanges with crossbar switches, system ARK, ART, NX-2.		Number of lines incl. extensions
Australia		
New South-Wales	2,120	
Queensland	3,330	
South Australia	4,900	21,170*
Tasmania	1,230	
West Australia	2,490	
Victoria	7,100	
Brazil		400
Canada		300
Denmark		9,750
Ecuador		100
Finland		6,280
Iceland		1,410
Ireland		4,090
Italy		6,730
Lebanon		800
Liberia		40
Mexico		1,020
Netherlands		400
Norway		3,120
Sweden		3,200
Thailand		2,800
Tunisia		300
USA[1]		11,910*
Yugoslavia		5,440*
	Total	**79,260**

[1] System NX-2, delivered by North Electric Co., Galion, Ohio.



Today there are more than 3000 automatic rural exchanges in service or on order of L M Ericsson Crossbar systems ARK of a total capacity of approx. 600,000 subscriber lines. The photo shows such an exchange of a capacity of 600 subscriber lines.

The total multiple capacity of L M Ericsson automatic transit exchanges in service or on order amounts today to more than 250,000 lines. The photo shows the group selector stage of an L M Ericsson transit exchange of a capacity of 2000 lines.

TRANSIT EXCHANGES

Transit exchanges with crossbar switches, system ARF, ARM, ART, or with 500-line selectors, system AGF.	Multiple Capacity
Canada	200
Colombia	880
Denmark	10,940
Ecuador	400
Finland	1,640
Iceland	520
Ireland	1,460
Italy	6,280
Lebanon	200
Liberia	80
Mexico	320
Netherlands	800
Norway	720
Sweden	9,335
Tunisia	1,380
UAR (Egypt)	400
Yugoslavia	3,660
Total	**39,215**

ERICSSON News from All Quarters of the World

Important New Contracts

BRAZIL

L M Ericsson has achieved a new advance in Brazil through the order obtained by its subsidiary company, Ericsson do Brasil, for telephone equipment for still another large city, Belo Horizonte, capital of the state of Minas Gerais with 800,000 inhabitants. The contract amounts to 50 million kronor.

The Belo Horizonte contract is for 50,000 lines of automatic local and long-distance switching equipment. It also covers 30,000 telephone sets.

Deliveries are to start in 1966 and be completed by the beginning of 1969, by which time all the earlier equipment will have been removed and replaced by L M Ericsson's modern crossbar equipment.

The bulk of the equipment vill be supplied from L M Ericsson's Brazilian factory at São José dos Campos.

KUWAIT

L M Ericsson has obtained a large order for telephone exchange equipment for Kuwait in the face of hard international competition.

The contract comprises the delivery and installation of five automatic telephone exchanges of L M Ericsson's crossbar system and is worth some 10 million Swedish kronor. The exchanges are expected to be in operation during the first half of 1968.

Kuwait is one of the world's largest oil producers. The country is undergoing rapid development and further expansions of the telephone network will therefore be necessary.

Kuwait is the fifth Arab country to adopt Ericsson crossbar for automatization of its telephone network. The others are the United Arab Republic, Lebanon, Tunisia and Saudi Arabia.

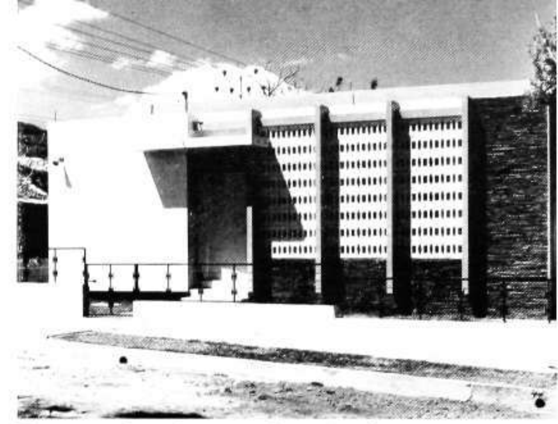
MALAYSIA

In cooperation with ASEA, L M Ericsson has received an order from National Electricity Board, Kuala Lumpur, Malaysia, comprising telephone equipments for power line carrier systems and v. f. metering channels, special telephone switchboards for these carrier systems, and remote control and telemetering equipment.

The project will mean that a large part of Malaysia's most important transformer and power stations will be supervised form a main control room at Kuala Lumpur.

The total contract is worth rather more than 4 million kronor. The order was obtained by ASEA/LME after lengthy negotiations and in keen competition with other suppliers.

From the signing of the contract in Kuwait. (From left) Mr. Hans Augustinson, LME, Mr. Morad Yousuf Behbehani, LME agent, Messrs. Abdul Rahman Ghoneim and Marzouk al Marzouk, Assistant Undersecretaries, PTT, and H.E. Mr. Saleh Abdulmalik Al-Saleh, PTT Minister.



The automatic exchange at Santa Ana is one of L M Ericsson's first in Costa Rica and has an initial capacity of 400 ARF lines.

Large Scale Automatization Project in Costa Rica

During the latter part of 1963 invitations for tenders were issued for a large scale project of automatization of the area centered on the Costa Rican capital, San José, and a large number of provincial towns as well. At the end of 1964 a contract was signed with L M Ericsson for the delivery of five new crossbar exchanges totalling 26,380 lines for San José and the surrounding area (Zona Metropolitana).

The first exchanges were ready for commissioning in early 1966 and on April 30 the two largest exchanges, San José I and San José II, were opened, totalling 17,600 lines. Earlier, 1000 lines had been cut-over at Escazu and 400 lines at Santa Ana.

It may be mentioned that this was one of the first development projects in telephony of which the financing was based on a loan from the World Bank.

To finance its continued expansion on the foreign market L M Ericsson has taken out a 20-year 6 ½ per cent loan of 20 million US $ through a bank consortium headed by S. G. Warburg & Co. Ltd., London, Stockholms Enskilda Bank and Svenska Handelsbanken. The loan was issued at a rate of 97 ¼ per cent and has been placed on the international capital market.
From the signing of the agreement with the banks in London on March 10, 1966. (From left) Mr. S. Wikander, Svenska Handelsbanken, Mr. Marc Wallenberg Jr., Stockholms Enskilda Bank, Mr. Björn Lundvall, and Mr. B. Kelly, S. G. Warburg & Co. Ltd.

Subscriber-Dialled Calls within Scandinavia

At the end of last year a section for outgoing subscriber-dialled international traffic was opened at the Stockholm International Centre. This section will initially handle only traffic from the Stockholm area to accessible parts of Denmark and Norway, but will later handle traffic transited through Stockholm from other zones as well.

Calls are charged by repeated indications directly on the subscriber's meter in the same way as calls within the national network. Under the present tariff calls to Denmark and Norway will be charged at the rate of one call unit per interval of 5.7 seconds.

For settlement between the countries a special settlement equipment has been supplied which permits measurement of the volume of traffic to the various destinations.

New Telex Exchange in Nigeria

On May 6 L M Ericsson's first telex exchange in Africa was opened in the Nigerian capital, Lagos. The initial capacity of the exchange is 120 lines and its ultimate capacity 400 lines.

In an address at the opening ceremony Mr. C. O. Lawson, Permanent Secretary to the Ministry of Communications, denoted the new exchange as a milepost in the development of Nigeria's telecommunications and stated also that plans exist for expanding the telex network to cover other main centres in the country as well.

The opening ceremony was attended by representatives of the Nigerian Chamber of Commerce, members of the government and of the diplomatic corps.

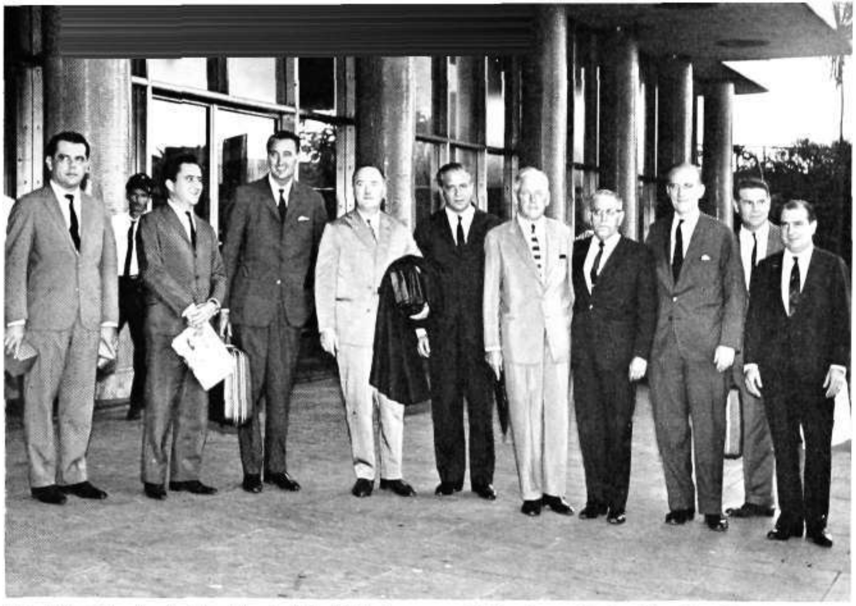
L M Ericsson's Largest Cut-over in Holland

The largest cut-over of LM Ericsson equipment in Holland hitherto took place at the beginning of April 1966. A new group centre, Vlietweg, was placed in service at Dordrecht comprising 15,000 ARF lines with a transit stage of 1400 ARM lines. In conjunction therewith 5000 ARF lines were cut over at Zwijndrecht, 2000 ARF at Berkel, a 400-group of ARM at Rotterdam DC, as well as two AKL 10 detached exchanges of 200 lines each.

A large scale plan of operations had been drawn up for the cut-over, which was completed in the remarkably short time of 21 minutes. Altogether 200 technicians were engaged on the operation.

Among the persons invited to the opening ceremony on April 5 were Mr. S. A. Posthumus, Secretary to the Ministry of Traffic and Water Regulation, and members of the PTT management, among whom Professor G. H. Bast, Mr. P. F. Blickman, Mr. R. Diks, Professor H. L. van Lommel, Mr. A. D. J. Uurbanus as well as representatives of The City Council, Rotterdam Telephone Area and L M Ericsson.

In conjunction with the opening of the new automatic exchanges in the Dordrecht sector an aerial view panel of the area had been prepared. (From left) the Mayor of Dordrecht, Mr. J. J. van der Lee, the Mayor of Dubbeldam, Mr. J. P. M. Beelaerts van Emmichoven, aad the Mayor of Zwijndrecht, Mr. C. Slobbe. On the far right is Mr. John C. Spakler, Director of the Rotterdam Telephone Area.

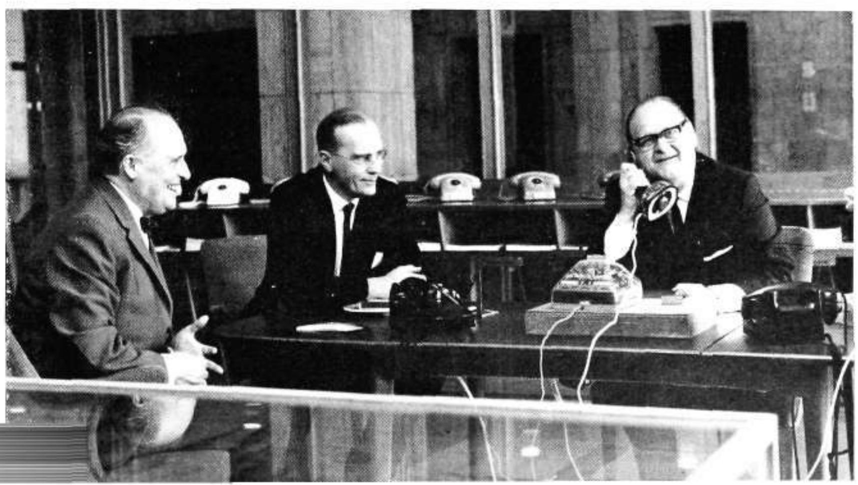


Mr. Björn Lundvall, President of L M Ericsson, and Mr. Arne Stein, Vice President, made an official visit to Brazil at the beginning of the year. The photo shows their arrival at the São Paulo airport. (From left) Mr. José Falcão of L M Ericsson's subsidiary company, Ericsson do Brasil (EDB), Dr. José Diniz, EDB, Mr. Ragnar Hellberg, President of EDB, Mr. Arne Stein, Dr. Geraldo Nóbrega, EDB, Consul General Erik Svedelius, member of the board of EDB, Marshal Nelson de Mello, chairman of the board of EDB, Mr. Björn Lundvall, and Messrs. Einar Bergstrand and Fernando Cenegaglio, EDB.

Mr. Lewis Chagfu (above), Minister of Information and Telecommunications of Zambia, and the new Ambassador to Sweden of the United Arab Republic, Mr. Mustafa Tawfiq (below, right), have visited L M Ericsson at Midsommarkransen. They are here seen being shown round the Exhibition Room by Mr. Erik Lundqvist.

In conjunction with a meeting at the Swedish Board of Telecommunications, the motto of which was "Efficiency and Service", the management of the Board and regional managers of the Administration visited L M Ericsson's Midsommarkransen plant on April 19. They were shown certain sections of the manufacture in conjunction with an examination of L M Ericsson's system for quality control. At the same time L M Ericsson's new features in the field of outside plant construction were demonstrated, during which this photograph was taken in the jointers' school. (From left) Mr. Lars R. Rönnebrink, Mr. Malte Patricks, Vice President, and, from the Administration, Director General Bertil Bjurel, Mr. Gösta Sjögren, Regional Manager, Mr. G. A. Pettersson, Technical Director, and Mr. Arvid Lundqvist, Director of Stores.

Another celebrated guest, Mr. Oiva Saloila of the Finnish PTT, is seen trying out an Ericofon with the assistance of Mr. Björn Lundvall, President of L M Ericsson, and Mr. Malte Patricks, Vice President (left).



Mr. Arvid Westling (left) receives from the new president, Mr. Yngve Åkesson, a split-up cable with an address of thanks from the staff of SKV.

New Head of Sieverts Kabelverk

Mr. Arvid Westling retired on pension at the end of February after more than 15 years as President of Sieverts Kabelverk (SKV).

After graduating from the Stockholm Institute of Technology in 1923 and holding various appointments in the following years, Mr. Westling joined L M Ericsson in 1929 as engineer at Radiobolaget. In 1936 he moved to the Long Distance Division and was appointed its head in 1940. In 1946 he was appointed Chief Engineer and since 1951 has been President of SKV.

His successor is Mr. Yngve Akesson, former Vice President of SKV.

Mr. Akesson, after graduating from the Chalmers University of Technology in Gothenburg in 1949, joined SKV as assistant to the Head of the Plastic- and Rubber-insulated Cable Division. After various other appointments during the years 1954–1965 he returned to SKV and became Vice President in September last year.

L M Ericsson Sells Controlling Interest in North Electric

L M Ericsson has concluded an agreement with United Utilities Inc. Kansas City, USA, under which United Utilities acquires 350,000 shares in the North Electric Company, Galion, USA, a subsidiary of L M Ericsson. The agreement is subject to the approval of the Swedish and United States authorities.

Through this acquisition, at a price of US $ 30 per share, United Utilities will become the holder of some 52 % of the shares in North Electric. L M Ericsson will retain the remainder of its holdings (some 30 percent) and has offered to purchase the shares of minority holders at a price not below the selling price to United Utilities.

The agreement implies that L M Ericsson will continue to participate very actively in the management of North Electric, will place its "know-how" within the fields of sales, engineering, production and administration at the company's disposal and will also cooperate in the development and introduction of new products.

North Electric's program consists of the manufacture and sale of automatic telephone exchanges based on L M Ericsson's crossbar switching systems, Ericofons, and power equipments for telephone operating companies and for manufacturers of data processing equipments and other customers with precise tolerance requirements. The company also manufactures telecommunication equipment for the American Defence Forces. In 1965 North Electric's invoicing amounted to rather more than 23 million US $.

United Utilities is a holding company for the second largest group of telephone operating companies in the United States outside the Bell group and also owns electricity, gas and water works. United Utilities has more than 850,000 subscribers in 17 states and in recent years has increased its range of activities through the purchase of telephone operating companies.

The cooperation between United Utilities and L M Ericsson in North Electric opens the way to further expansion of North Electric's activities and is considered to be of great importance for L M Ericsson through the exchange of experience and the opportunities for introduction of new equipments offered by cooperation with a large American telephone operating company.

Ericsson Technics

Ericsson Technics No. 1, 1966, was issued in April and contains three papers.

The first, "Active Network Synthesis" by T. Fjällbrant, presents a synthesis method for amplifiers using negative resistance elements such as metric amplifiers and controlled sources such as transistors. The synthesized amplifiers have a very low gain sensitivity. A considerable improvement in the gain and phase stability is obtained without any loss in gain, bandwidth or noise figure. In this way a very serious drawback of the parametric amplifier has been overcome.

The second paper, by G. Einarsson, is entitled "Time-Frequency Coded Pulse Communication Systems". The author deals with communication systems of "RADAS" type using time-frequency coded signals. A comparison between different modulation procedures based on the probability of false signals shows that Delta modulation appears most appropriate for this type of system. In this case around five disturbing stations can be allowed per MHz of system bandwidth. The communication facilities for radio stations distributed at random over irregular terrain are being studied.

The last paper, "Statistical Analysis of the Times of Non-Repeated Tasks. A Study of the Ratio of Two Normally Distributed Variables", has two authors, J. Ehrenborg and G. Elofsson. Statistical methods are used to deal with an important problem of administrative rationalization. For qualified office work the hypothesis is set up that both planned and real times have a normal distribution around merely intuitively known standard times. A test for the hypothesis is presented, as also a practical application.

Donation

To assist technological research in Mexico, Mr. Hugo G. Beckman, Head of Teléfonos de México, S.A., has donated 10,000 shares in the company to "Patronato del Centro de Investigación y Estudios Avanzados del Instituto Politécnico Nacional" (Centre for Technological Development and Research). The value of the shares corresponds to nearly half a million kronor and the yield will be used in whatever manner is found appropriate.

UDC 621.395.722
658.58
LME 1540 8344

ERICSSON, O.: *Centralization Trends in Exchange Maintenance*. Ericsson Rev. *43*(1966): 2, pp. 56—66.

The rapid increase in telephone density, the automatization of international as well as national trunk traffic, the introduction of new traffic facilities, and the demand from subscribers for still higher quality of service—all these facts make it necessary to concentrate attention on maintenance to a greater degree than before. Consequently the telephone administrations are forced to choose a telephone system which both requires the least possible maintenance and has inherent facilities for far-reaching rationalization of maintenance. This article shows how L M Ericsson's crossbar exchanges satisfy these requirements and suggests means of rationalization.

Before discussing the centralization trend, L M Ericsson's basic maintenance philosophy will be briefly reviewed.

UDC 669.1.013.5
681.3
LME 872

LANTZ, O.: *Automatic Data Collection in a Swedish Iron and Steel Works*. Ericsson Rev. *43*(1966): 2, pp. 38—41.

L M Ericsson has designed an automatic data collection system HDC 800. The system is based on components of the very highest reliability, which have been thoroughly tested in telephony.

In the past two years an installation has been in use within a Swedish iron and steel works comprising data collection for steel plant-cogging mill, i.e. for the production of steel billets and slabs. The system includes a special signalling plant for direction of the flow of materials through pit furnaces.

UDC 621.395.454
621.376.56
LME 8436

EINARSSON, G.: *An Experimental 24-Channel System with Pulse Code Modulation*. Ericsson Rev. *43*(1966): 2, pp. 42—48.

The article presents an account of an experimental transmission system with pulse code modulation developed at Telefonaktiebolaget L M Ericsson. The system has 24 speech channels and is mainly intended for unloaded cables with repeaters connected at the loading points.

The article describes the operation of the system and its electrical and mechanical structure. Technical data and some experience from a field test in cooperation with the Swedish Telecommunications Administration are presented.

UDC 621.395.636
621.395.721.7
LME 8223

EKSTRÖM, H. & NYLÉN, P.: *MAGICALL—Automatic Dialler*. Ericsson Rev. *43*(1966): 2, pp. 49—55.

MAGICALL, the automatic dialler, is a valuable aid to persons who make large numbers of telephone calls daily. It can be connected to an ordinary telephone set. It memorizes a large quantity of telephone numbers, and with it a call is put through to the desired subscriber by pressing a single button without needing to use the telephone dial. MAGICALL was developed by an American company, DASA Corp., and will be sold by L M Ericsson in many parts of the world. The article presents an account of the dialler and its mode of operation.

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CONTENTS

On cover: Channel pack for three channels in M4-type carrier systems. In the foreground: picture of a channel and group translating bay for the formation of four basic supergroups.

A New Generation of Transmission Equipment

E. ERIKSEN, TELEFONAKTIEBOLAGET L M ERICSSON, STOCKHOLM

UDC 621.395.44
LME 8400

In the following article are described the guiding principles that have been used in the work of designing a new generation of terminal equipment for carrier systems. The requirements which must be placed on the mechanical design so as to be able to make best use of the latest progress in component development are dealt with in particular. One objective has been to design equipment that can be flexibly used in the formation of small and large terminal stations and that permits easy expansion and rearrangement and also requires a minimum of maintenance.

Carrier technology continues to expand in telecommunications. In Sweden in 1955, about 30 % of the junction network, reckoned in circuit kilometres, consisted of carrier circuits. In 1965 this proportion increased to 75 %, despite the network as a whole having more than doubled in that time. There is a similar development in all other countries.

To be able to use cables and radio links as efficiently as possible, telephone channels are combined into ever-increasingly wide bands. At the moment, the CCITT is discussing systems of 10,800 channels per tube pair. In frequency division multiplex systems, the formation of such wide frequency bands is made by a series of repeated modulations so that the individual channels are combined to give groups, after which the groups are combined to form basic supergroups etc. These repeated modulations are a technical necessity, but it has also proved that the systems have great flexibility as through connections between different systems can easily be arranged between these modulation stages. The CCITT has nowadays standardized the basic group, basic supergroup, basic mastergroup and basic supermastergroup frequency bands with a view to simplification of through connection.

The different terminal equipments for coaxial cables and wide band radio links to a large extent contain the same type of equipment, owing to these standardized frequency bands. It can be said that all equipment forms a family. Fig. 1 shows the most important blocks in this carrier family which as regards to cost and volume comprise the dominating portion of the transmission material in most repeater stations.

It is therefore natural that an immense amount of work is being carried out at L M Ericsson so as to be able to continually supply our customers with modern equipment fulfilling all requirements concerning electrical performance, occupying small space and having great reliability. A new design of all blocks shown in fig. 1 has been carried out. In this number of Ericsson Review, a number of the basic ideas and a description of some of the most important modulation stages will be given. The type of construction used in this new design has been designated *M4*.

Design Objectives

Development of all types of transmission material has so far tended toward smaller and smaller volume. As regards carrier systems, the major part of the terminal equipment consists of channel translating bays. If the volume per terminated channel is calculated for these bays, a good measure of the volumetric development of carrier systems is obtained. Fig. 2 shows how the space requirement has decreased over the years.

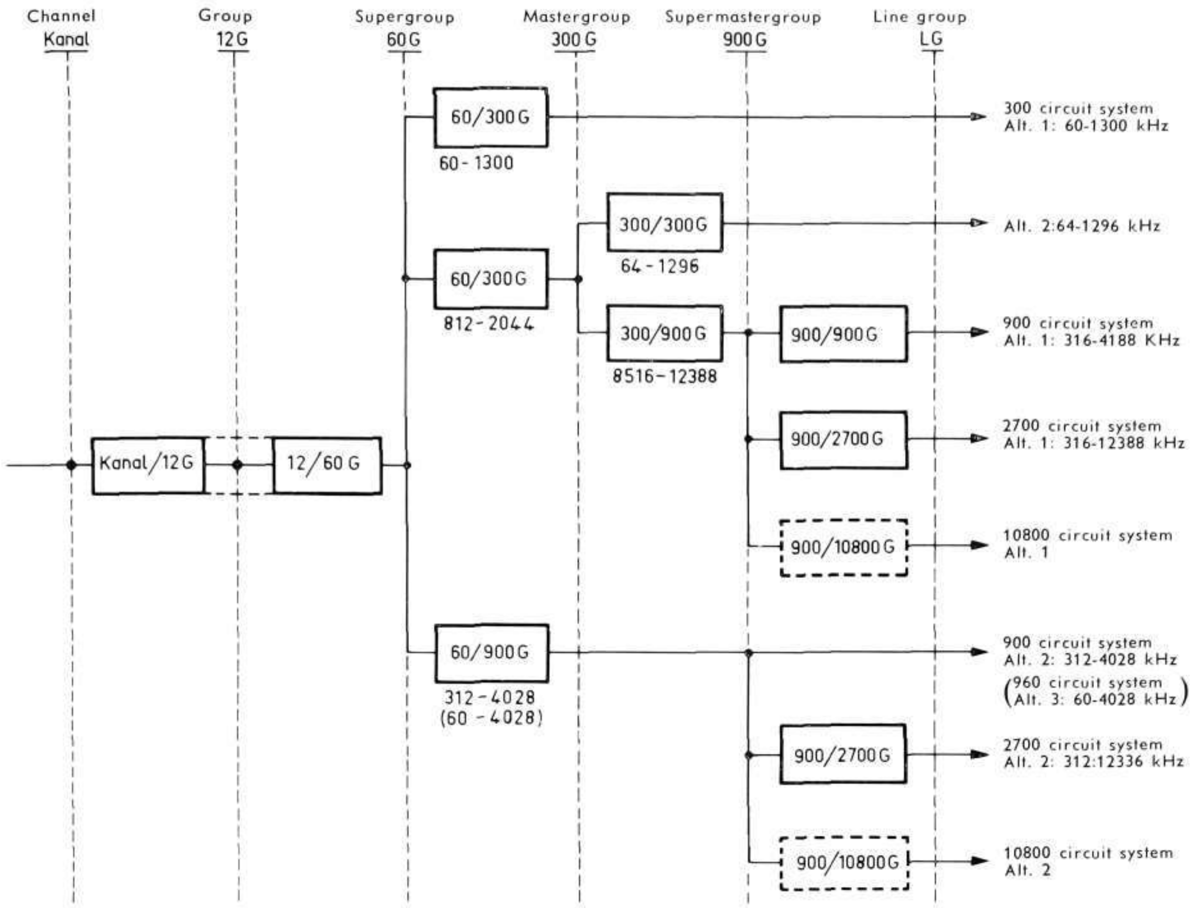


Fig. 1

Modulation block used in terminal equipment for the most important carrier systems for coaxial cables and radio links.

This development has meant that telecommunications administrations have been able to use existing station buildings for many more terminated channels than originally planned. This normally does not mean so much as regards the cost of the equipment rooms as this is, as a rule, only a few percent of the cost of equipment. From the telephone administration's point of view it is more important that the erection of new station buildings can be postponed for the future and that its heavily tried personnel resources are not loaded with a large amount of planning work. This work is particularly difficult if the repeater station cannot be increased in size but must be geographically moved.

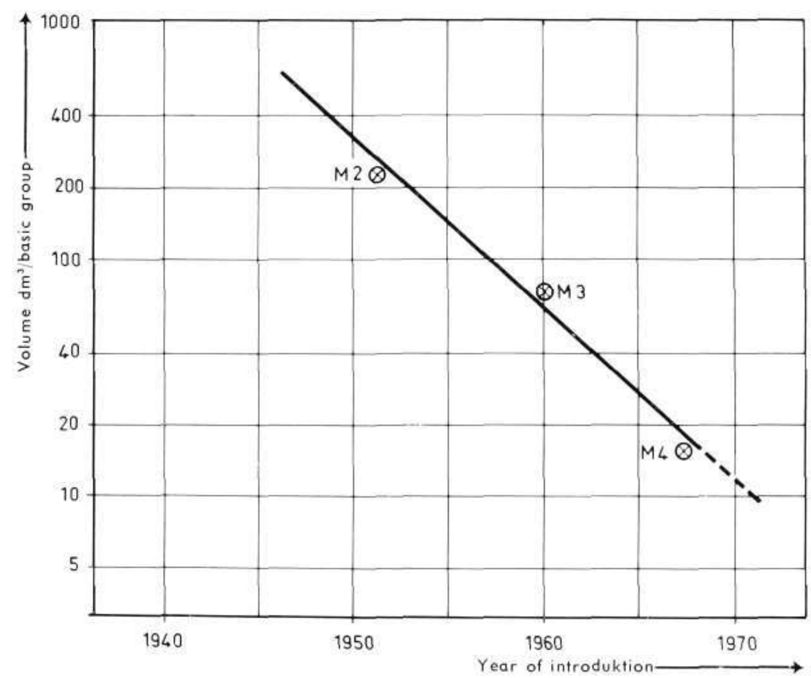


Fig. 2

Reduction in volume of channel translating equipment of L M Ericsson's manufacture.

The trend toward miniaturization is also to be found in a general desire to replace raw material by technology. This development applies to all parts of the carrier equipment from components to complete sections of systems. By using less raw material but subjecting what is used to more refined manufacturing processes, which for their maturity require a great amount of development work, a different cost distribution is obtained. This distribution has higher development and tool costs but on the other hand there are lower variable costs, which give optimum economic results with still larger production series.

The objective has therefore been to make every effort toward miniaturization and to obtain the optimum ratios of the different equipments in the station buildings. When using the best coil ferrites and the most advanced electronic components available on the market, associated with highly developed filter calculation technology, it was considered at the start of development that a reduction in volume by a factor 3:1 could be obtained for the channel translating equipment. Even for the other stages of modulation it was possible to make very great reductions in volume as in this equipment tubes could be replaced by transistors.

Now, after the development work has been completed, it can be established that the objectives stated above have been more than fulfilled. Fig. 3 shows a bay layout drawing for a proposed 12 MHz terminal equipment with 7200 terminated circuits and a normal number of through connected supergroups, mastergroups and supermastergroups. In the method of construction used so far, this equipment occupies 13 rows of bays, whereas using the *M4* construction only 3 rows are needed.

Mechanical Construction

A consequence of the reduction in volume is that an *M4* bay side contains so much equipment that the bay side has become too large to be used as a unit for subdivision of terminal equipment into suitable functional equipment sections. The *M4* bay side as a unit would lead to bad utilization of the space, or to a large number of different bay types if an attempt was made to improve the space utilization.

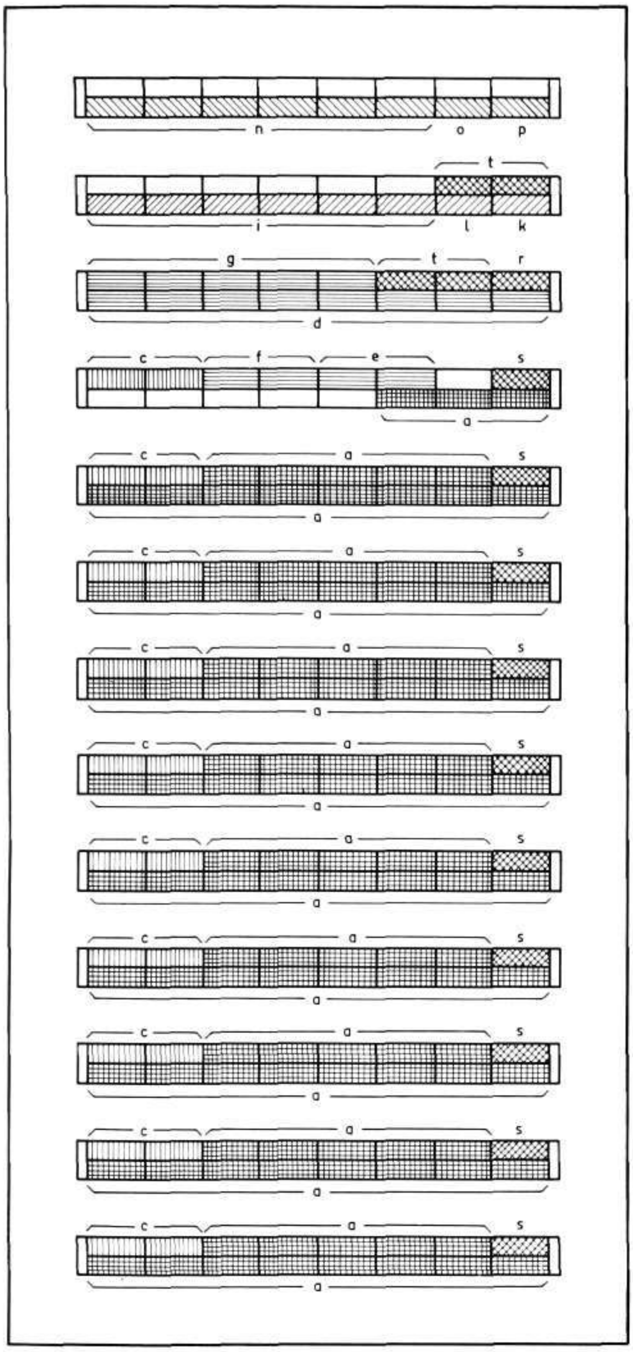
To avoid these disadvantages, a smaller unit than the bay, the pre-wired sub-bay assembly or shelf stack has been introduced in *M4*.

The Shelf Stack

This is characterized by the following:

- ☐ The shelf stack is connected to the bay plug and jack. The station cabling is brought direct to the shelf stack.
- ☐ The shelf stack is a pre-wired and tested functional unit of the system and therefore contains maintenance test points.
- ☐ The shelf stack is made in a few sizes containing 1–5 shelves so that different-sized functional system sections fill the shelf stack in the best way.
- ☐ The equipment units in the shelf stack are removable and provided with plug and jack in the same way as the units in bays of the present construction.

Even if the shelf stack and units are connected with plug and jack, the *M4* design contains fewer contact connections per system than the present construction (designated *M3*) owing to the highly developed miniaturization.



M3

BAY TYPES

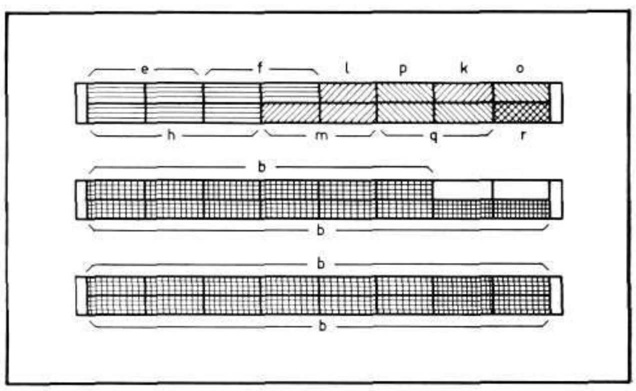
a) Channel/basic group (Ch/G)
b) Channel/supergroup incl. carrier generation

c) Group/supergroup (G/SG)
d) Supergroup/mastergroup (SG/MG)
e) Supergroup through connection
f) Supergroup distribution frame
g) Supergroup regulation
h) Supergroup/mastergroup incl. carrier generation

i) Mastergroup/supermastergroup (MG/SMG)
k) Mastergroup through connection
l) Mastergroup distribution frame
m) Mastergroup/supermastergroup incl. carrier generation

n) Supermastergroup/2700 line group
o) Supermastergroup through conneciton
p) Supermastergroup distribution frame
q) Supermastergroup/2700 line group incl. carrier generation

r) Master oscillator
s) Carrier generation and amplification 12—612 kHz
t) Carrier generation and amplification 1364—16720 kHz



M4

Fig. 3

Station plan for carrier terminal for six 12 MHz h.f. lines

The following assumptions have been made

1. 7200 circuits are terminated
2. 30 supergroups of 150 are through connected
3. 6 mastergroups of 36 are through connected
4. 6 supermastergroups of 18 are through connected

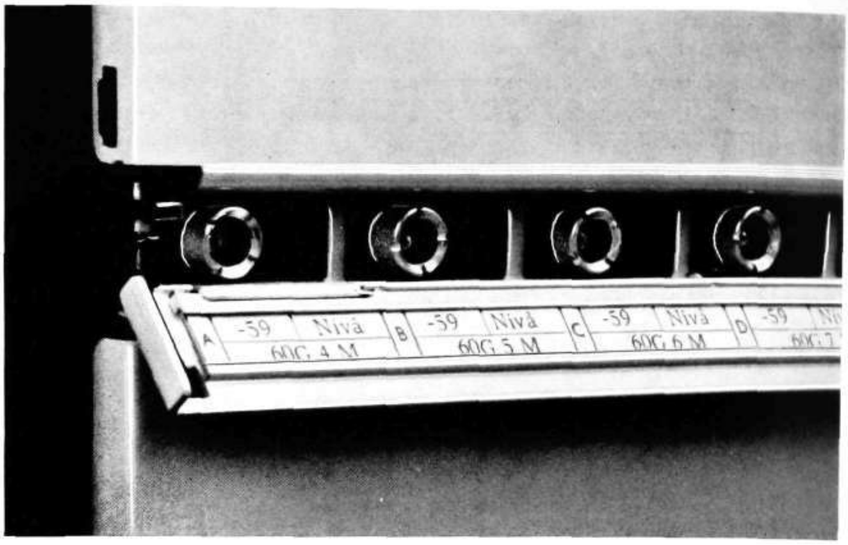


Fig. 4

Maintenance test points are easily accessible under the apparatus units.

The Bay

The introduction of the shelf block influences the design of the bay frame and cabling. The *M4* bay has been constructed in the following way:

- ☐ The left bay upright forms a suitable channel for stowing station cables to the shelf stacks.
- ☐ The right bay upright contains cabling joining the shelf stacks in the bay.

The bay height, width and depth have not been changed from the corresponding *M3* dimensions. This is done so that there will be no difficulties when extending existing L M Ericsson carrier terminal equipment. The general appearance and colour composition of the equipment has likewise been retained.

It should be noted that the maintenance test points do not belong to the fixed bay equipment but have now been placed on the shelf stack. The principle of having the maintenance test points directly accessible for measurement purposes is still followed, however. This has been realized in *M4* by the test points being placed behind a retractable cover which when folded down acts as a designation strip (see fig. 4).

The way the shelf stack functionally replaces the bay side as a planning unit when composing terminal equipment is shown in the diagram, fig. 5.

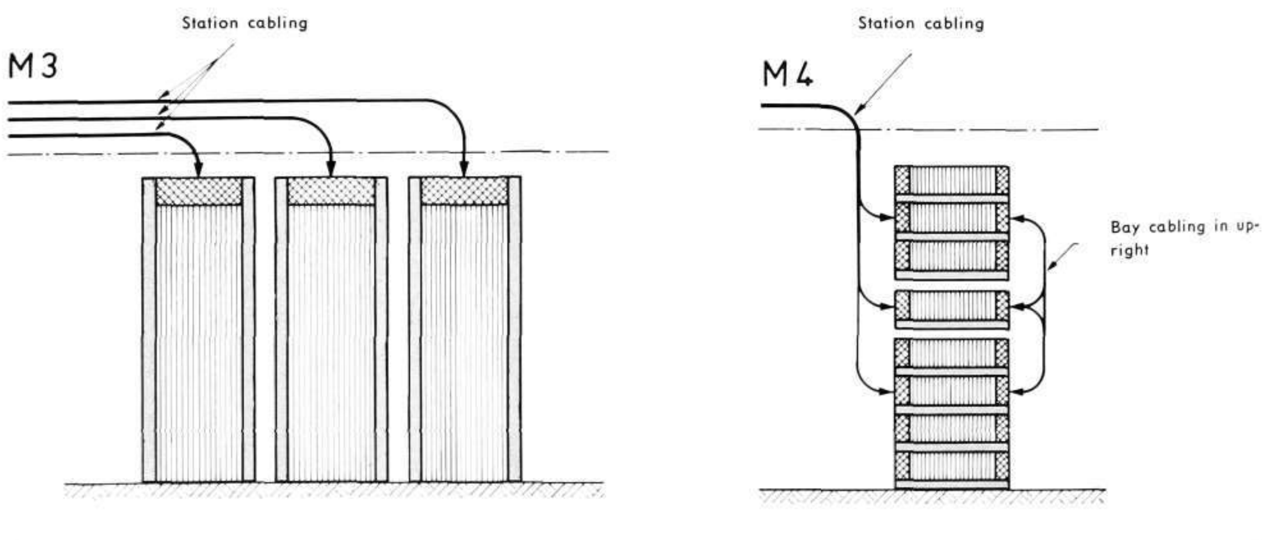
Fig. 5

Comparison betwen M3 and M4 methods of construction regarding bay layout

Bay and shelf cabling

Test field for maintenance

Terminal strip field



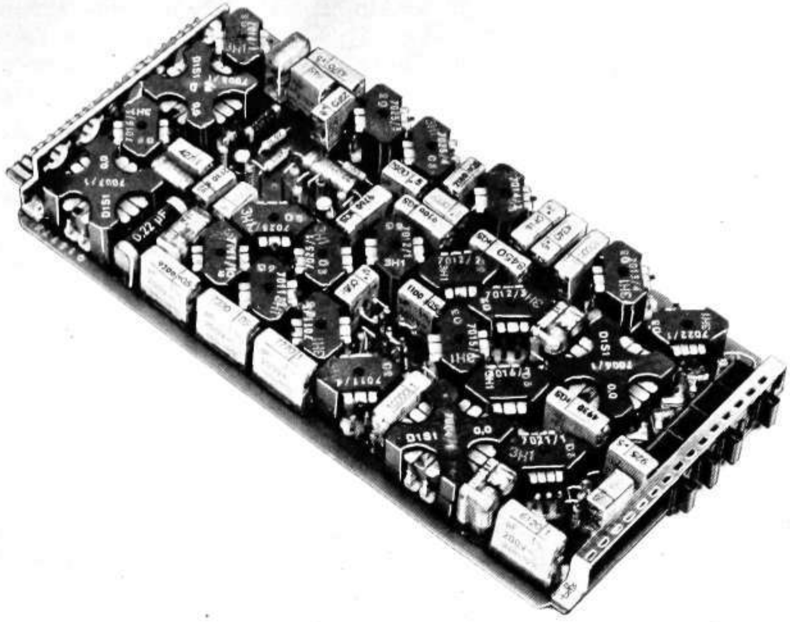


Fig. 6

Printed circuit card contain channel modulator, demodulator, channel amplifiers, limiters and signal sender.

Apparatus Units

The apparatus units are produced to very fine tolerances as far as their electrical characteristics are concerned so that no subsequent adjustment is necessary after replacement. To facilitate fault finding, each unit is provided with fault finding test points on its front. These test points, which, due to the high operational reliability of the equipment, are very seldom used, are placed behind the shelf stack dust covers.

The apparatus components are mounted on etched copper foil laminate cards. As the size of the components has been reduced, the number of components per card has increased (see fig. 6). It has not proved necessary to resort to double foiled laminate. On the other hand, the number of contacts per board has increased from 16 to 22. Furthermore, the apparatus design permits a maximum of 5 coaxial connections (see fig. 7). The screening between

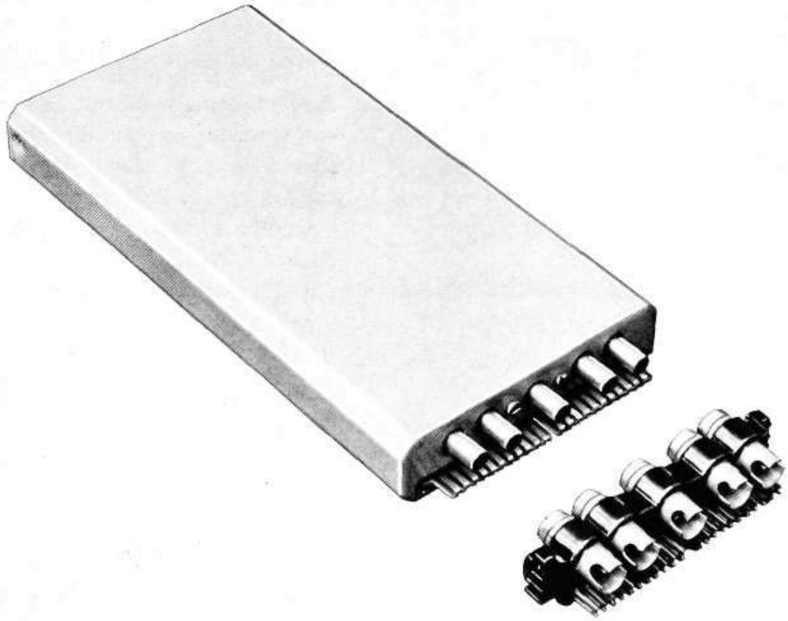


Fig. 7

Apparatus unit with coaxial connectors

the units has also been improved, thereby enabling the same unit construction to be used in the design of almost all equipment used in a 12 MHz terminal station.

To obtain optimum coil design with cubic dimensions as far as possible, it has been necessary to introduce a new component height when using new ferrite materials. The height obtained in this way has been fixed at a maximum of 15.5 mm. The IEC Commission TC 52 which is concerned with the standardization of component heights has suggested 15.0 mm, thereby enabling us to use components to the IEC standard in the *M4* method of construction to advantage.

The etched wiring card with components is placed in an aluminium case which provides the necessary electrical screening between the units and at the same time gives reliable protection from dust and mechanical interference.

Using the new component height, a shelf contains 21 single card units. To be able to obtain equipment which can be more comprehensible and also make better use of the space, aluminium cases holding two, three or four wiring cards are used wherever possible from the crosstalk point of view. The shelf design is so flexible that all width variants lying in a module square of 4.25 mm are acceptable. Even units of our present design can be used in the new shelf.

Practical Advantages of the Shelf Stack Form

With this method of construction, the following have been gained:

☐ *Simplified installation planning*

When installing a terminal station of *M4* type, all the station cabling can be made irrespective of the delivery situation of the shelf stacks. The right hand and left hand bay uprights consist of entirely separate units. The left hand bay upright is identical for all types of bay and can be supplied together with the runway material. It is therefore possible to complete all station wiring as far as the shelf stack at a time suitable to the installation teams which are available. When the time is suitable the right hand bay upright is supplied which is only used for the individual bay cable. This cable does not require connection to the station cable.
The shelf stacks can then be placed in the bay. These stacks are connected to the station and bay cables by plugs and jacks and this means that qualified installation staff need not be used to make these connections.

☐ *Simplified planning of extensions*

A telephone administration can utilise the flexibility of the *M4* method of construction so that important shelf stacks, e.g. supergroup shelf stacks (the shelf stack that assembles 60 telephone channels into 1 supergroup, see fig. 1), are kept in a central store. This material can then be used for extending stations which at the time in question have the greatest need of channels. As the shelf stack is made as a completely tested unit, it can be put into traffic at very short notice.

☐ *Better economics*

In the case of partly equipped bays the basic equipment is not so expensive. By subdivision of each shelf stack it is sufficient to acquire only those parts which are immediately required.

Electrical Construction

In the previous paragraph, a description has been given of a mechanical method of construction where the building elements permit a division of the terminal station into system sections of practically any size. The question now is how the station equipment should be subdivided so as to obtain a "building block" system of shelf stacks which is economic and provides attractive system solutions from the maintenance point of view for all cases of terminal station belonging to the carrier family shown in fig. 1. Furthermore, a system should be evolved which can use the same shelf stack to advantage for equipment having many or a few terminating channels.

Modulation Equipment

It is quite clear that each stage of modulation between a CCITT standardized group band should form a separate shelf stack because the equipment is then independent of the number of through connected groups. As all administrations do not use the basic group for through connection, some variants of channel translating equipment are required. The shelf stack subdivision, however, is mainly the same as the block shown schematically in fig. 1.

Frequency Generating Equipment

The construction of the frequency generating equipment is not so self-evident. So far, it has been most usual to use central carrier supply. For economic reasons one tries to feed as many modulators as possible from each carrier amplifier. In the event of a fault on such an amplifier, however, a large part of the terminal is put out of action and one is forced to duplicate the whole equipment and to provide automatic change-over equipment on all carrier outputs.

In the *M4* method of construction, the carrier generating equipment has been decentralized so that only the 84.08, 411.92 etc. kHz pilots and certain basic frequencies 12, 124 etc. kHz are generated centrally.

The centrally generated frequencies feed the decentralized harmonic generators with associated filter equipment. All higher modulation stages have been allocated one such carrier generating equipment. Only in the case of channel translating equipment has this not been done for economic reasons. Here, there is one harmonic generator per 300 (240) channels.

The method using decentralized carrier supply has many advantages, among which are:

- The equipment is more economic for small terminal stations
- Temporary breaks in the signal path caused by the different phase relationships between the carriers from regular and standby equipment, with both manual and automatic changeover are avoided. These breaks do not disturb speech transmission but disturb other forms of information transfer e.g. v.f. telegraphy or data transmission.

As the carrier generation has been decentralized and placed together with its associated modulation equipment, there is no longer any reason for duplicating these parts of the carrier supply. It is true that a fault in a harmonic generator puts the whole block out of function but the same can be said about the amplifier used to amplify the groups modulated in the block. As the harmonic generator only generates frequencies for a few modulators, the power requirements are low and fault probability is no greater than the wide band amplifiers used in the modulation equipment which are normally not duplicated in transistorized equipment.

The same principles as previously are used for the central part of the generator equipment, i.e. completely duplicated equipment and automatic changeover as near to the frequency outputs as possible. Even if it has not been completely possible to avoid the changeover equipment, the number of equipments has been reduced appreciably. In an *M4* type 12 MHz terminal equipment there are a total of 3 changeover switches for the frequencies 12, 124 and 440 kHz. According to the previous arrangement there were at least 22 changeover equipments.

Furthermore it should be noted that the number of components in circuit before the changeover points has been appreciably reduced and therefore the fault probability in this equipment has decreased and as a result of this the number of changes over. Also, as the manual changeover facility from regular to standby equipment has been removed, changeover occurs only in the event of a fault in the common frequency generating equipment. The mean time between failures (MTBF) for this equipment and therefore the mean time between automatically controlled changes over is better than 10 years for a 12 MHz terminal equipment. We therefore consider that the new design of the generator equipment has eliminated the disadvantages of the automatic changeover. When there are small terminals, the decentralized equipment is economically more advantageous than the equipment using the previous principles.

Finally, it can be said that the carrier distribution has been appreciably simplified as the carriers are generated at the point of use. Only distribution of the basic frequencies and certain pilots need occur within the station.

Power Supply

In the *M4* method of construction, a decentralized power supply has been retained, i.e. each bay has been provided with its own power supply unit.

Each of these units is available in different types so that the primary voltage can be obtained from the a. c. mains (220 V, 127 V or 110 V) or from a possible station battery (24 V, 36 V, 48 V or 60 V).

To facilitate connection to these different primary voltages, the power supply units are provided with built-in voltage stabilizers which have such a regulating range that normally occurring voltage variations of the a. c. mains and station batteries are compensated.

The M4 Method of Construction Used in Mechanical Design

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LME 60 84

The article describes the M4 method of construction from the mechanical point of view, how the problems of reduction of volume while retaining flexibility were solved, how the design has been carried out to obtain simplest installation work and to a certain extent what experience has been gained during the development period.

General and Objective

When regarded as a mechanical design the present method of construction *M4* is a new development which has taken advantage of the technological advances made in different branches since the previous method of construction *M3* (see Ericsson Review No. 4, 1960) was designed. The design work which has been explained in the previous article in this number has followed the guiding principles given below.

- The reduction in volume of electrical components and their smaller height 15.5 mm (previously 23.5 mm) shall be fully exploited.
- The method of construction shall permit a division into mechanical units which shall fully correspond with the electrically functional sub-division. As mentioned in the previous article, this results as a rule in appreciably smaller, more easily handled mechanical units than in previous methods of construction.
- Owing to continually increasing cost of salaries and wages the method of construction shall be made so that installation work is kept to a minimum.
- If possible, one should be able to connect units of *M3* method of construction to equipment of the *M4* type.
- The units shall be mechanically designed as regards screening, connections etc., so that they can be used for higher frequencies than units of previous methods of construction.
- The main dimensions of the bay shall be the same as those for an *M3* bay, likewise the method of installation and appearance shall be suitable for its inclusion in stations arranged for *M3* bays.
- Otherwise, the same assumptions for *M4* as regards flexibility, availability of maintenance test points, dust protection etc., apply as in *M3*.

The method of construction which will now be described in more detail fully satisfies the specified objectives and has enabled very compact designs to be made that take full advantage of available space. This is clearly seen in figs. 1 a and 1 b.

Basic Dimensions and Module Sizes

The determination of the basic dimensions and module sizes has been made in collaboration with the designers who have developed the digital equipment method of construction used in L M Ericsson. Consequently, a certain agreement can be discerned in this respect.

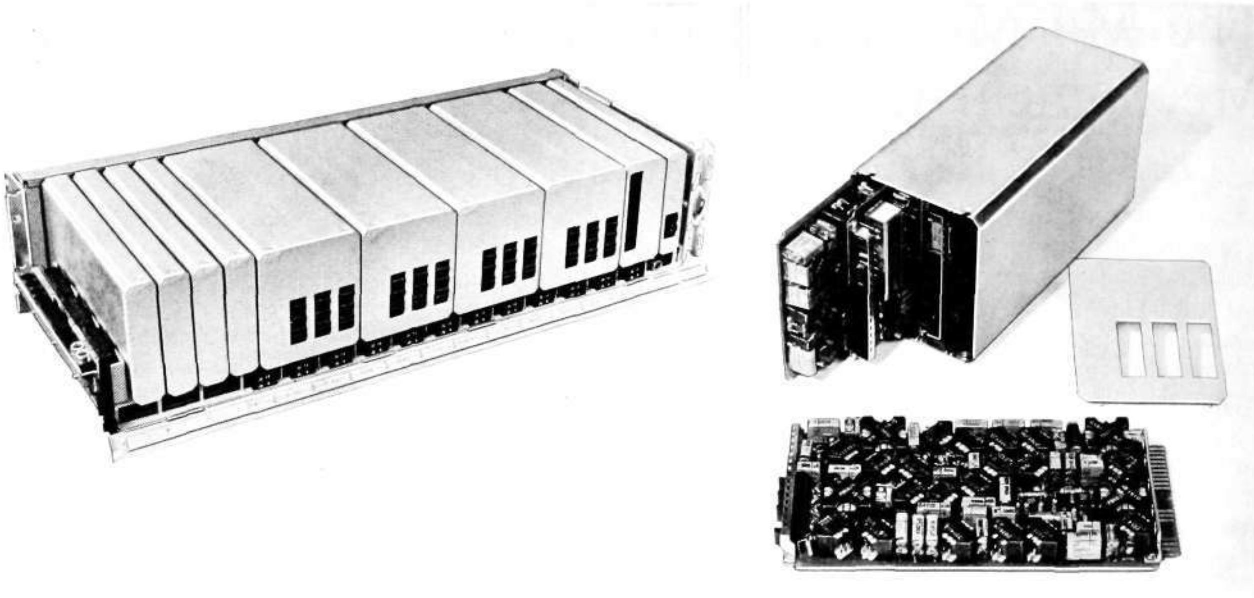


Fig. 1

Shelf complete with units; right, an unmounted 21 module unit

The pictures give a good idea of how well the space has been utilized in this method of construction.

The development work has resulted in a bay design having the same main dimensions as previously 670 × 236 × 2743 (max.) mm (26.4" × 9.3" × 9'). A bay with this height is sub-divided vertically into 67 height modules of 40 mm (1.57") [previously 36.5 mm (1.4")].

The units are placed in shelves that are sub-divided horizontally into 128 width modules of 4.25 mm (0.16") [previously 16 modules of 34 mm (1.34")]. This somewhat uneven module dimension has evolved as the highest common factor for space requirements for component heights of 23.5 mm (0.9") and 15.5 mm (0.6").

The contact module for unit and shelf connections is $3^1/_3$ mm (0.13"). This uneven dimension is determined by requirements of the automatic wiring equipment which is expected to be used in the manufacture of certain equipment.

Apart from the width module (as seen inserted in the shelf) the units have the same main dimensions as in *M3*.

Unit Construction

Mechanically, the units consist of one or more sub-assemblies mounted in an aluminium case of suitable size. This flexibility permits a mechanical subdivision which nearly always agrees with the sub-division into electrically separate functions.

Each sub-assembly is made as a circuit card where the electrical components are mounted on a printed wiring board like the previous method of construction, i.e. a board where the etched foil pattern only acts as wiring between the connecting tags of the electrical components. The card material is usually phenolic paper laminate. Owing to the smaller and smaller dimensions of the electrical components, the requirements of the accuracy in manufacture of these printed wiring boards have been made more stringent. It can be mentioned, for example, that the smallest permissible conductor width and insulating distance has been reduced from 0.8 mm (0.0315") to 0.6 mm (0.0236") and the smallest distance between two adjacent component tag holes for different conductors has been reduced from 5.08 mm ($2 \times {}^1/_{10}$") to 3.59 mm ($= \sqrt{2} \times {}^1/_{10}$"). The external dimensions of a normal board are the same as the previous method of construction, except for small cuttings out. Owing to technical advances in manufacture of the cases it has been possible in the new method of construction to have printed boards of half the normal width. These are of particular use in units requiring a small or a long, narrow component mounting space. See fig. 2.

One end of the sub-assembly is shaped as a plug strip. To ensure good contact function when connecting to a matching jack strip, the printed wiring which has been brought out to the edge of the card is terminated in gold-plated contacts bent round the edge of the card. This prevents the socket contacts from scraping away phenolic powder when plugging in the sub-assembly which can thus endanger the good contact function. With a contact module of $3^1/_3$ mm (0.13") the maximum number of contacts for the whole card width is 22 and for half width is 8. The contact end is also provided with a bracket, the main purpose of which is to hold the sub-assembly in place in the case with the help of captive screws, but also acts as a fixing bracket for any coaxial connectors that may be required. These connectors when in the form of coaxial plugs (up to 5 per apparatus unit of full width and 2 per unit of half width) are screwed directly into the bracket and are connected to the wiring board with connecting wire and a screening bracket or with coaxial cable. See fig. 2.

The other end of the sub-assemblies can be provided, if required, with test blocks, strapping strips, U-link strips, push button switch strips etc.

The strips which are made of carbonate plastic are assembled and in most cases mounted with the help of hot rivetting and are held in place on the card by a bracket holed at 5.08 mm ($^2/_{10}$") centres. Figs. 1 b and 2 show the strips and their mounting.

The cases in which the sub-assemblies are mounted act as protectors from mechanical damage and from dust. They also act as electrical screens between the units and sub-assemblies and as a frame holding the sub-assemblies together. The cases are produced by cold flow moulding. The units are placed in shelves so that the sub-assemblies are vertical. Consequently there is a direct relationship between the number of sub-assemblies in the unit and the space required in the horizontal direction [module = 4.25 mm (0.16")]. Each sub-assembly having a component height of 15.5 mm requires 5 such modules. To this is added 1 module to allow for case walls and necessary play.

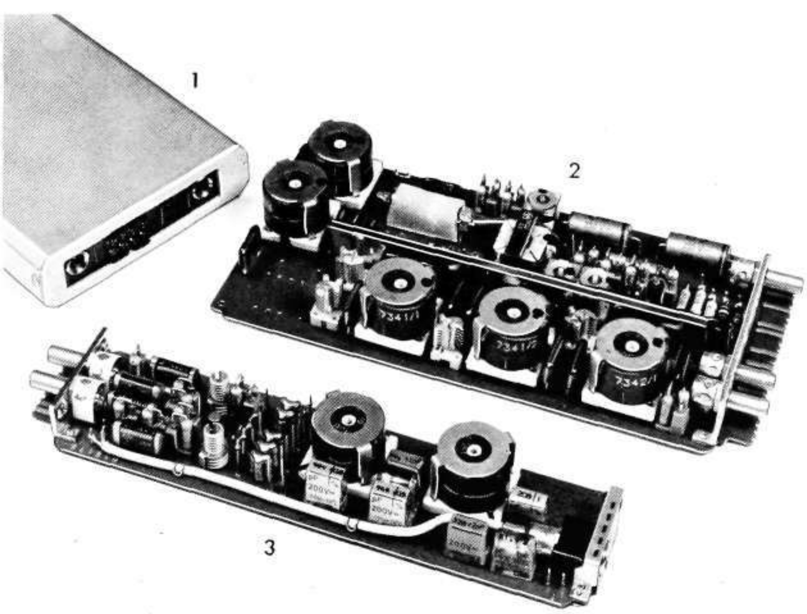


Fig. 2
Unit and sub-assemblies

1 Unit for 15.5 mm component height with coaxial test points and strapping field
2 Sub-assembly (component height 23.5 mm) with normal width and coaxial connectors
3 Ditto of half width

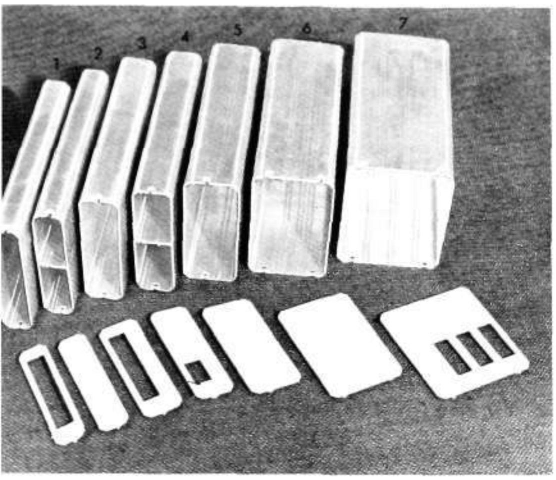


Fig. 3
Cases (types SDD 551-555) with matching front plates (733250-254)

1 Case of six 4.25 mm modules width
2 Ditto with intermediate wall
3 Case of 8 modules width
4 Ditto with intermediate wall
5 Case of 11 modules width
6 Case of 16 modules width
7 Case of 21 modules width

It has been considered necessary to have the following unit widths and maximum contents for the cases.

Case shape			Sub-assemblies accommodated		
No. of 4.25 mm with modules	Intermediate wall width	without	No.	Width	Component height (mm)
6		×	1	$^1/_1$	15.5
6	×		2	$^1/_2$	15.5
8		×	1	$^1/_1$	23.5
8	×		2	$^1/_2$	23.5
11		×	2	$^1/_1$	15.5
16		×	3	$^1/_1$	15.5
			2	$^1/_1$	23.5
21		×	4	$^1/_1$	15.5

The case height and depth are the same as in the *M3* method of construction, i.e. 101 mm (4") and 198 mm (7.8") respectively.

The open end of the case which is the front end of the unit is covered with a die cast aluminium lid provided with suitable holes for the front strips of the sub-assemblies and with the code number of the unit embossed at the bottom left. Cases with matching fronts are shown in fig. 3.

The lid is held fast to the case with a dowel in the lower edge of the case and a screw at the top edge. This arrangement is made so that the screw need only be loosened a little to allow removal of the lid.

Like the previous methods of construction the cases are subjected to a pickling process so as to give a matt aluminium finish. The lids, on the other hand, have been given a stove dried grey painting so as to obtain a good finish.

Shelf Design

The shelf which supports the units occupies a space of 3 vertical modules of 40 mm (1.57") each and mainly consists of a supporting box girder design with bent up ends and a rear frame screwed to this for holding the requisite contact sockets for connecting to the units. See figs. 4 and 5.

The upper plate of the box girder and the rear frame are provided with holes and grooves respectively having a module spacing that corresponds to the horizontal width module 4.25 mm (0.16"). This enables a unit having a width suited to this module and to the requisite contact sockets, to be placed in any position in the 128 modules of the shelf. The holes in the upper plate of the box girder are used for mounting the guiding studs required to guide the unit into the contact socket. The upper plate of the box girder can easily be removed after undoing three screws.

The front edge of the box girder has been formed to hold the maintenance test strips, fuse and lamp strips, strips with switches, sockets for plug-in type pads, etc., a selection of which is shown in fig. 6.

By spring loading the front edge and providing it with shoulders, each strip can easily be mounted by inserting it from the back. Details of the frame are seen in fig. 5. There is space for 16 strips.

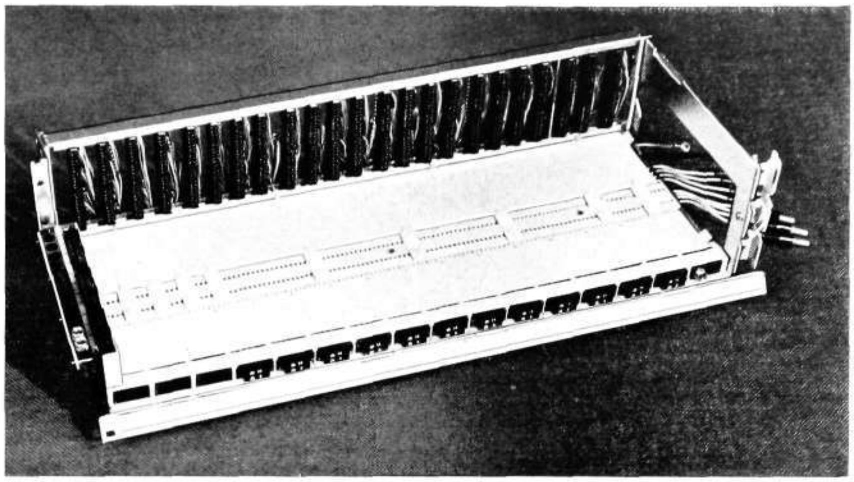


Fig. 4
Shelf for plug-in type units
Left, connector field for connection to station cabling and right, connectors to bay cabling. On the upper side of the box girder can be seen the holes for the guiding studs and in its front edge the retractable designation strip and strips for supervision etc.

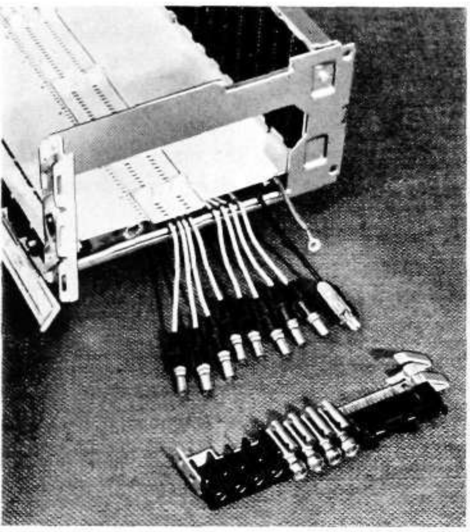


Fig. 5
Detail of right hand end of shelf with connectors for bay cabling. At the bottom, shelf guides with connectors

The contact sockets for unit connections are held to the frame by two longitudinal bars having a few screws. The body of the contact socket is made in four different types:

a) only for flat pin contact sockets with $3^1/_3$ mm module,

b) for both flat pin contact sockets and coaxial sockets,

c) only for coaxial plugs, and

d) for flat pin contact sockets with 4 mm module.

Contact sockets types c and d are used for connecting units developed using the previous method of construction.

Contact sockets a to c are shown in fig. 7.

The soldering side of the contacts is protected by a rear cover plate secured by two screws at the shelf ends.

The shelf is connected to the station cabling by fixed contact sockets placed along the left end of the shelf. Here there is space for up to 9 strips each holding either 26 (alternatively 3×6) flat pin contacts or 4 coaxial sockets.

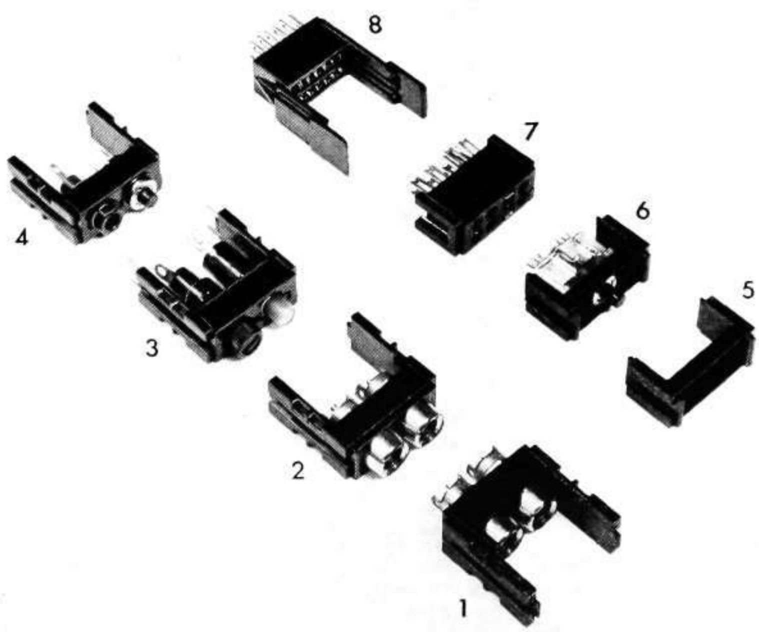


Fig. 6
A selection of strips for the shelf front
In the front row, strip 730080 equipped for four different fields of use
1 Coaxial sockets RNT 14802 for U-link connection
2 Ditto for test purposes
3 Fuze holder and lamp holder (NFS 14402)
4 Sleeve connector RNT 16021 and push button switch RMD 94001

In the far row,
5 Dummy strip 730082/1
6 Strip 730082/2 with push button switch RMD 94002
7 Flat pin contact socket RNV 22004 for test purposes
8 Flat pin contact socket RNV 22001 for plug-in pads

The shelf is connected to the internal bay cabling, i.e. the connections between different shelves in the same bay, with the help of contact sockets joined to the cables which are drawn out at the right hand end bracket of the shelf. Here, one 6 pole contact socket and up to three 26 (or 3 × 6) pole contact sockets or twelve coaxial contacts can be mounted. The upper limit is governed by the available space in the guides shown at the bottom of fig. 5.

All wiring required between different contact sockets, test blocks etc., is laid in the box girder behind the strips. To obtain good earthing connections which are so important for transmission equipment, an earthing bar has been mounted inside the box girder and shaped so that it is automatically connected to the left hand earthing bar of the bay when the shelf is screwed into the bay. It can also be connected via a cable lug and screw connection to the right hand earthing bar of the bay.

In the front, the shelf is provided with a cover plate which covers the fronts of all units (see fig. 8). The cover plate is fastened to the shelf by a snap fastening of formaldehyde plastic. To allow ease of access to the maintenance test blocks etc., without having to remove the cover plates the lower part of the shelf in front of the box girder is provided with a retractable strip, the inside of which is shaped as a holder for labels required for identifying the test blocks etc. The strip is kept in the vertical position by a spring in the left hand plastic fixing of the cover plate. The designation plate has a window at its right hand side covered with translucent material on which the code number of the shelf is given. The translucent material allows the alarm indication lamp situated behind the window to be seen.

The cover plates and designation strip are painted in the same light blue coloured paint used in the *M3* method of construction.

Without relaxing the functional sub-division and to satisfy the more extensive transmission equipment requirements of greater space than that offered by a shelf, up to five shelves can be mechanically joined to form a shelf stack. In addition to the internal cabling for each shelf, this stack is provided with an interconnecting cable and one common rear cover plate. Each shelf in the stack, on the other hand, has its own front cover plate and designation strip. The stack is connected to station and bay cabling in the same way as for a single shelf.

Certain units and functions, however, cannot be built up in the cases and shelves described above. A method of construction has therefore been specially developed, for example for mains supply units which require just over three vertical modules and the front of which consists of cooling fins. For power distribution and concentration of alarm functions etc., in the bay, a service shelf occupying one vertical module has been designed. The front has in this case been arranged for mounting test blocks, fuse strips etc. of the same type as used in the normal shelves described above.

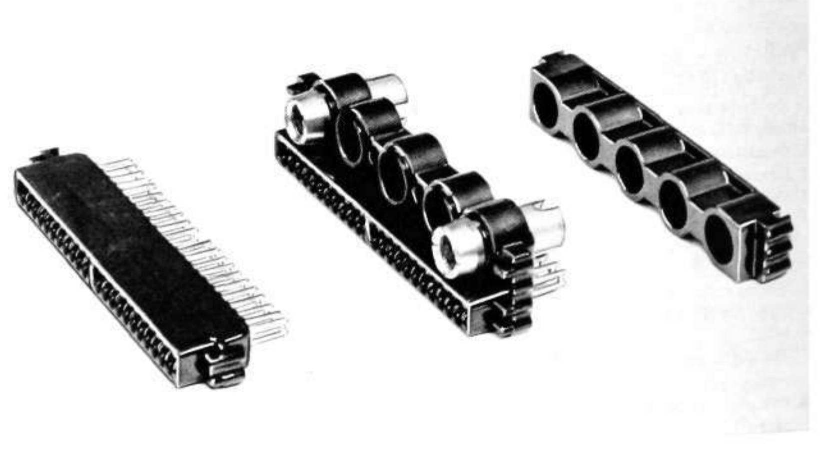


Fig. 7
Sockets for connecting units

From left, socket RNV 21901, socket RNV 21951 with two coaxial sockets RNT 14801 and contact housing 730135 for up to five coaxial plugs (M3)

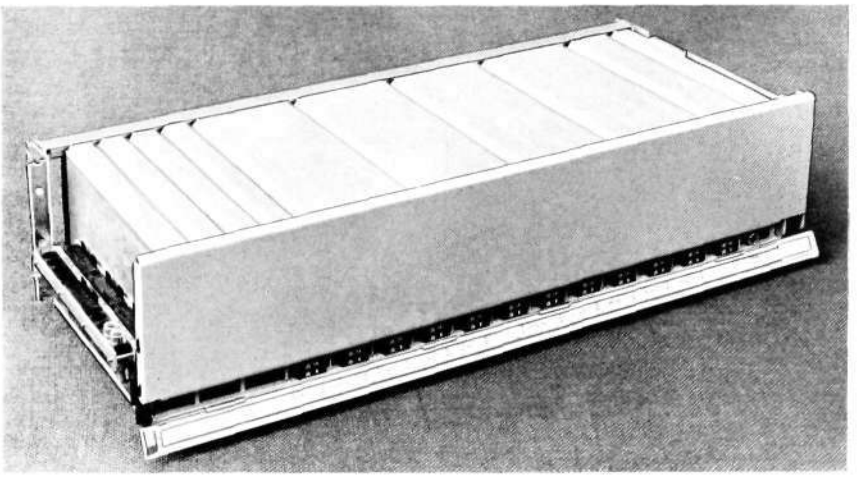


Fig. 8
Shelf with units, dust cover in place and designation strip folded down

Bay Construction

The bay construction is shown in figs. 9 and 10.

As opposed to the case in the previous method of construction, bays in the *M4* method of construction do not consist of assembled, pre-cabled products but are erected and cabled when the station building is being constructed.

When installed, the bays have the same external dimensions as previously. They are composed of two vertical beams, a floor plate and a top iron which are joined together with screwed fittings.

The floor plate is provided with four set screws for vertical and horizontal adjustment of the position of the assembled bay.

The vertical beams which are different from each other are provided with requisite holes with 40 mm (1.57") module centres for mounting of shelves and shelf stacks. Each vertical beam has furthermore been provided with an earthing bar of copper so as to ensure good earth connections.

The left hand beam which is wider—about 85 mm—is used to house the station cabling drawn to the shelf connector strips and is therefore provided with notches so that up to five cable supports can be mounted in it. The cable support which is easily adapted to the size of the bunch of cables and which by its design permits sub-division of the bunch of cables, is secured to the frame by only one screw.

The beam with cable mounted in it is covered by a vertical black anodized aluminium strip. On this strip or part of it are mounted the service devices which are required for the bay such as bay alarm lamps, telephone unit, location chart, measuring instrument etc.

The right hand beam which is about 25 mm wide contains the internal bay cabling. In the beam is mounted—here again with only one screw—a number of transverse frames or guides, one for each shelf to be mounted in the bay. In addition to acting as supporting arrangements for the shelf, these frames act as supports for the fixed contact arrangements that are required for connecting the shelves to the cable and as a holder for the cable itself.

The change from an all-welded bay frame (*M3* method of construction and earlier) to a bay which can be assembled in the station, results in simplified store keeping, fewer packing and transport problems and most important of all, results in less time being required as the work of station installation and cabling can be started before the particular part for the respective bay i.e. the right hand beam with cable and contact arrangement has been delivered.

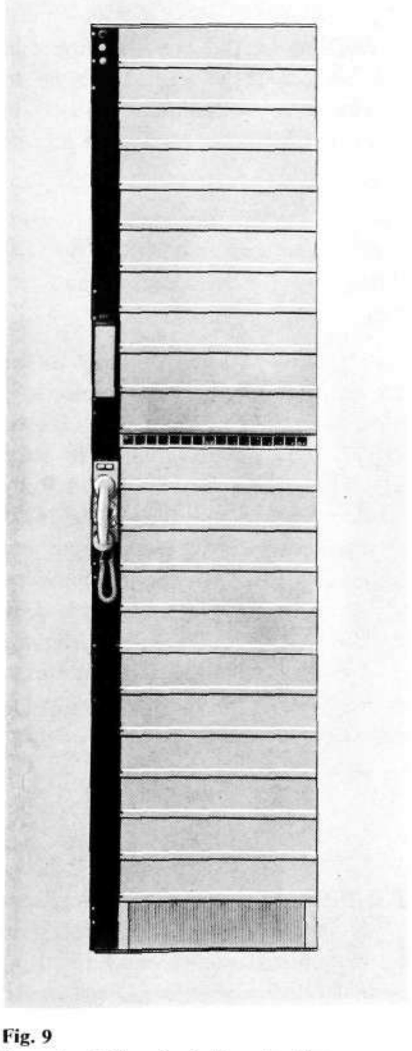
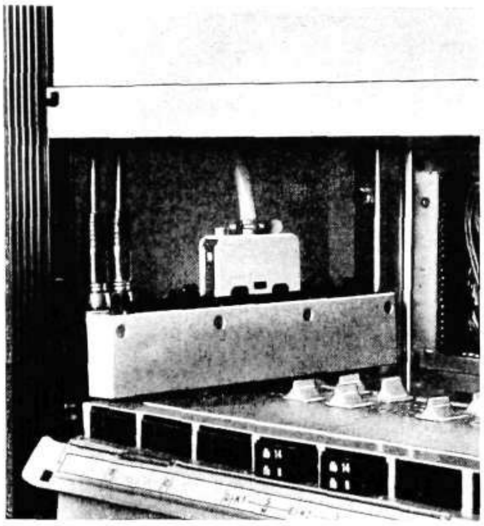
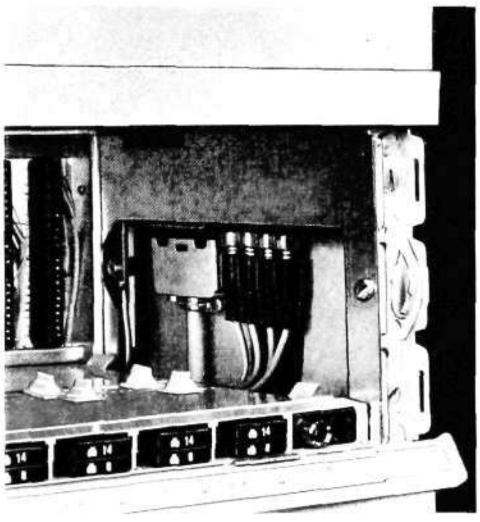


Fig. 9
Bay using M4 method of construction



a



b

Fig. 10
Shelf (excluding units) mounted in a bay
a Left hand connectors
b Right hand connectors

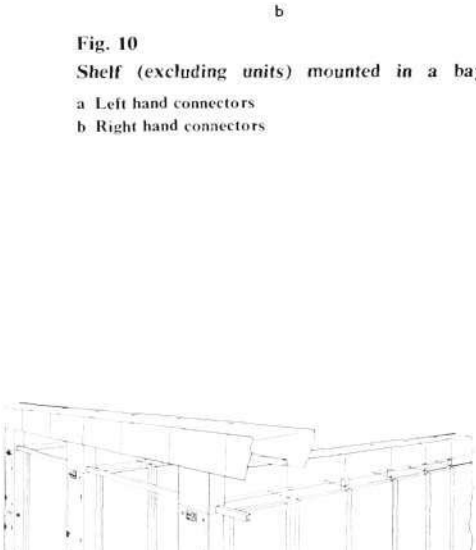


Fig. 11
Perspective drawing of station construction

Station Installation

A perspective drawing of suites of bays in a station is shown in fig. 11.

The bays standing back to back are assembled in suites in the station. At either end of the suite there is a transverse suite cabinet containing the necessary arrangements for the suite for power distribution, alarm indication etc.

The suites are held together and joined to each other by the same type of dust protected cable runway as that used in the previous method of construction.

It is therefore possible to put in bays of the *M4* method of construction in existing suites containing bays of the *M3* method of construction.

Due to the requirements of increased space for the station cabling caused by the reduction of the equipment volume, the assortment of parts for the cable runway construction has, however, been increased so that wider cable runways can be installed, if required.

Connectors

The design of the *M4* method of construction has also meant new development of contact arrangements for non-screened and coaxial connexions, U-links, lampholders etc. A brief description will now be given for some of these.

Flat Contact Plugs and Sockets

In the previous method of construction the type of flat contact plugs and sockets used there has proved to be so good that there was no reason to change from this contact principle. Consequently, all connectors used in transmission paths in the *M4* method of construction have plugs and sockets of this type.

New connector housings have been developed to suit the method of construction. For example, this is the case for plugs and sockets of type *RNV 219* for connecting the units to the shelf cabling and for jack sockets and test blocks for unit and shelf fronts (figs. 6 and 7).

It is worth mentioning the connectors for joining the shelf cabling to the station and bay cable. These connectors are made in 6-pole and 26-pole types as shown in fig. 12. The 6-pole flat pin contact plug *RPV 23101* has a plastic cover and mates with the jack socket *RNV 22101* to which it is held in place by means of a snap fastener made of plastic. This connector combination only requires a space of 13 × 18 mm (0.51" × 0.71"). The 26-pole plug *RPV 23106* which mates with socket *RNV 22106* is provided with a sheet metal cover and a bracket acting as a cable clamp. If required, the socket can be provided with a locking device for holding the plug securely. As one side of the plug case can be removed it can be mounted on the flat pin contact strip after the cables have been soldered in. This 26-pole contact combination requires a surface of 13 × 50 mm (0.51" × 1.97"). A jack socket *RNV 22107* occupying the same area has been developed for connection of up to three 6-pole plugs *RPV 23101*.

Coaxial Connectors

The coaxial connectors *RPT 159/RNT 149* for 75 ohms cable impedance which were designed previously and used as standard coaxial connectors in transmission equipment could not be used in terminal equipment built using the *M4* method of construction owing to their size. For this reason coaxial plug type *RPT 148* and mating coaxial socket type *RNT 148* have been developed. These are to be seen in fig. 13.

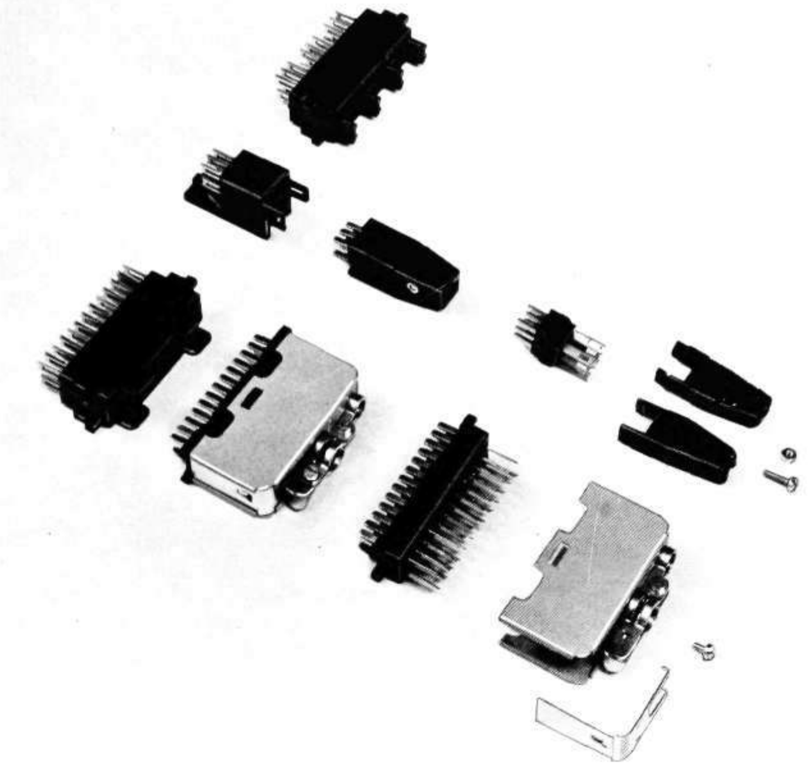


Fig. 12
26- and 6-pole connectors

First row, left, flat pin contact socket RNV 22106, complete flat pin contact plug RPB 23106, the flat pin strip RPV 23107 used in this and the case. Note the removable side and the shape of the cable clamp. Second row, left, flat pin contact socket RNV 22101, complete plug RPV 23101, the flat pin strip RPV 23102 and case halves.
Far row, flat pin contact socket RNV 22107 suitable for three flat pin contact plugs RPV 22101.

All contact surfaces in these connectors are gold plated. The centre conductor contacts consist of a cylindrical pin in the plug and a spring loaded sleeve with cross cut slots in the socket. Each of these centre contacts is centred and fixed in the respective connector by a ceramic washer in which it has been mounted by hot upsetting.

Contact between the outer conductors is obtained using a contact spring cage of beryllium bronze spot welded to the inside of the coaxial socket.

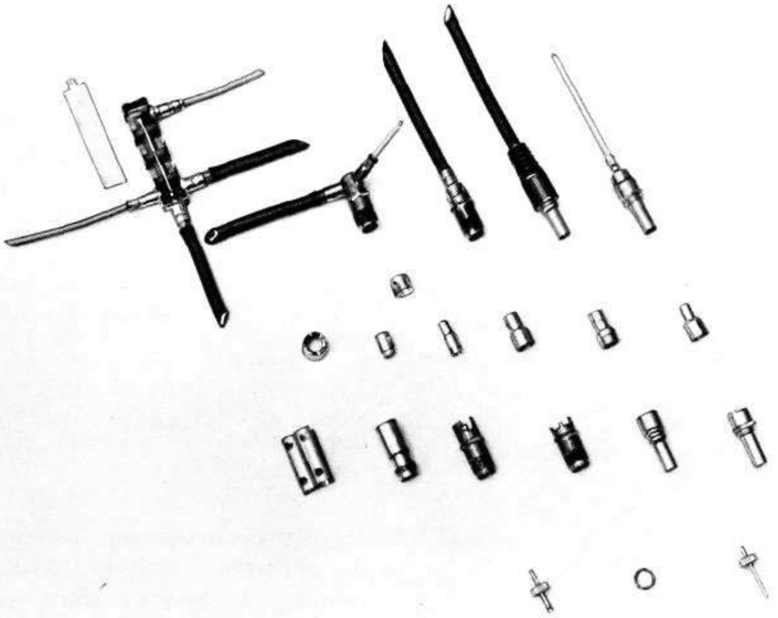


Fig. 13
Coaxial connectors

First row, centre contacts with ring nut.
Second row, from right, coaxial plugs RPT 14801 and -02, coaxial sockets RNT 14802, -01 and -03 and jointing sleeve.
Third row, mounting details for cable connections etc.
Fourth row, examples of applications, from left, connecting box NED 40301 adjacent to coaxial socket RNT 14801 with two cables connected at an angle.

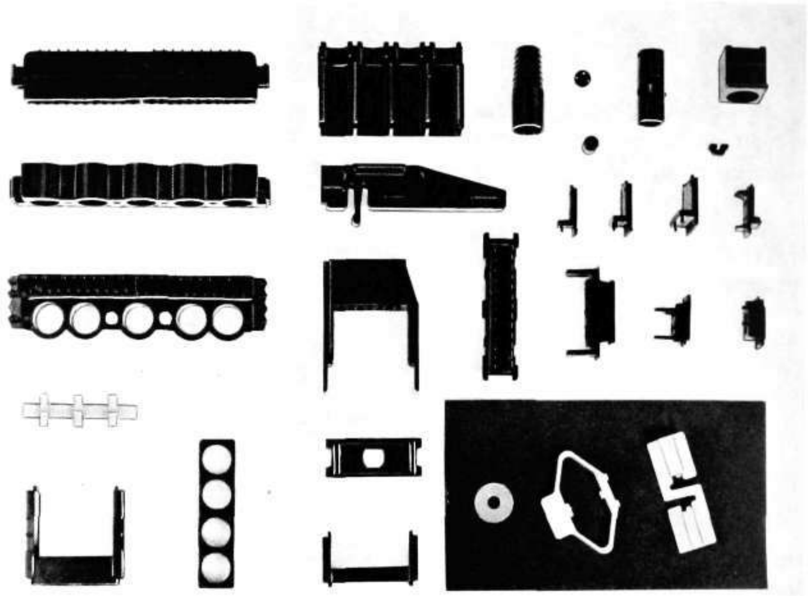


Fig. 14
A small selection of plastic details, mainly in carbonate plastic, which have been designed for the new method of construction.

There are two types of coaxial plug

- *RPT 14801* for connecting the units to the shelf cabling
- *RPT 14802* for connecting to free cable ends.

Mounting details have been developed for connexion of coaxial cable *TZC 75005* (double screened with 75 ohms characteristic impedance and 5.6 mm external diameter) and screened conductor *TEL 42031* (screen of aluminium foil and longitudinal wires, external diameter 2.8 mm). *RPT 14802* is provided with a snap fastening plug cover of formaldehyde plastic.

Three types of coaxial sockets have been designed

- *RNT 14801* for connecting units to the shelf cabling
- *RNT 14802* for normal use
- *RNT 14803* for flying lead connections for through-going cables.

Due to the restricted space in the rear edge of the shelf, *RNT 14801* is made for radial connection of up to two coaxial cables of the types mentioned above. For this purpose the cables are terminated with specially designed grooved nipples that are fixed in recesses, the whole being covered with a lid. Owing to the double connection facility it is possible to have multipled cabling.

The nipples are also used when connecting to the connecting box type *NED 403*, shown in fig. 13 which is mounted in the shelf cable space in the box girder.

RNT 14802 are used for normal axial connection of the cable types mentioned earlier, the same assembly details being used as for the coaxial plugs type *RPT 148*.

To obtain flying lead connections, *RNT 14803* is provided with a jointing sleeve having a pear-shaped section in which the through-going cable is jointed and connected. When assembled, the socket which is only used for connecting to *TZC 75005* lies beside and parallel to the cable.

The coaxial sockets are secured by a cone-shaped nut which helps to guide the plug into the socket. Another type of this nut has been provided with snap fastening springs to hold plug *RPT 14802* in place.

Plastic as Material for Construction

When developing the *M4* method of construction the properties of modern plastics and the possibilities of their use as construction material has been fully exploited.

In many instances, both the work of design and assembly has been greatly simplified due to the ease with which plastics can be made into complex shapes, their ability to be thermally formed and also to their resilience. Consequently in the *M4* method of construction there are only a few plastic details that are mounted in screwed joints. Several details have snap fastenings using heels and recesses and many of these snap fastened plastic details have enabled the assembly of other constructional elements in, for example, metal to be made without using screws. A selection of plastic details designed for the *M4* method of construction is shown in fig. 14.

These design simplifications have resulted in the number of screws used per bay being reduced by a factor of 4 to 1 (per supergroup, by a factor of 15 to 1) compared with the *M3* method of construction. This means a reduction of screws per bay by about 1200. In this connection the 6–7 screws (which are the same in number in both methods of construction) per sub-assembly included in the units, are not taken into account.

Mechanical Data

Bay

width	670 mm (26.4")
depth	236 mm (9.3")
height (max.)	2743 mm (9')
height module	40 mm
max. no. of height modules	67
weight (excluding shelves)	about 70 kg (155 lbs.)

Shelf (standard)

width (including securing lugs)	597 mm (23.5")
depth	236 mm (9.3")
height	118 mm (4.64") $(3 \times 40 - 2$ mm)
width module	4.25 mm (0.17")
no. of width modules	128
max. no. of front strips	16
weight (excluding units)	about 5 kg (11 lbs.)

Unit

width	$(n \times 4.25 - 1.5)$ mm $n = 6, 8, 11, 16$ or 21
depth	199.6 mm (7.85")
height	101 mm (3.97")
no. of unit assemblies	see text
weight	about 0.1 kg per 4.25 mm width

Carrier Terminals for 300- to 2700-Circuit Systems, System Design

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UDC 621.395.44
LME 8424 8442

This article gives an outline of the system design for large-capacity terminals to be included in carrier systems using coaxial line links or radio links.

Further details of the component subsystems are given in separate articles.

The terminal equipments for carrier systems engineered in the *M4* construction practice fully conform to the frequency allocations recommended by the CCITT for 300-, 900-, 960- and 2700-circuit systems. Regarding the traffic bands to be through connected two types of terminal are available, one providing for the through connection of supergroups, mastergroups and supermastergroups, another for the through connection of supergroups and 15-supergroup assemblies.

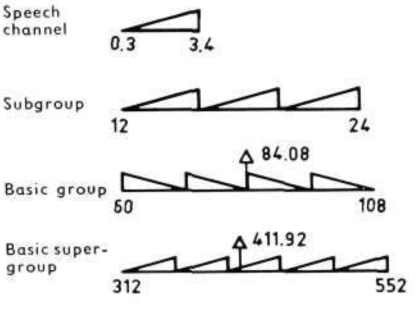


Fig. 1
Modulation plan for the translation of 60 speech channels into a basic supergroup
Frequencies in kHz

Translating Equipment

Formation of Basic Supergroups

The translating equipment for the formation of basic supergroups consists of the channel translating equipment, which assembles speech channels into 12-channel basic groups in two modulation stages (double modulation), and the group translating equipment, which assembles basic groups into 60-channel basic supergroups. The frequency allocations for the respective frequency blocks are shown in fig. 1.

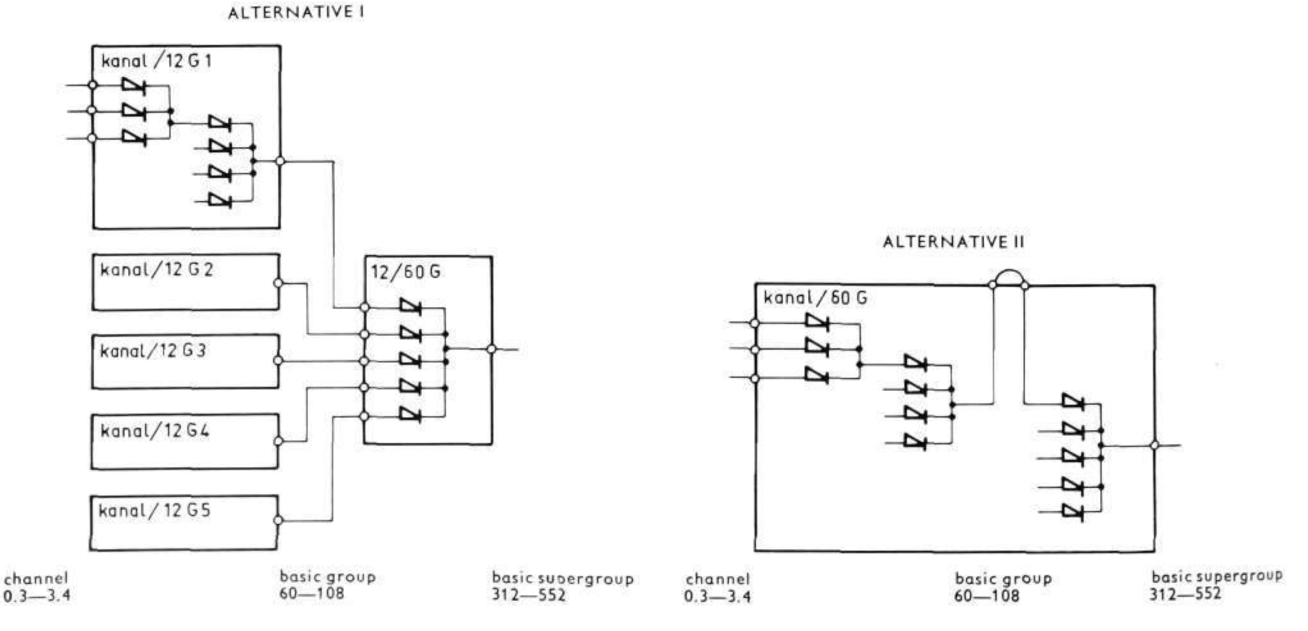
The equipment for forming and breaking down basic supergroups is provided in two versions, as shown in fig. 2.

Alternative I employs separate shelves for the channel translating equipment sets and the group translating equipment. This arrangement is designed for use in network configurations where the traffic band normally through connected is a group. In that case a group distribution frame with through group filters, if required, is inserted between the channel and group translating equipments.

Fig. 2
Channel and group translating equipment

kanal/12G Channel translating equipment
12/60G Group translating equipment
kanal/60G Combined channel and group translating equipment

Frequencies in kHz



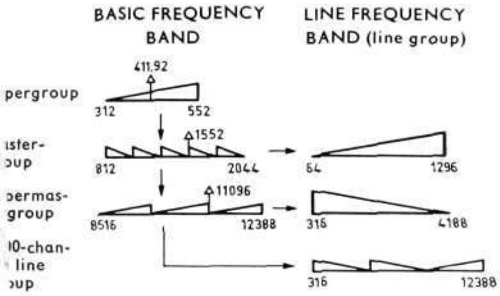


Fig. 3

Frequency arrangements for terminals with mastergroups

Frequencies in kHz

Alternative II is employed for network configurations where the smallest batch of through-connected channels is a supergroup. In this version the channel and group translating equipments are combined in a shelf stack consisting of five shelves. Nevertheless, it is possible to connect services requiring wider transmission bands than that occupied by a speech channel, such as program channels and broadband data channels, direct to the group translating equipment.

For the supervision of the group and supergroup levels facilities are provided for the injection of the 84.08 kHz group reference pilot and the 411.92 kHz supergroup reference pilot standardized by the CCITT.

The group translating equipment can be provided with equipment for the automatic level supervision and regulation of the incoming groups.

Signalling facilities are incorporated in the channel translating equipment. The standard versions available offer the following alternatives:

- out-band signalling, 3825 Hz, at a level of –18 dBm0
- out-band signalling, 3825 Hz, at a level of –6 dBm0
- in-band signalling, 2400 Hz, at a level of –6 dBm0

Translation of Supergroups into Line Groups

Terminals with Mastergroups

This type of terminal assembles basic supergroups via a 300-channel basic mastergroup stage into the line frequency band.

This arrangement of the multiplexing equipment facilitates economic expansion into larger-capacity transmission networks mainly consisting of 2700- or 1800-circuit systems. In addition, the mastergroup is a convenient frequency block for through connection in these systems. The frequency allocation in figure 3 shows the modulation plans for line groups used in 300-, 900- and 2700-circuit systems. The basic subdivision of the translating equipment into different shelf stacks is shown in fig. 4.

The 300-channel (1.3 MHz) line group is obtained by double modulation of an 812–2044 kHz basic mastergroup to the 64–1296 kHz band.

The 900-channel (4 MHz) line group is formed by assembling three basic mastergroups into a basic supermastergroup in the 8516–12,388 kHz range and then modulating this to the 316–4188 kHz line frequency band.

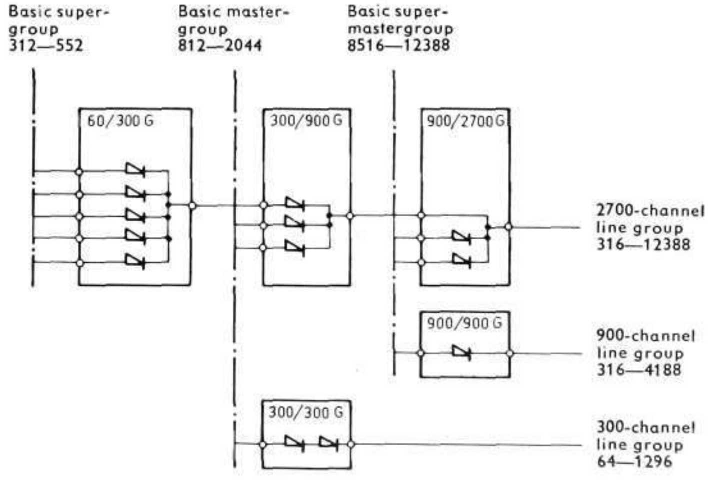


Fig. 4

Translating equipment for terminals with mastergroups

60/300G	Supergroup translating equipment
300/900G	Mastergroup translating equipment
900/2700G	Supermastergroup translating equipment
300/300G	Mastergroup modulating equipment
900/900G	Supermastergroup modulating equipment

Frequencies in kHz

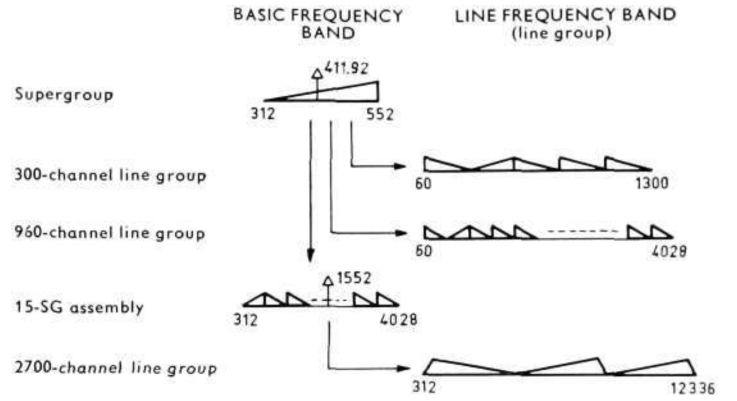


Fig. 5
Frequency arrangements for terminals without mastergroups
Frequencies in kHz

The 2700-channel (12 MHz) line group is formed by assembling three basic supermastergroups into the 316–12,388 kHz range. For 1800-circuit radio-relay systems use is made of a 316–8204 kHz line group consisting of supermastergroups 1 and 2 of the 12 MHz line group.

Level supervision in this type of terminal is arranged by means of the standardized 1552 kHz mastergroup reference pilot and the 11,096 kHz supermastergroup reference pilot, which are injected into the basic mastergroup and supermastergroup bands immediately after their formation in the supergroup and mastergroup translating equipments.

Injection of the 411.92 kHz supergroup reference pilot has taken place earlier, namely in the group translating equipment, immediately after the formation of the basic supergroup.

Terminals without Mastergroups

Terminals without mastergroups are an alternative to the arrangement of multiplexing equipment for 300- to 2700-circuit systems. This type of terminal is suitable for use in transmission networks mainly consisting of 300- and 960-circuit systems, where the 2700-circuit system is not predominant. Of course the two types of terminal can co-operate within the same terminal station by using the common supergroup for through connection.

The CCITT has mentioned the two types of terminal equipment as alternatives in its recommended frequency allocations, but given preference to the mastergroup arrangement for international traffic over 2700-circuit systems.

The frequency allocation in figure 5 shows the modulation principles for 300-, 960- and 2700-circuit systems. The subdivision of the equipment into shelf stacks is illustrated in fig. 6.

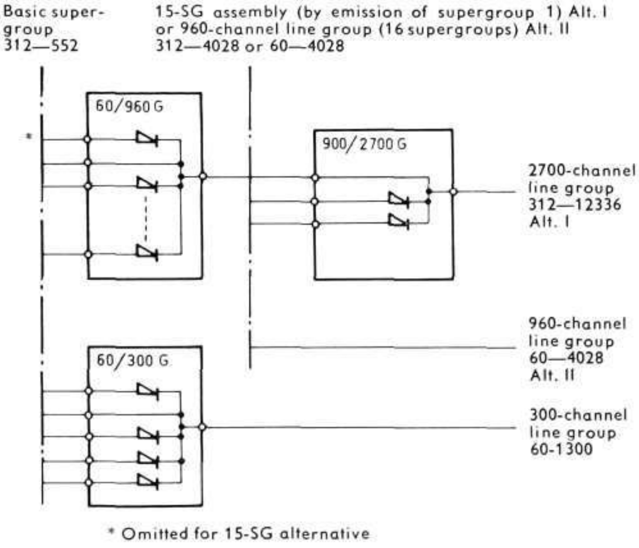


Fig. 6
Translating equipment for terminals without mastergroups

60/960G	Supergroup translating equipment for the formation of a 960-channel line group or 15-supergroup assembly
60/300G	Supergroup translating equipment for the formation of a 300-channel line group
900/2700G	15-supergroup translating equipment

Frequencies in kHz

The 300- and 960-channel line groups are formed by assembling supergroups by a single modulation process. Supergroup 2 is used in the basic frequency band.

The 2700-channel line group is obtained by using a 960-channel line group from which supergroup 1 has been omitted. Three such 15-supergroup assemblies in the 312–4028 kHz band are assembled into the 312–12,336 kHz line frequency band.

Level supervision in this type of terminal is based on the use of the 411.92 kHz supergroup reference pilot injected immediately after the formation of the basic supergroup, and a special 1552 kHz pilot used as reference pilot for the 15-supergroup assembly 312–4028 kHz.

Equipment for automatic level regulation and supervision is provided for the supergroups and 15-supergroup assemblies.

Frequency Generating Equipment

The frequency generating equipment is divided into two parts, namely a centralized equipment for the generation of frequencies common to the whole terminal equipment, such as master frequency, carrier basic frequencies and reference pilots, and a decentralized equipment for the generation of the carriers required for the different modulation stages.

Centralized Fundamental and Pilot Generation

The carrier frequencies employed for the formation of the frequency blocks standardized by the CCITT generally consist of harmonics of the fundamental frequencies 12, 124 and 440 kHz. These carrier basic frequencies are derived from the master frequency generated by the master oscillator. Two different master oscillators are employed, one generating 124 kHz and having a frequency stability of $5 \cdot 10^{-8}$ per month, the other generating 2500 kHz and having a stability of 10^{-8} per month. The former oscillator is applicable in carrier systems having a bandwidth of up to 12 MHz, the latter in systems of 12 MHz and larger bandwidths.

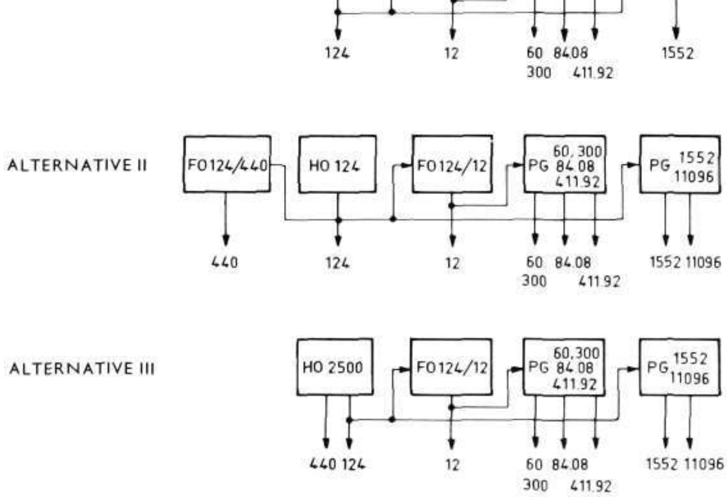


Fig. 7
Centralized fundamental and pilot generating equipment (common frequency supply)
HO Master oscillator
FO Frequency converting shelf
PG Pilot generating shelf
Frequencies in kHz

The pilot frequencies generated by the common frequency supply are the 60 and 300 kHz frequency comparison pilots, the 84.08, 411.92, 1552 and 11,096 kHz for level maintenance of the group, supergroup, mastergroup and supermastergroup respectively. All pilot frequencies are obtained by conversion of the master frequency concerned. Thus frequency maintenance in the terminal equipment can be concentrated entirely on the master frequency.

The division of the common frequency generating equipment into shelves and shelf stacks is illustrated in fig. 7. Alternative 1 is suitable for all 300-circuit terminals as well as for 960-and 2700-circuit terminals where mastergroups are not employed. Alternatives 2 and 3 are used in 900- and 2700-circuit terminals with mastergroups. The difference between alternatives 2 and 3 is that the latter provides higher frequency stability.

The generated frequencies are used as shown in the table below:

Carrier Basic Frequencies

12 kHz: channel translating equipment,
group translating equipment,
supergroup translating equipments for the formation of mastergroups and 960-channel line groups.

124 kHz: supergroup translating equipments for the formation of basic mastergroups and 960-channel line groups,
mastergroup modulating equipment,
supermastergroup modulating equipment,
supermastergroup translating equipment.

124 kHz: supergroup translating equipments for the formation of basic supermastergroups,
supermastergroup modulating equipment,
supermastergroup translating equipment.

Pilot Frequencies

60, 300 kHz: frequency comparison pilots

84.08 kHz: group reference pilot

411.92 kHz: supergroup reference pilot

1552 kHz: reference pilot for mastergroup and 15-supergroup assembly

11,096 kHz: supermastergroup reference pilot

The common frequency generating equipment consists of two separate sets of equipment. These two sets are connected together by automatic changeover equipment, which in the event of failure of the regular equipment immediately connects the standby equipment.

Distribution of Carrier Basic Frequencies and Pilots

The carrier basic frequencies are distributed from the common frequency generating equipment to the decentralized carrier generating equipment incorporated in the various modulation stages. Each of the outgoing frequencies generated by the centralized equipment is distributed via 10 outlets. Where necessary further distribution can be arranged by subdividing each outlet into 10 more outlets. Provision has been made for the accommodation of this distribution equipment in the suite end cabinets. When fully equipped, the common frequency generating equipment can supply a terminal with a capacity of approximately 10,000 circuits.

The reference pilots are distributed to three points in the terminal equipment, firstly to the injection point immediately after the formation of each basic group, secondly to through-connected reserve frequency groups in the respective distribution frame and, thirdly, to the centralized pilot receiver included in each modulation stage to provide a reference level.

The frequency comparison pilots are distributed to line systems for further transmission to other stations. Figure 8 illustrates the frequency distribution in a 2700-circuit terminal.

Decentralized Carrier Generation

The carrier frequencies for the various modulation stages are obtained by filtering the harmonics from the output of the harmonic generator controlled by one of the carrier basic frequencies. In equipment translating supergroups and larger frequency blocks, each shelf stack has its own carrier generating equipment, i.e. each carrier frequency is applied to only one modulator and one demodulator and no parallel feeding arrangements to other similar equipment occur. Figure 9 shows a shelf stack for assembling basic mastergroups into a basic supermastergroup.

In the channel and group translating stage several groups can be supplied in parallel from a carrier generating equipment common to all the sets of translating equipment housed in the same bay. However, a maximum of 300 channels is supplied from one set of carrier generating equipment.

The desired signalling frequency for the channel translating equipment is obtained by conversion of the same carrier basic frequency as is used for the generation of the channel, subgroup and group carriers.

Equipment for Level Supervision and Regulation

Immediately after its formation each frequency block is provided with a reference pilot for the supervision of its level. The reference pilots for the different frequency blocks have the following frequencies, which conform to CCITT recommendations.

basic group B	84.08 kHz
basic supergroup	411.92 kHz
basic mastergroup	1552 kHz
basic supermastergroup	11,096 kHz
15-supergroup assembly	1552 kHz

Supervision of Transmitted Pilot

The common frequency generating equipment has facilities for level supervision and automatic alarm for pilot level deviations of more than ±0.5 dB from the nominal value. Each pilot can be supervised by means of a recorder, for which purpose the equipment is provided with a recorder outlet.

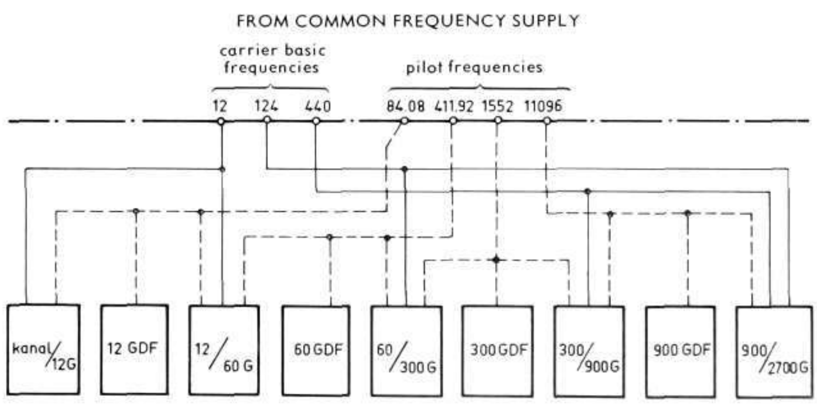


Fig. 8

Distribution of carrier basic frequencies and pilot frequencies in a 2700-circuit terminal

kanal/12G	Channel translating equipment
12 GDF	Group distribution frame
12/60G	Group translating equipment
60 GDF	Supergroup distribution frame
60/300G	Supergroup translating equipment
300 GDF	Mastergroup distribution frame
300/900G	Mastergroup translating equipment
900 GDF	Supermastergroup distribution frame
900/2700G	Supermastergroup translating equipment

Frequencies in kHz

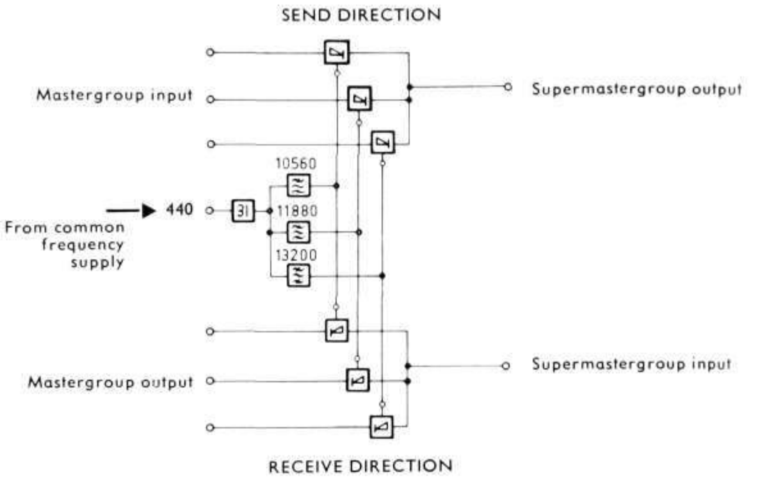


Fig. 9
Block diagram of mastergroup translating equipment with built-in carrier generating equipment
Frequencies in kHz

Supervision of Received Pilot

In the receive direction incoming frequency blocks are supervised at the output of the respective demodulator by means of a centralized pilot receiver, which automatically checks the incoming frequency blocks in turn.

The resulting information can be used to control an automatic level regulator or to give an alarm if the level deviation exceeds a predetermined amount.

All modulation stages from group translating equipment upward use the same type of equipment for supervision and regulation, only the selective part of the pilot receiver being different according to the various reference pilot frequencies. Figure 10 shows the different pilot receivers employed in a 2700-circuit terminal. The pilot receivers for 84.08 and 411.92 kHz are the same shelf construction. Where the 411.92 kHz is received, this frequency is caused to modulate the 496 kHz to produce 84.08 kHz.

The pilot receivers for the mastergroup translating equipment and the supermastergroup translating equipment are identical. In this case the supermastergroup pilot 11,096 kHz modulates the 12,648 kHz to produce 1552 kHz.

The pilot receivers have been made self-checking, i.e. once during each test cycle the respective pilot frequency from the local common frequency supply is connected and its level checked.

This built-in check obviates all manual routine checks of the levels, so that the pilot receivers for supervision can be dispensed with. A more detailed description of the pilot receive equipment will be found in a subsequent article dealing with the supergroup translating equipment.

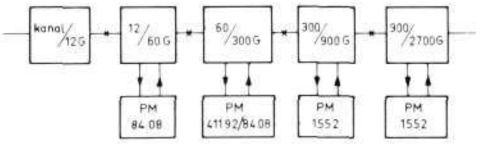


Fig. 10
Equipment for level supervision and regulation for a 2700-circuit terminal

kanal/12G	Channel translating equipment
12/60G	Group translating equipment
60/300G	Supergroup translating equipment
300/900G	Mastergroup translating equipment
900/2700G	Supermastergroup translating equipment
PM	Centralized pilot receiver

Frequencies in kHz

Power Supplies and Alarm Circuits

The shelves and shelf stacks are supplied from a common power pack in each bay. The standardized voltage at which the output from this power supply is distributed is 21 volts ±2 %, the positive pole being earthed.

Power supply variants are available for the following primary voltages:

- a. c. supply, 50–60 Hz, 110, 127 or 220 volts ±10 %
- d. c. supply, 24, 36, 48 or 60 volts, +20 %, −10 %

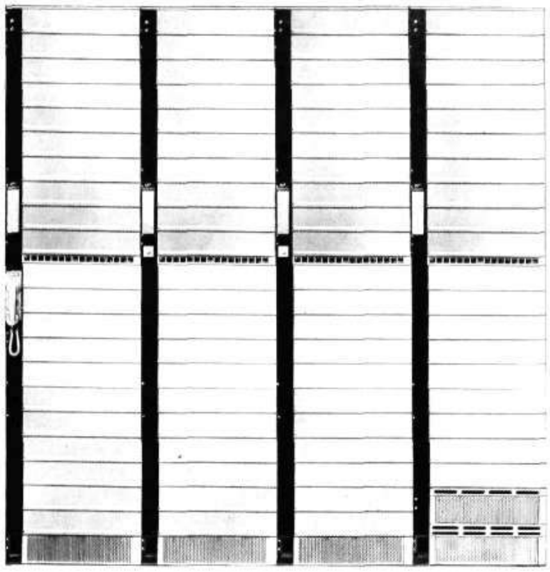


Fig. 11

Bay arrangement for a 2700-circuit terminal

1 Channel and group translating bay for forming 4 supergroups (240 channels)
2 Supergroup translating bay for forming 10 mastergroups (50 supergroups)
3 Mastergroup and supermastergroup translating bay for forming one 2700-channel line group (9 mastergroups)
4 Common frequency generating bay

If required, the power supply can be duplicated, one serving as standby to the other, regular, supply. The standby power pack can serve as standby to several regular power packs accommodated in other bays.

The primary voltages from the central power pack are distributed to the various bays via individual fuses in the suite end cabinets.

The secondary voltage from the power supply is distributed to the various shelves and shelf stacks via fuses in a common service shelf in the centre of the bay.

Separate alarm indications are given for failures of secondary voltages and fuses as well as excessive level deviations where level supervision is provided. These separate alarms are extended to the bay alarm circuit and via the end cabinets transmitted to the central alarm system of the station. Two distinct types of alarm are provided: urgent (A) alarm and non-urgent (B) alarm. All alarm conditions interfering with traffic are classified as urgent alarms, other alarm conditions as non-urgent. Level alarms from incoming traffic bands can be optionally arranged to be indicated as urgent or non-urgent. In addition, facility is provided for the disconnection of alarm functions, a reminder indication being brought up at the same time. Each separate alarm indicator is provided with an additional terminal enabling special supervisory equipment outside the bay to be connected, for instance for remote alarm indication.

Bay Arrangement

Since in the *M4* construction practice shelves and shelf stacks form the basic functional units of the terminal, the assembly of the equipment into bays is very simple. Generally the inter-shelf wiring consists only of the wiring for power supply and alarms. Consequently a large variety of bay arrangements can be offered. Fig. 11 shows the different bay types forming a 2700-circuit terminal. This terminal employs three bay types for the translating equipment. The shelf stacks for channel and group translation have been combined into one bay, which makes this arrangement suitable for applications where groups are not normally through connected. Also the mastergroup and supermastergroup translating shelf stacks have been accommodated in one bay, producing a complete 2700-channel line group.

Channel and Group Translating Equipment

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621.376
LME 8421 7544

The channel and group translating equipment is engineered in L M Ericsson's new construction practice for transmission equipment and has been designed in accordance with the principles described in the introductory articles in this issue of Ericsson Review.

The present article describes the electrical design of the equipment and its mechanical assembly into shelves and shelf stacks. Finally a few practical applications of these in different bay arrangements are shown and a summary of technical data is given.

The channel translating equipment is the first stage of all carrier terminals and forms the main part of the equipment in a station. It assembles voice frequency channels into 12-channel basic groups.

In systems providing 60 or more circuits the next modulation stage always consists of group translating equipment, which assembles five basic groups into one basic supergroup.

A description is given below of the new equipment for channel and group translation. All requirements recommended by the CCITT are fulfilled. Silicon-type transistors are employed throughout as active elements.

ELECTRICAL DESIGN

Modulation

Modulation Plan

The CCITT recommends two different frequency bands for the basic group in carrier systems using channels spaced at 4 kHz intervals, namely basic group *A* in the 12–60 kHz band and basic group *B* in the 60–108 kHz band. It is the *B*-type basic group that is normally used for building up large-capacity carrier systems. It provides flexibility in through group connection between different systems and also fulfils the requirement for a group to lie within an octave, which means that the highest frequency transmitted must be below the lowest frequency of the second harmonic. This results in less stringent demands on the equipment regarding harmonic distortion and intermodulation.

As in our earlier equipment designs, the double modulation version has been chosen in preference to the single modulation alternative. The chief advantage of the double modulation design is the fact that only seven filter types and seven carrier frequencies are needed compared with twelve of each when single modulation is used. Modulation in two stages has thus proved to provide a good economical solution to the electrical design of the channel translating equipment. In addition, less stringent selectivity requirements on carrier filters are achieved, which permits a simpler carrier generating equipment design to be used. The subgroup employed consists of three 4 kHz channels in the 12–24 kHz band. This frequency range lying within an octave permits an optimum compromise between the attenuation introduced by the channel and subgroup filters and the number and size of the components required.

Figures 1 and 2 show the modulation plans for the formation of the basic group and supergroup respectively.

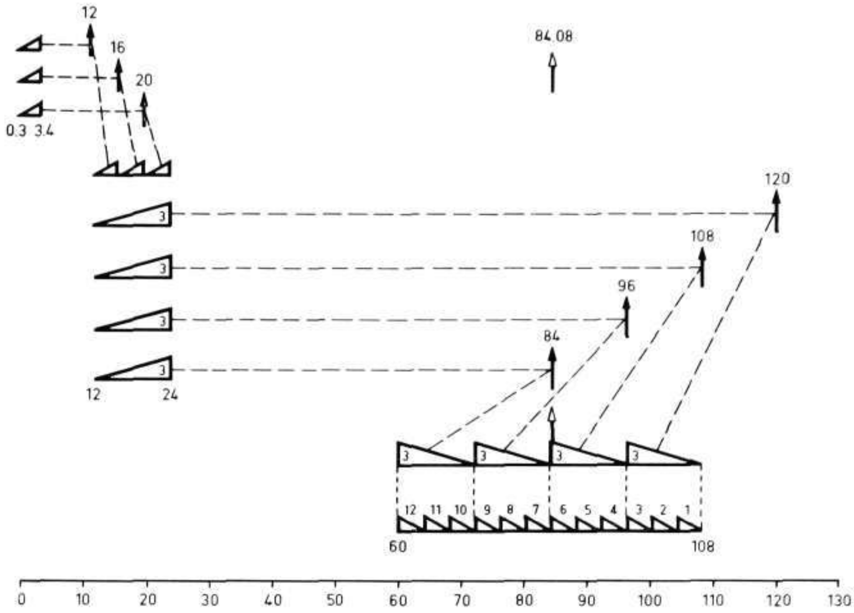

Fig. 1
Modulation plan for assembling 12 channels into a basic group
All frequencies in kHz

Block Diagrams

Block diagrams of the two translating equipments are shown in figs. 3 and 4, the upper part of each diagram representing the sending equipment, the lower part the receiving equipment.

Plug-in pads are provided on the channel four-wire side of the channel translating equipment permitting different incoming levels to be adjusted to the equipment input level, –14 dBr. Also on the basic group side alternative levels can be chosen, namely –26 or –37 dBr in the send path and –8 or –30 dBr in the receive path. The choice between the two level alternatives can be made by connecting or disconnecting fixed attenuators which are built into the equipment. The supergroup send and receive levels are fixed at –35 and –30 dBr.

The impedance at all distribution points is 75 ohms unbalanced, except on the channel side, where 600 ohms balanced is used. At the basic group distribution point an alternative impedance of 150 ohms balanced can be obtained by means of appropriate matching transformers.

The channel translating equipment is available in versions with built-in out-band or in-band signalling equipment. If desired, the signalling equipment can be omitted.

In applications using out-band signalling the group translating equipment can be provided with signalling blocking equipment.

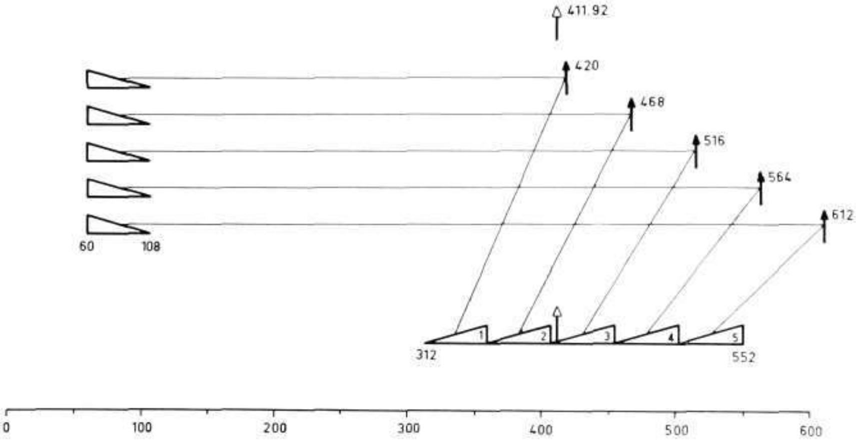

Fig. 2
Modulation plan for assembling 5 groups into a basic supergroup
All frequencies in kHz

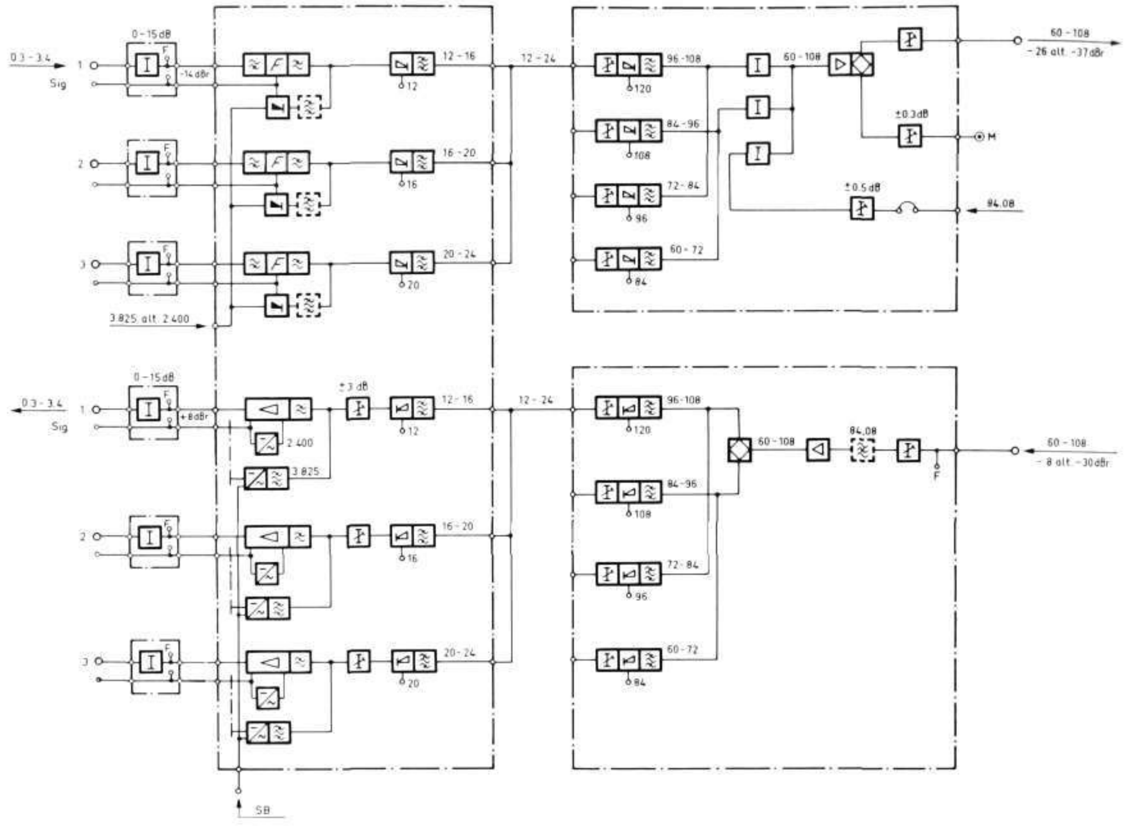

Fig. 3
Block diagram of channel translating equipment

M	Maintenance test point
F	Fault location test point
Sig	Incoming and outgoing signal
SB	Signalling blocking

All frequencies in kHz

By including a pilot receiver, automatic regulation with supervision or only supervision of the incoming groups can be arranged. For a detailed description with diagrams reference should be made to a following article on this subject.

Modulators

An active transistor modulator is used in all modulation stages of the channel and group translating equipment. The transistor modulator is a push-pull amplifier switched on and off by the carrier between full amplification and cut-off, which provides a modulation function with a suppressed carrier. The circuit diagram of the modulator is shown in fig. 5.

When compared with the diode modulator used in earlier designs, the transistor modulator offers several advantages. Among these are the following:

- It has a lower carrier power consumption, which permits a simpler design to be used for the carrier generating equipment.
- It provides amplification, which has made possible a reduction of the number of amplifiers included in the equipment. Indirectly it means that the transmission level can be maintained at a high value, which results in a low basic noise contribution.
- It has better linearity, which contributes to a higher transmission level.
- Its input and output are isolated from each other. This improves matching to the impedances of associated filters, which as a result have better pass-band characteristics.

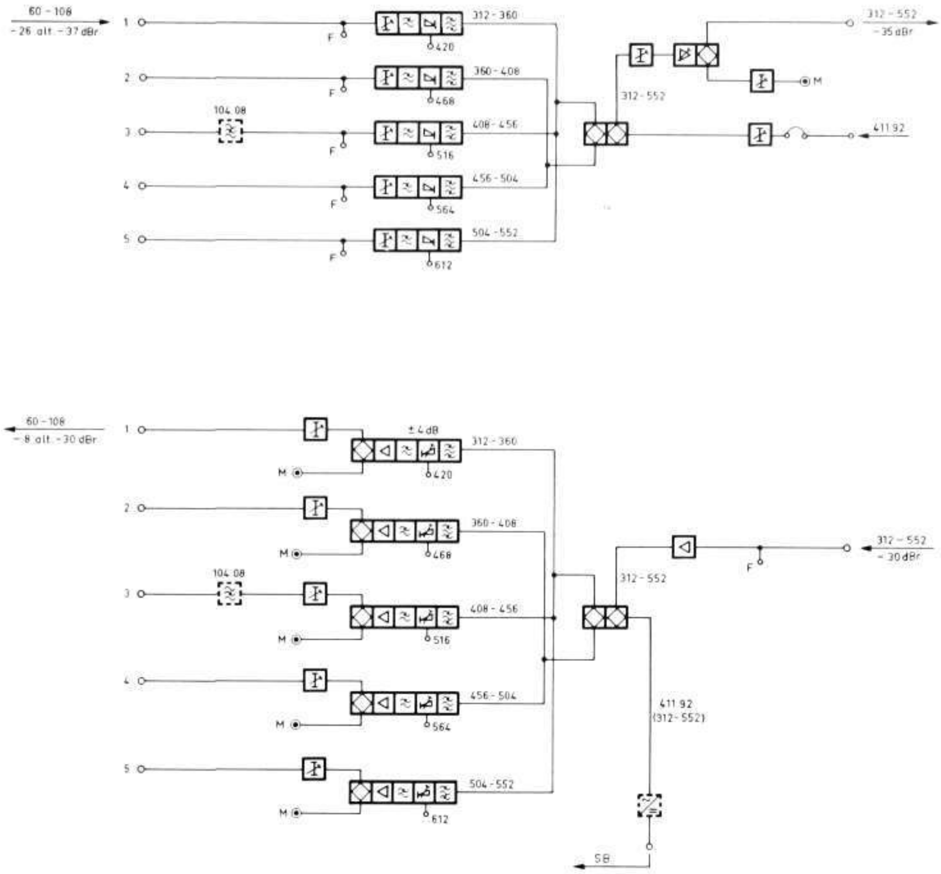

Fig. 4
Block diagram of group translating equipment

M Maintenance test point
F Fault location test point
SB Signalling blocking
All frequencies in kHz

☐ It provides simple gain regulation facility, which feature is utilized in the group demodulator for regulation of the incoming signal level.

Filters

Filters occupy a central position in a carrier system. The largest group of filters is formed by band-pass filters, which select desired frequency bands or frequencies. A smaller group consists of band-stop filters with very narrow stop bands, which are designed as crystal filters. With the help of computers it has been possible to achieve an optimum filter design with regard to attenuation distortion, stop-band attenuation and the number of components. All band-pass filters included in the equipment for the translation of speech channels are compensated for dissipation in order to reduce attenuation distortion in the pass band to a minimum.

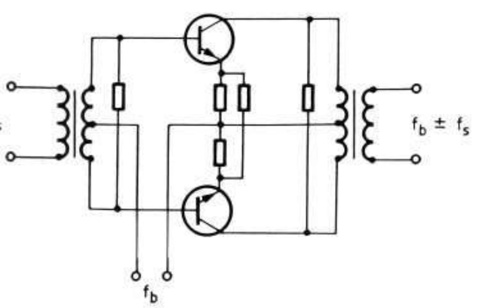

Fig. 5
Circuit diagram of modulator

f_s **Signal frequency**
f_b **Carrier frequency**

The band-pass filters used for the translation of channels into subgroups and vice versa have a nominal pass band for a voice-frequency band of 0.3–3.4 kHz. However, the actual pass band is wider to permit the transmission of the out-band signalling frequency at a low and controllable attenuation. In the send direction the stop bands of the band-pass filters protect adjacent channels, in the receive direction their own allotted channels, from unintelligible and intelligible crosstalk resulting from modulation and demodulation respectively. The low-pass filters limit the voice-frequency band effectively transmitted to 3.4 kHz and protect frequencies outside that range.

A high-pass filter at the input of the channel translating equipment suppresses noise below the v. f. range.

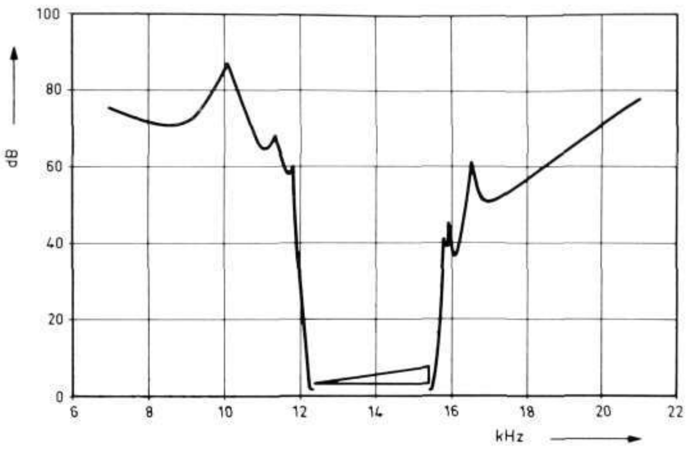

Fig. 6
Attenuation characteristic of sending channel filter

Figures 6 and 7 show typical channel filter characteristics.

To protect the associated channel as well as adjacent channels in the send direction from interference due to impulsing in the case of out-band signalling, a band-pass filter for 3825 Hz has been inserted in the signalling path. In the receive direction the signalling receiver is protected from other frequencies by a band-pass filter for the signalling frequency.

In the subgroup modulation stage the gap between the upper and lower sidebands is wider than in the channel modulation stage, as will be clear from fig 1. Consequently the subgroup filter flanks need not be so steep as those of the channel filters.

The subgroup filters in both directions of transmission are identical, all frequency variants having the same attenuation characteristic.

Also in the group modulation stage the gap between the two sidebands is relatively wide so that the filter flanks need not be made so steep. Effective suppression of the image sideband and of the 60–108 kHz direct leak is required. On the basic group side of the modulator and demodulator a low-pass filter is included to suppress interference consisting of noise and modulation products above 108 kHz.

The group filters used in the send and receive paths are identical. A typical attenuation graph is shown in fig. 8.

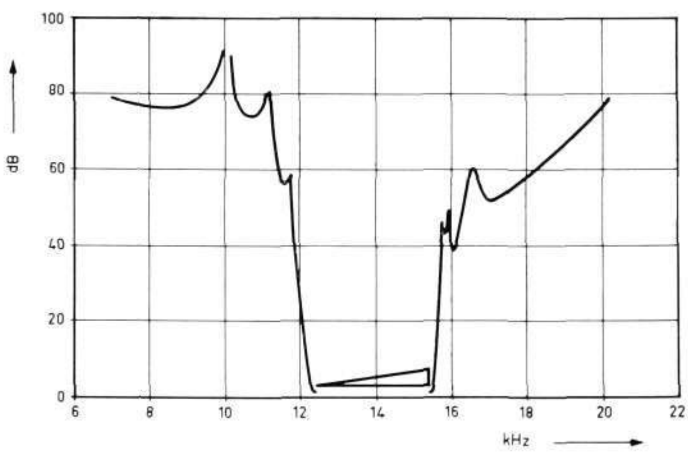

Fig. 7
Attenuation characteristic of receiving channel filter

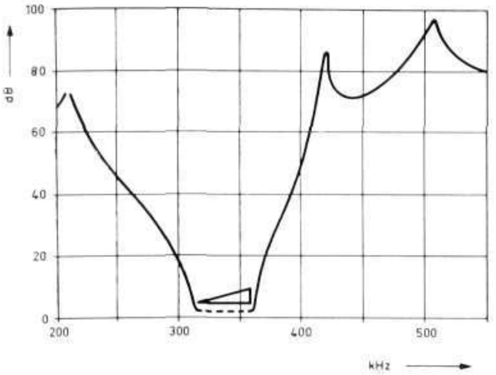

Fig. 8
Attenuation characteristic of group filter

Amplifiers

All amplifiers used in the channel and group translating equipment are transistorized. They are a single- or two-stage transistor amplifier design using negative feedback to obtain good transmission performance. By the introduction of the active transistor modulator and utilization of its amplifying function it has been possible to reduce the number of amplifiers.

In those amplifiers placed at positions where the group and supergroup bands can be through-connected the output has been arranged as a differential transformer via which a maintenance test point is branched off.

Limiter

The limiter prevents occasional speech power peaks and disturbing voltages from overloading subsequent modulators and amplifiers.

In this construction practice the limiter has been designed as a functional unit separate from the channel modulator, by which arrangement good linearity and limiting performance are obtained. This design is also compatible with built-in injection of the signalling frequency on a v. f. basis.

The limiter is a single-stage feedback transistor amplifier having a level characteristic as shown in fig. 9.

Injection and Suppression of Pilots

To provide a level reference following through with the respective frequency block in the transmission path, facilities are included for the injection of the pilots recommended by the CCITT. For the basic group and supergroup the frequencies of these pilots are 84.08 and 411.92 kHz respectively.

Injection into the send path is arranged immediately after the formation of the frequency block concerned before the respective amplifier. The pilot, which is obtained from a pilot distributor common to several frequency blocks, is transmitted at a nominal level of –20 dBm0. At the injection point facility is provided for adjustment by ±0.5 dB in steps of 0.15 dB to compensate for minor differences in attenuation between the different frequency blocks.

The attenuation introduced by the channel modulator and demodulator filters is sufficient to protect the pilot frequency from speech interference and

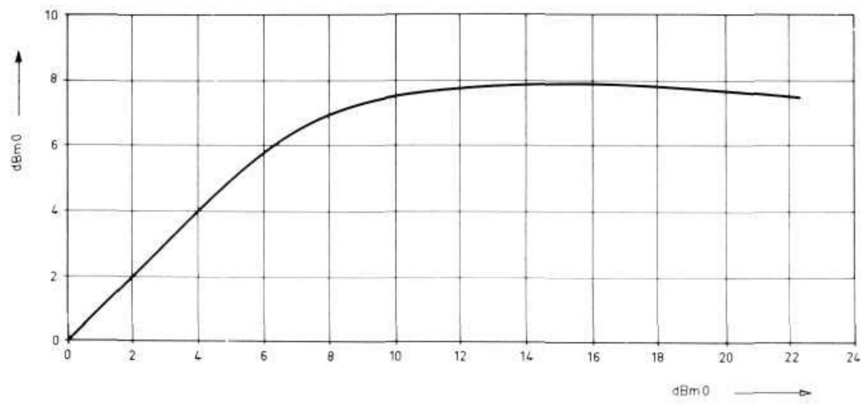

Fig. 9
Limiting characteristic of channel translating equipment

The output level as a function of the input level measured as the rms value at the group output

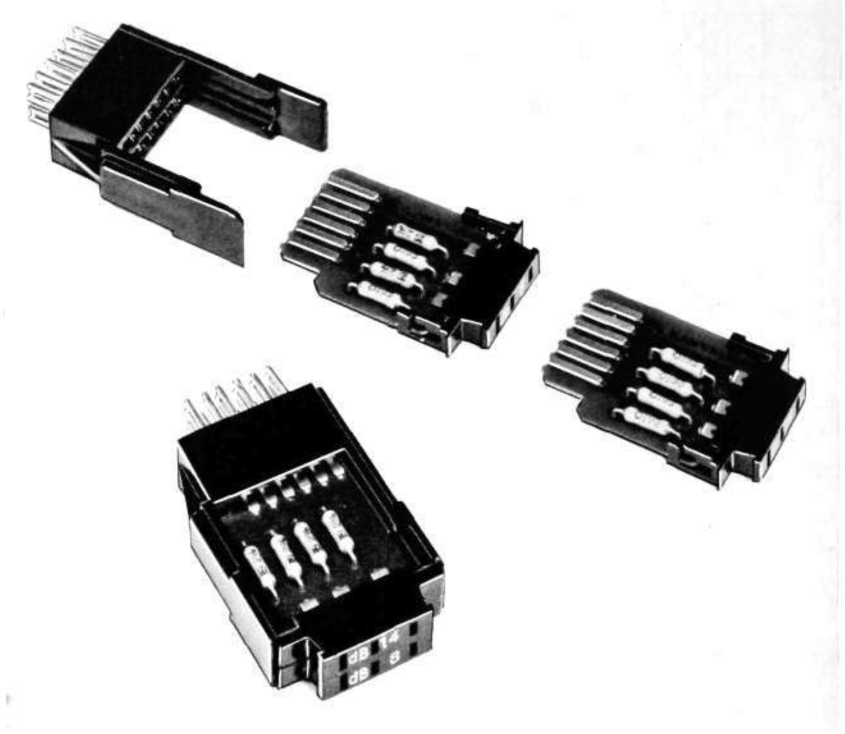

Fig. 10
Channel pads. Design and assembly

the respective speech channels from pilot interference. However, separate pilot stop filters are required in applications with low-level out-band signalling, to protect the signalling channel, and in the case of through group connection, to prevent interference with the next supergroup link. The stop filter design employs quartz crystals.

Level Adjustment

As mentioned previously, the adjustment of the equipment to different system levels can be made by means of the adjustable attenuators provided at the inputs and outputs.

In the receive path, where considerable attenuation distortion may occur in incoming groups, for instance after several through connections, adjusting facilities have been arranged to permit individual level adjustment at each group and channel output. The range of adjustment for a channel is ±3 dB and for a group ±4 dB. In both cases adjustment is provided in steps of 0.5 dB by means of plug-in type U-links at the front of the respective demodulators.

By replacing the group demodulator by a variant whose gain is controlled by a thermistor, automatic regulation can be arranged by means of an external pilot receiver for the 84.08 kHz reference pilot.

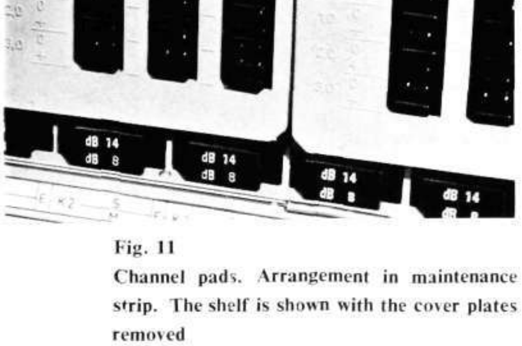

Fig. 11
Channel pads. Arrangement in maintenance strip. The shelf is shown with the cover plates removed

Test Points

One of the main objectives of the *M4* design has, of course, been to ensure the highest possible degree of service reliability. Nevertheless, preventive maintenance may sometimes be required as well as facilities for rapid location of any fault that might occur.

To facilitate various measurements different types of test points have been included in the equipment according to certain principles. A distinction is made between maintenance test points and fault location test points, denoted by *M* and *F* respectively in the block diagrams of figs. 3 and 4.

The maintenance test points, which are decoupled from the transmission path by a differential transformer, are short-circuit-proof, i.e. a short circuit at the test point does not noticeably affect the level in the transmission path. The level at the test point is not impaired by poor matching with the impedance of the load connected to the transmission path. Generally the test points are also provided with a strap-in pad which permits minor adjustments to be made relative to the level at the distribution frame concerned. All outputs associated with more than 12 or more channels in all equipment of this type are provided with maintenance test points of the design described above.

Fault location test points, however, are designed as bridging points and not protected against short circuits. They are located on the respective apparatus units, access being obtained by removing the shelf dust cover.

Electrically the fault location test points are arranged at all equipment outputs and inputs not already provided with maintenance test points as well as at other strategic points from which fault location can be suitably carried out.

The plug-in pads on the channel side of the channel translating equipment can also be used as break-type U-links for maintenance and fault location purposes. The signalling sending (*M*) and receiving (*E*) wires pass through the respective channel pads, so that the signalling circuit is broken at the same time as the associated speech circuit. The pads are small printed-circuit card assemblies provided with fault location test points at the front edge of each pad card, one of these giving access to the signalling wire. The pad assemblies for the sending and receiving paths of one speech circuit can be plugged into a card receptacle strip, one above the other; see fig. 10. The various pairs of channel pads are mounted side by side in a maintenance strip below the apparatus units along the lower edge of the shelf. Access to the test points is obtained by opening the hinged cover plate, whose inside is provided with a designation strip for the respective test points (see fig. 11). The channel pads are available in values ranging from 0 to 15 dB in steps of 0.5 dB.

Signalling

To enable connections between two telephone exchanges to be arranged via a carrier system, the system is required to permit the use of d. c. signalling. The signalling equipment of the sending terminal receives d. c. signals from the associated exchange and converts these signals into a. c. signals to be transmitted by the carrier system. At the receiving terminal the d. c. signals are then reproduced and applied to the associated exchange. The a. c. signals use a discrete frequency in or outside the speech frequency band of the respective channel.

Various types of signalling can be provided. Built-in signalling equipment is available in standard versions for the following types of signalling:

- Out-band signalling, low-level
- Out-band signalling, high-level
- In-band signalling, one-frequency

The arrangement of the equipment required for connection to the channel translating equipment is shown in the block diagram of fig. 3.

In those applications where built-in signalling is not required, the channel translating equipment can be provided in a version without signalling equipment.

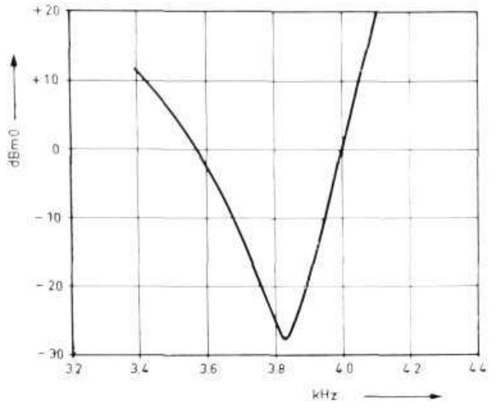

Fig. 12
Selectivity characteristic of low-level out-band signalling receiver. The curve shows the level needed to operate the signalling receiver relay for a signal applied to the input of the group receive equipment.

Out-Band Signalling, Low-Level

The low-level out-band signalling system uses a frequency of 3825 Hz at a level of —18 dBm0.

The signalling sender, a static relay, is controlled by a d.c. voltage from the exchange. The static relay may be said to have a "make" function if, when this voltage is extended to it, signalling tone is emitted, and a "break" function if, on receipt of the voltage from the exchange, signalling tone ceases. The choice between these two functions can be made by strapping. The out-band signal is injected into the transmission path across a series coil built out into a transformer at the output of the low-pass filter preceding the channel modulator.

The signalling receiver consists of an amplifier section and a level sensing section which controls the signalling receiver relay. This is a polarized relay with mercury-wetted contacts similar to that used successfully in our earlier construction practice. However, the relay has now been miniaturized and designed for direct mounting on the printed-wiring board. Like the signalling sender, the signalling receiver can be strapped for either breaking or making when energized. The reed contact of the signalling receiver relay can be connected to optional polarity from the exchange.

The out-band signal follows through with the speech band and is passed through the pad for individual adjustment of the received channel level. Consequently, when the channel level has been adjusted, the signalling frequency will automatically be received at the correct level. Thus it will seldom be necessary to make use of the ±6 dB level variation permissible for the out-band signal, which contributes to maintaining a low signal distortion rate. The out-band signal is branched off via a transformer arranged in series with the transmission path.

Mutual interference between the speech and signalling channels is prevented by filter protection as described in a preceding section. Fig. 12 shows a selectivity characteristic for the signalling receiver.

Out-Band Signalling, High-Level

In high-level out-band signalling a signalling frequency of 3825 Hz is used at a level of –6 dBm0.

The same signalling equipment is used as for low-level signalling. The desired signalling level is obtained by appropriate strappings in the frequency generating equipment as well as in the signalling receiver.

Out-Band Signalling Types

In the table below a list is given of the different types of signalling employed and the corresponding arrangements of the signalling equipment.

Type of signalling		Strapping for	
		making	breaking
semi-continuous, low-level	tone-on idle		×
	tone-off idle	×	
discontinuous, high- or low-level		×	

In-Band Signalling, One-Frequency

Normally in in-band signalling a frequency of 2400 Hz is used at a level of –6 dBm0. However, the channel translating equipment has been designed to permit the use of other frequencies and levels recommended by the CCITT for one-frequency in-band signalling.

Transmission of the signalling tone is arranged in the same way as described in the section on out-band signalling. In in-band signalling, however, the static relay is arranged to provide a make function. To prevent noise from the exchange from interfering with the speech channel while signalling tone is transmitted, the speech path is blocked. This is done by blocking the limiter by means of the same voltage that controls the signalling sender. The signal is injected into the transmission path in parallel across the channel modulator input.

The in-band signal is branched off and applied across the signalling receiver after passing through the first of the two cascaded stages of the channel amplifier. The second stage provides effective decoupling of the signalling receiver from near-end interference.

The signalling receiver consists of an amplifier with a guard circuit and a level sensing device which controls the signalling receiver relay, the same type of relay being used as in the out-band signalling version. The guard circuit prevents any speech frequencies or noise that enter the signalling receiver from causing undesired operation of the relay.

To prevent a through-connected in-band signal from giving rise to false relay operations in any subsequent signalling receivers included in the network, speech transmission is blocked while signalling tone is received. This is effected by blocking the final stage of the channel amplifier.

The signalling receiver is designed in accordance with CCITT recommendations for in-band signalling.

Signalling Blocking

In the majority of systems provided with low-level out-band signalling use is made of the "tone-on-idle" signalling code. With this code signalling tone is transmitted as long as the circuit is idle, interruption of tone indicating seizure. The tone remains absent for the duration of the call, its return indicating termination of the call.

The consequence of this is that an interruption of the transmission path will result in seizing signal on all idle circuits, which may cause overloading of the exchange equipment. To prevent this, in large capacity terminals the signalling receivers concerned should be blocked immediately when an interruption occurs. This is effected by the signalling blocking equipment on failure of the 411.92 kHz supergroup reference pilot, which is thus used as the criterion of an unbroken connection.

The block diagram in fig. 13 illustrates the basic operating principles.

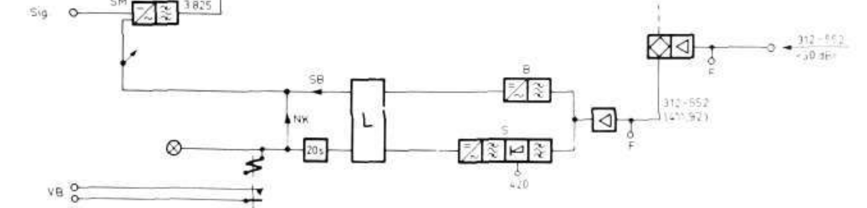

Fig. 13

Block diagram of signalling blocking equipment

B	**Broad-band pilot receiver**
S	**Selective pilot receiver**
L	**Logic circuit**
20 s	**Delay circuit approx. 20 sec**
SB	**Signalling blocking**
NK	**Release**
VB	**Blocking of exchange**
SM	**Signalling receiver 3825 Hz**
Sig	**Outgoing signal**
F	**Fault location test point**

All frequencies in kHz

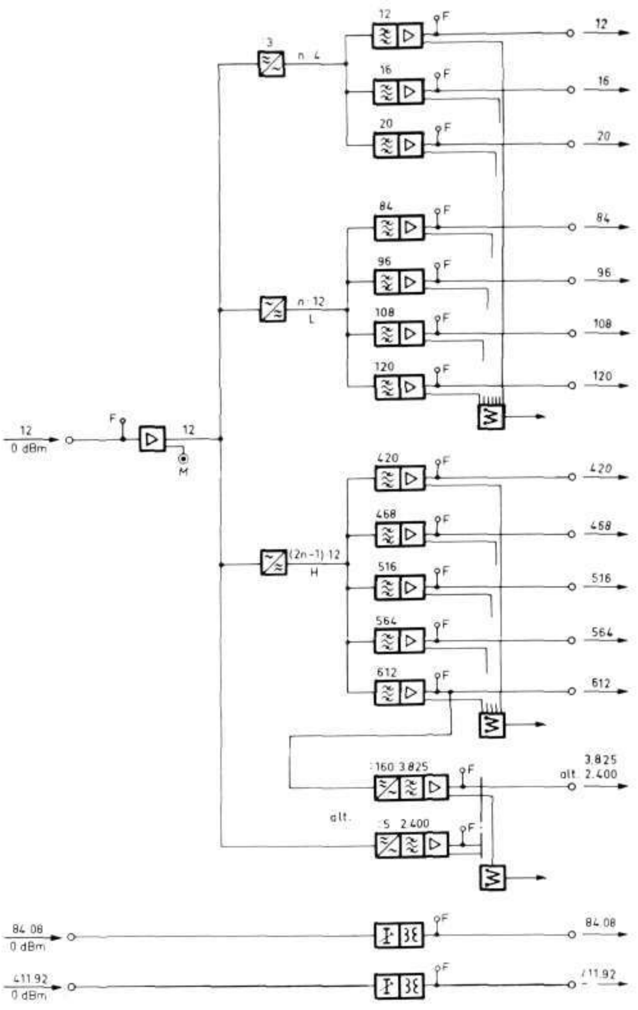

Fig. 14
Block diagram of carrier generating equipment

In the event of supergroup failure all signalling receivers associated with this supergroup are blocked via the two paralleled pilot receivers, one passing a wide band, the other a narrow one. The broad-band pilot receiver gives rapid blocking action, the narrow-band version maintains the blocking condition even if the noise level in the supergroup band rises after the interruption. High noise levels at the pilot frequency do not affect the signalling blocking condition as the narrow-band receiver has a release time delay of about 1 sec.

In case of interruptions of long duration it is desirable that those channels of the supergroup on which calls were in progress at the time the interruption occurred be released. 10–20 Seconds after failure of the pilot, therefore, the signalling receivers are released and clearing signal is transmitted to the exchange. If desired, the exchange equipment associated with the supergroup can be blocked simultaneously, thus preventing connections being set up in the opposite direction.

On release an alarm is sent out.

Carrier Generation

Block Diagram

For the channel and group translating stages the following carrier frequencies are required:

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

The following additional frequencies are required: the 3825 Hz out-band signal or the 2400 Hz in-band signal as well as the 84.08 kHz group pilot and the 411.92 kHz supergroup pilot. All these frequencies are derived from the 12 kHz basic frequency by an appropriate arrangement of harmonic generators and frequency dividers.

In the *M4* construction practice the equipment for the generation of the carrier and signalling frequencies is decentralized, i.e. it is mounted in direct association with the modulating equipment it serves. The 12 kHz carrier basic frequency as well as the 84.08 and 411.92 kHz pilot frequencies are obtained from a centralized frequency supply common to the entire terminal. The decentralized carrier generating equipment can feed up to 300 circuits, i.e. 5 supergroups.

The electrical design is shown in the block diagram, fig. 14.

The carrier frequencies are generated by converting the 12 kHz basic frequency into frequency spectra of the $n \cdot 4$ and $n \cdot 12$ types and then selecting from these spectra the desired harmonics by means of narrow-band filters. The signalling frequencies are obtained by frequency division.

Harmonic Generators

The operating principles are illustrated by fig. 15.

After substantial amplification the 12 kHz fundamental frequency via a series circuit is caused to feed a sinusoidal current into the harmonic producer coil. At a certain voltage value the coil is saturated, acting as a short circuit, thereby producing a sudden fall in voltage. This process is inversely repeated during the negative half-cycle. The symmetrical voltage is differentiated in the *RC* network, producing a train of very short pulses containing a wide spectrum of odd harmonics of 12 kHz, from which the carrier frequencies 420–612 kHz are selected.

If a direct current is passed through the coil by feeding back the output voltage via a rectifier, a bias is obtained in one direction. Hereby the pulses of one polarity are suppressed, giving rise to an unsymmetrical function containing both odd and even harmonics. In this manner the carrier frequencies 84–120 kHz are obtained from the 7th, 8th, 9th and 10th harmonics respectively.

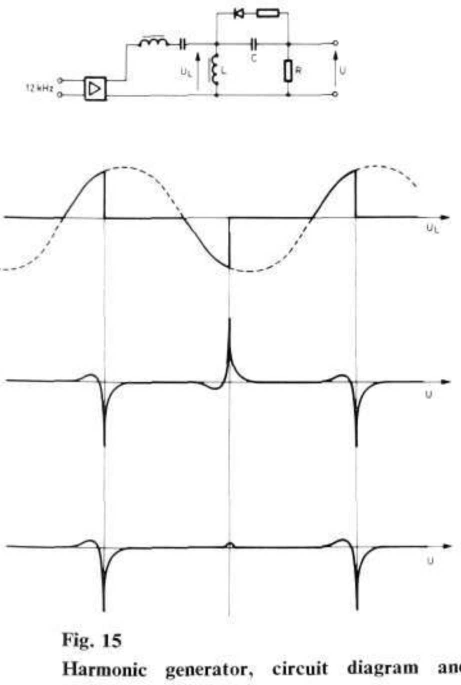

Fig. 15
Harmonic generator, circuit diagram and function

Curve H: odd harmonics
Curve L: odd and even harmonics

The input amplifier is a symmetrical design which suppresses the even harmonics in the drive current to the harmonic producer coil. This greatly simplifies the design of the filters for the 420–612 kHz carrier frequencies.

Carrier Filters

The carrier filters are narrow, single-frequency filters, for which it has been possible to use an *LC* circuit design.

Each filter is followed by a single-stage transistor amplifier, whose output can be loaded with any number of modulators required for the translation of up to 300 channels into the respective frequency blocks desired. The modulator carrier inputs are arranged in parallel, the necessary decoupling being provided by the low output impedance of the amplifier. To cope with the considerable variations in its load conditions, the amplifier output has been provided with voltage stabilizing facilities. Another advantage of this arrangement is that the amplifier is made insensitive to minor level deviations at its input, thus producing the same level at all frequencies derived from one harmonic generator, even though the spectrum is not homogeneous at the output of the harmonic generator.

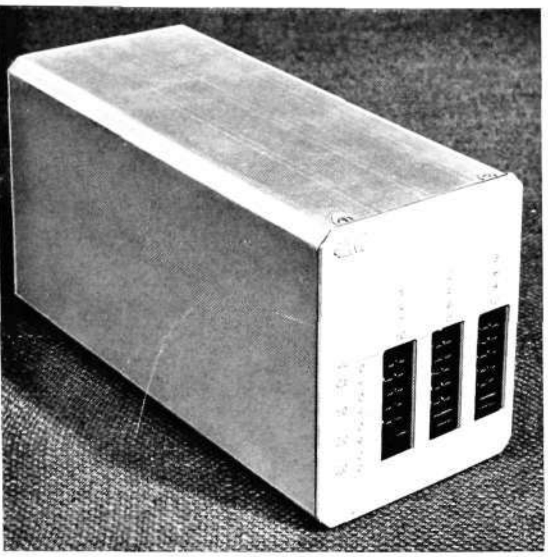

Fig. 16
Channel pack

Frequency Dividers

Frequency dividers are used for several functions. The main function is the 12-to-4 kHz division for the generation of the 12, 16 and 20 kHz channel carrier frequencies.

The principle is as follows. The incoming a. c. voltage having a frequency of 12 kHz is first squared. A capacitor is gradually charged by *three* such pulses, i. e. during three periods. The voltage across the capacitor will then have reached a certain value. On a further increase of this voltage, i.e. when the next pulse is applied, a blocking oscillator is triggered, which produces *one* pulse. At the same time the capacitor discharges and the process is repeated. Thus one outgoing pulse is obtained for each three incoming periods of 12 kHz, i.e. division by three. The output voltage, consisting of pulses of short duration, is rich in harmonics which are multiples of 4 kHz. The desired frequencies are selected by means of carrier filters.

The frequency divider producing the 2400 Hz in-band signalling frequency has a similar circuit design. It serves to divide 12 kHz by five. The divider is followed by a filter for 2400 Hz and a stabilizing amplifier of the same type as used in association with the carrier filters.

Another principle is used to obtain the 3825 Hz out-band signalling frequency. In this case the 612 kHz is divided by 160, for which purpose the above circuit is not suitable. Instead, the divider is designed as a flip-flop circuit of the shift-register type and divided into three stages with the divisors 2, 5 and 16 respectively.

For the circuit design use has been made of integrated microcircuits, which compared with the conventional design using individual semiconductor devices and resistors give a superior solution in all respects. The main advantages are

- considerable reductions in size
- comparatively large savings in power
- increased reliability, chiefly by a reduction of the number of soldered connections.

Also in this application the frequency divider is followed by a filter for the desired frequency, 3825 Hz and a stabilizing amplifier.

Level Supervision

The levels of the generated frequencies are supervised by level limit indicators. To this end a d. c. voltage is taken from the output of the respective carrier filter. To simplify alarm indication the frequencies have been grouped together via a digital OR-gate. Thus if a level fault occurs, an indication is obtained of which group of frequencies is involved; the channel carriers, for example.

By carrying out level tests in the fault location test points on the apparatus units concerned, the fault can then be located to a certain frequency.

The signalling frequency is individually supervised.

Pilot Distributors

For the 84.08 and 411.92 kHz pilot frequencies two distribution units are provided. These serve to adjust the pilot level obtained from the common frequency supply to that required at the respective injection point in the translating equipment.

MECHANICAL CONSTRUCTION

Apparatus Units

Channel Translation with Signalling

The channel translating equipment contains no more than three types of apparatus units: the channel pack, the sending subgroup pack and the receiving subgroup pack.

All functions required for forming and breaking down a subgroup, including the signalling equipment, have been combined in one unit: the channel pack. This unit contains four printed-wiring boards. The design features are shown by the block diagram, fig. 3, and figs. 16 and 17. Three of the four boards mount all the electronic circuits belonging to one channel, such as modulator and demodulator with associated filters, limiter, channel amplifier and signalling sender. The fourth board accommodates three identical signalling receivers.

Three attenuators are provided at the front of each channel pack to permit the channel levels to be adjusted by means of small U-links. To facilitate adjustment, dB values and channel numbers have been die-cast in the unit front plate; see fig. 11.

The dimensions of a complete three-channel pack are only 101 × 88 × 198 mm.

To meet different requirements regarding signalling type and frequency, the channel pack is manufactured in several versions. Thus, for example, there is one version designed for out-band signalling using 3825 Hz, and another for in-band signalling with 2400 Hz. The out-band version can be strapped for high-level or low-level signalling as well as for providing a make or break function. A further variant is provided without signalling circuitry.

The other two apparatus units of the channel translating equipment, the sending and receiving subgroup packs, provide for the translation of subgroups into a basic group and vice versa as well as group amplification; see block diagram, fig. 3.

The sending unit, all whose components are assembled on a single printed wiring board, contains the four subgroup modulators with filters, group amplifier and attenuators for pilot injection.

The receiving unit requires two boards, one of which mounts the 84.08 kHz pilot stop filter, the group amplifier and the subgroup separator, the other accommodating the four subgroup filters with demodulators. The receiving

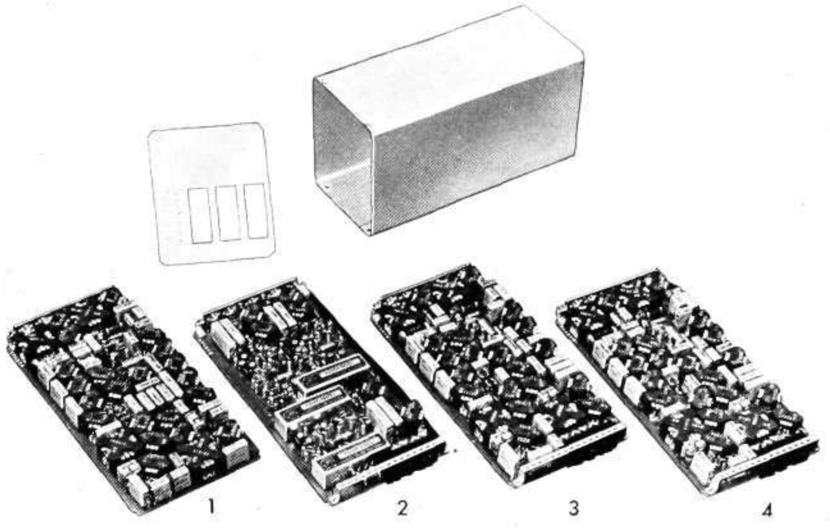

Fig. 17
Channel pack

1 Channel modem 12—16 kHz
2 Signalling receivers
3 Channel modem 16—20 kHz
4 Channel modem 20—24 kHz

Fig. 18
Sending subgroup pack

unit is available in two versions, one with and the other without pilot stop filter. The variant with filter is applicable where low-level out-band signalling and the 84.08 kHz pilot are used.

Figures 18 and 19 show the design of the subgroup packs.

If desired in certain two-wire applications, a four-wire terminating set containing equipment for three channels can be provided.

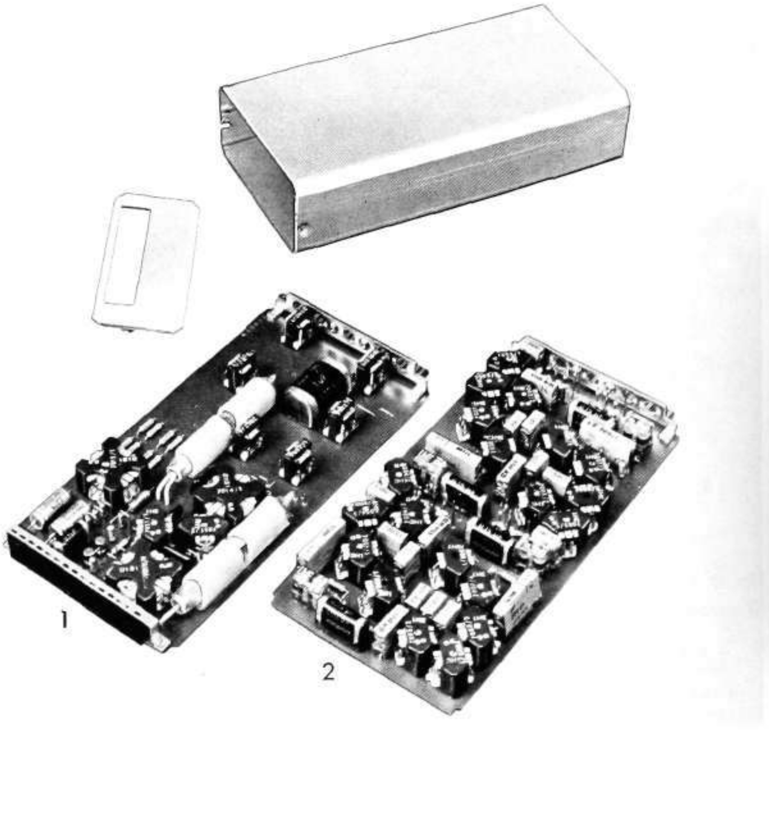

Fig. 19
Receiving subgroup pack
1 Group amplifier and pilot stop filter 84.08 kHz
2 Subgroup demodulators with filters

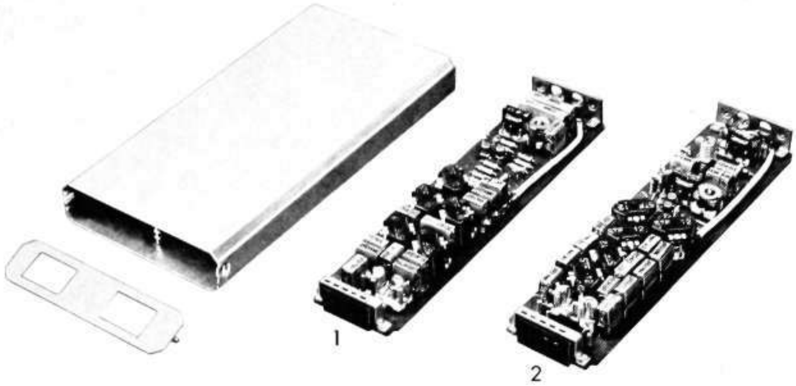

Fig. 20
Group modem
1 Group modulator
2 Group demodulator

Group Translation and Signalling Blocking

In the group translating equipment the group modulator and demodulator with associated filters have been combined into a single unit, available in five frequency variants. By assembling all the equipment needed for group combination and separation as well as supergroup amplification into one unit and the two pilot stop filters 104.08 kHz into another, a reduction of the number of types of apparatus units has been achieved also in this case.

All units making up the group translating equipment are contained in cases taking up six width modules. These units are provided with a partition to shield the sending and receiving paths from each other. For this reason the components for either direction of transmission are assembled on half-size wiring boards; see fig. 20.

The equipment for signalling blocking has been assembled in two single-board units. One contains the two pilot receivers including the rectifier stages, the other all logic circuits and relays for controlling the associated equipment.

Frequency Generation

The majority of the frequency generating units handle signals which are very rich in harmonics. Since this involves considerable risks of crosstalk and requirements for purity of the generated frequencies are comparatively high, integration has not been so extensive in these units as in the translating equipment. Thus the two harmonic generators have been designed as separate units. This is also the case with all carrier filters, each of which is combined with its respective amplifier to form a single unit occupying six width modules. For the frequency divider providing the signalling frequency a similar design is employed.

The pilot distributor 84.08 kHz, however, has been combined with the frequency divider 12 to $n \cdot 4$ kHz. This is quite feasible since any leakage originating from harmonics of 4 kHz cannot interfere with the group band.

The level supervisory functions have been assembled in two units, one of which also comprises the pilot distributor 411.92 kHz.

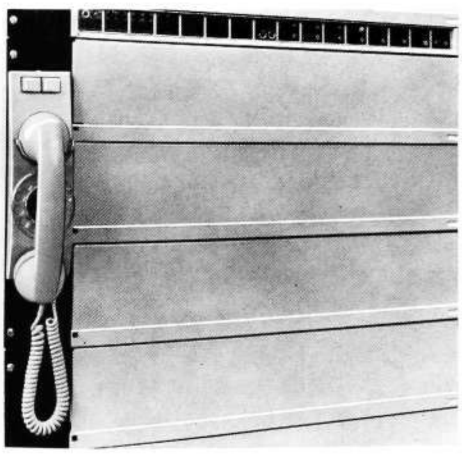

Fig. 21
Telephone unit and service shelf

Telephone Unit

In direct association with the service shelf, which contains fuses, jacks for trunks, service circuits, etc., a telephone unit can be placed in the cover strip at the front of the left-hand bay upright; see fig. 21.

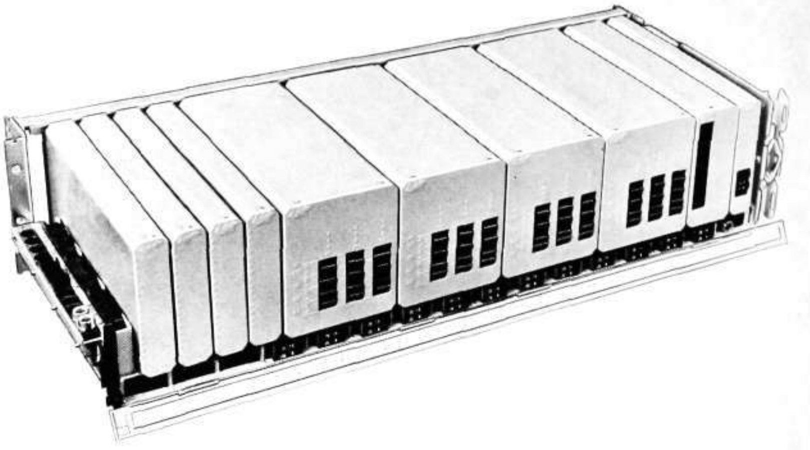

Fig. 22

Channel translating shelf

The shelf is shown with the front cover plate removed and equipped with the translating equipment and four-wire terminating equipment for one basic group

The telephone unit, which has several applications, can be connected to two automatic service circuits or exchange line circuits, which are selected by means of push-button switches. For this reason the telephone has been fitted with a dial. In addition, connection can be made to the service circuits in the service shelf by means of patch cords. With the help of a 2-W/4-W transformer monitoring and talking can be carried out over circuits in the carrier system or directly towards the exchange.

Shelves and Shelf Stacks

Channel Translating Shelf

The basic building block for all carrier systems of less than 60 circuits is the channel translating shelf containing the equipment for the formation of one basic group, i.e. four identical channel packs and the two subgroup packs as shown in fig. 22. The shelf can also accomodate twelve four-wire terminating sets assembled into four units. Their mounting positions are on the extreme left. The maintenance strip accommodates the 24 channel pads and also contains a coaxial maintenance test point for the outgoing basic group. All connections to the shelf are made by means of plugs and sockets, the connectors for incoming and outgoing channels and groups being located on the left of the shelf, those for the carrier and d. c. supplies etc. on the right. The power consumption of one channel translating equipment with signalling is 10 W.

Channel and Group Translating Shelf Stack

In large stations many administrations, the Swedish Board of Telecommunications for example, preferably use the supergroup as the smallest batch of through-connected channels. In that case the group band usually need not be accessible, so that the channel and group translating equipments can be combined into a single mechanical unit containing all the equipment needed for assembling 60 channels into a basic supergroup, and vice versa. Five shelves are joined mechanically to form a shelf stack, each shelf containing the greater part of the apparatus units belonging to one basic group, such as channel packs, subgroup packs and group modulators. The common items in the equipment for the formation of the supergroup, such as hybrids with amplifiers, pilot stop filters 104.08 kHz as well as signalling blocking equipment, are distributed over the remaining mounting space in the different shelves. The shelf stack is illustrated in fig. 23.

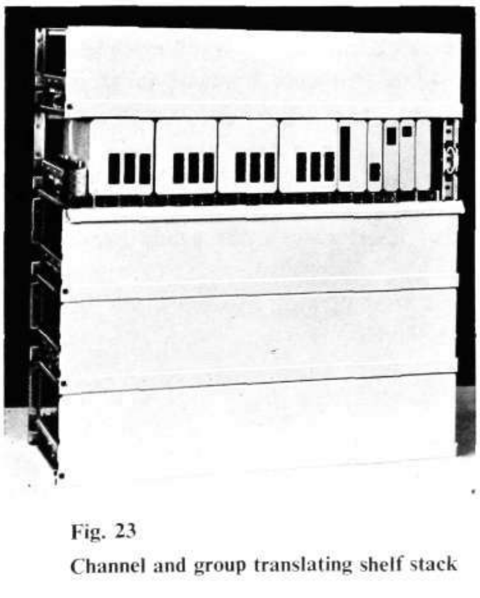

Fig. 23

Channel and group translating shelf stack

For those applications where continuous regulation of the group receive level is desired, space has been provided for a special level control beside the respective group modulator unit. For this purpose use must be made of a group demodulator version which includes a thermistor network for d. c. gain control. For a more detailed description reference should be made to a separate article on level regulation.

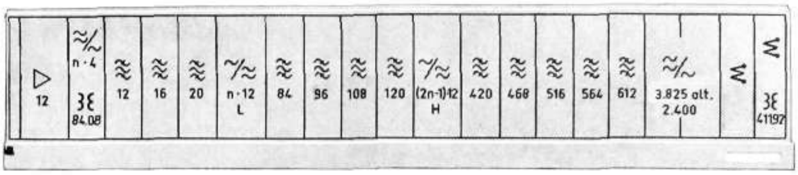

Fig. 24
Carrier generating shelf

The channel pads are arranged in the respective shelves in the same manner as in the channel translating shelf. This also applies to the external connections. In addition, to facilitate lining-up and fault location, coaxial sockets giving access to the basic group in both directions of transmission are provided on the left-hand side of the shelf, where the channel and group translating equipments have been joined together by means of a coaxial plug-in U-link. This arrangement also allows groups to be taken out to a group distribution frame for through connection where desired.

Carrier Generating Shelf

This shelf, whose mechanical design is shown in fig. 24, houses the entire carrier generating equipment described in a preceding chapter and shown in the block diagram of fig. 14.

The 12 kHz, 84.08 kHz and 411.92 kHz obtained from the common frequency supply of the station are connected to the left-hand side of the shelf. The carrier, signalling and pilot frequencies are taken out at the opposite end of the shelf.

Outgoing and incoming levels can be checked at fault location test points provided on the respective filter units and on the input amplifier. In addition, there is a maintenance test point for the 12 kHz in the maintenance strip, which also accommodates alarm lamps for the level limit indicators, one lamp being provided for each group of frequencies.

Group Translating Shelf

This shelf type is used for applications where the group translating equipment is required to be separate from the channel translating equipment, for example where groups are through connected, the ratio between the numbers of each of the two translating equipment types being determined by the requirements of each particular application.

The shelf contains all the apparatus units needed for assembling five basic groups into one basic supergroup; see fig. 25.

The shelf also contains the carrier generating equipment for the group carriers 420–612 kHz, which takes up only a minor part of the carrier generating shelf described in the preceding section. As mentioned previously, this equipment can feed up to five supergroups, which means that it is needed only in every 5th group translating shelf if a number of these are mounted in the same bay. The connectors for all five carrier frequencies are accessible on the right-hand side of the shelf.

Continuous level regulation of the incoming group can be arranged in the same way as described in the section dealing with the channel and group translating shelf stack.

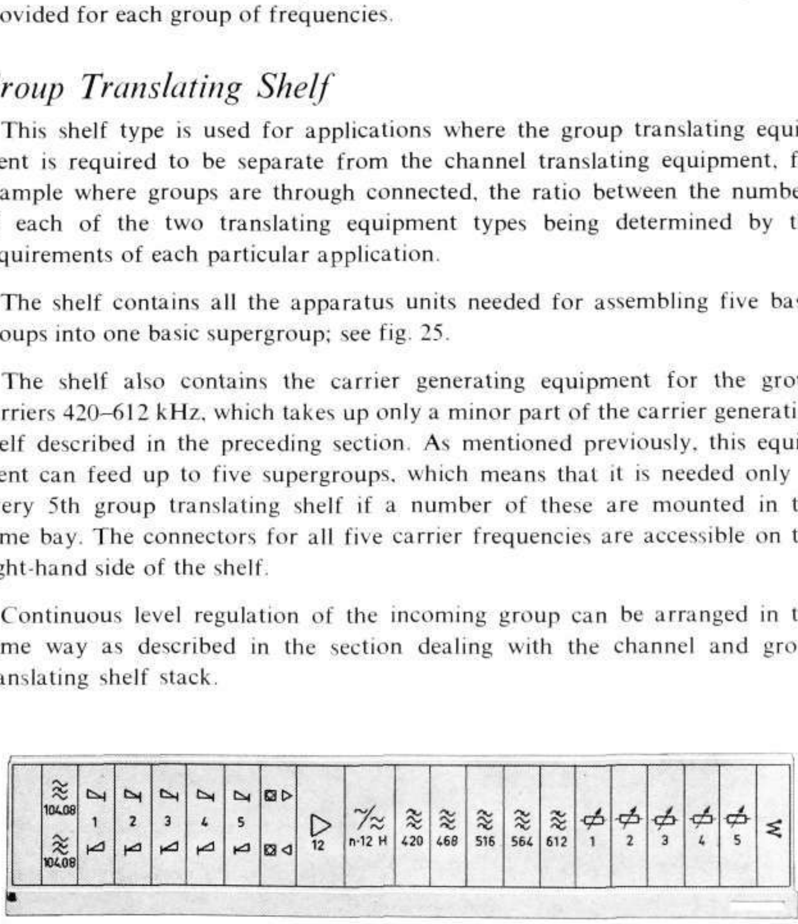

Fig. 25
Group translating shelf

Bays

Channel and Group Translating Bay

This bay, which is illustrated by fig. 26, contains four channel and group translating shelf stacks. Thus each bay has a capacity of 240 circuits or 4 supergroups. This corresponds to a capacity of 300 circuits in one bay containing only channel translating equipment without four-wire terminations.

The carrier generating shelf is also included in the bay and is mounted immediately under the service shelf. Since it can feed a maximum of 300 circuits, it is not loaded to capacity.

If desired, a channel translating bay for assembling 240 channels into 20 basic groups can be arranged by omitting all equipment for group translation.

Distribution of the carrier, signalling and pilot frequencies is arranged by means of 15 cables run vertically along the right-hand upright of the bay framework. On a level with the carrier generating shelf and the individual translating shelf stacks plug-in type connectors are fitted to mate with their counterparts in the respective shelves. Connection of the d. c. supply, alarm circuits, etc. to the shelves and shelf stacks is arranged in a similar way.

In the wide space inside the left-hand bay upright accommodation is provided for all incoming and outgoing station cabling, which is connected by means of plugs and sockets. The greater part of the cabling consists of the speech and signalling wires for the channels. When group translation is integrated, no coaxial cables are needed on the basic group side, which means a valuable saving of cost and space.

By omitting one channel and group translating shelf stack, mounting space can be obtained for a pilot receiver shelf for 84.08 kHz. This gives a bay for the translation of 180 channels into 3 supergroups with automatic level regulation and supervision or only supervision of the groups.

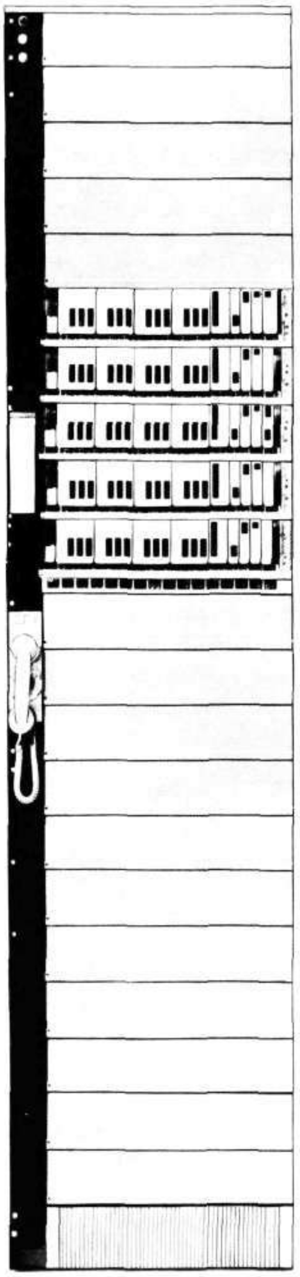

Fig. 26

Channel and group translating bay

The bay is shown with the cover plates for one channel and group translating shelf stack removed

Group Translating Bay

The layout of a group translating bay is shown in fig. 27. This bay can be equipped with up to 19 group translating shelves, i.e. 95 basic groups. For regulation or supervision of the groups two 84.08 kHz pilot receiver shelves are required besides these, each shelf having a capacity of 50 groups.

Equipment for the generation of the group carriers is incorporated in every 5th translating shelf. Inter-shelf distribution is arranged via the right-hand upright, which also accommodates the cabling between the pilot receiving and the translating equipment. All station cabling is housed in the left-hand upright and connected to the respective shelves by means of plugs and sockets.

TECHNICAL DATA

Frequency Ranges

Nominal bandwidth occupied per channel	4 kHz
Effectively transmitted speech band	0.3–3.4 kHz
Nominal band occupied by a group	60–108 kHz
Nominal band occupied by a supergroup	312–552 kHz

Nominal Levels

At Channel 4-wire Points

sending direction	–14 dBr
receiving direction	+8 dBr

At Basic Group Points

sending direction	–26 alt. –37 dBr
receiving direction	–8 alt. –30 dBr

At Basic Supergroup Points

sending direction	–35 dBr
receiving direction	–30 dBr

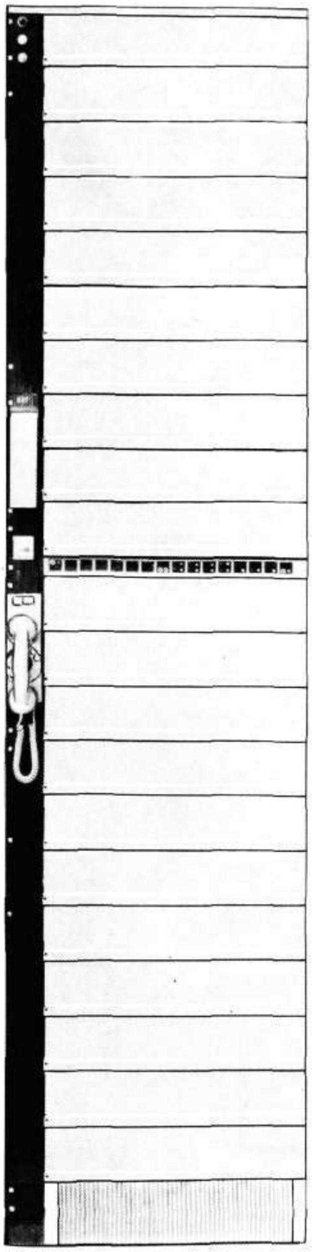

Fig. 27
Group translating bay

Nominal Impedances

at channel 4-wire points	600 ohms bal.
at basic group points	75 ohms unbal. alt. 150 ohms bal.
at basic supergroup points	75 ohms unbal.

Amplitude Frequency Response

Channel Translating Equipment

Variation of overall loss with frequency relative to 800 Hz in speech channels	In conformity with CCITT recommendation G. 232 (Blue Book); see figs. 28 and 29

Group Translating Equipment
Send and Receive Path Respectively

Attenuation distortion referred to loss at 84.08 kHz is less than	±0.5 dB

Linearity

For 3.5 dB increase in level above nominal test level, the equivalent measured for channels looped at group frequencies does not increase more than	0.3 dB

Limiting

For 15 dB increase in level above nominal test level at the 4-wire input, the output at the group side does not exceed	+10 dBm0

Carrier leak

	CTE	*GTE*
Carrier leaks measured selectively at the output of the send equipment do not exceed	–28 dBm0	–40 dBm0

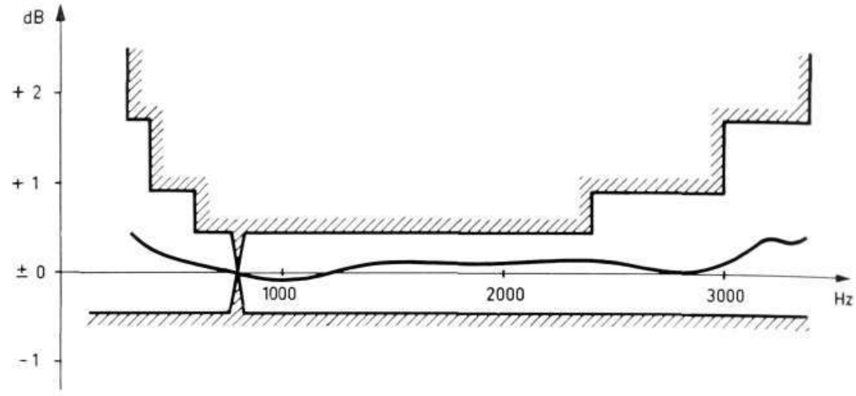

Fig. 28

Variation with frequency of the overall loss relative to 800 Hz for all 12 channels of a group, cascaded at voice frequencies and looped at group frequencies. (Mean value per channel)

Tolerance limits according to CCITT Blue Book, volume III, Recommendation G.232 A

	CTE	*GTE*
Intelligible Crosstalk		
For all combinations of near-end and far-end crosstalk, the crosstalk ratio exceeds	75 dB	85 dB
Near-end crosstalk ratio between go and return channels of the same circuit exceeds	53 dB	85 dB
Unintelligible Crosstalk		
Crosstalk noise ratio, measured psophometrically, for inverted sideband of adjacent channel fed by a noise source with same spectral distribution as average speech, better than	65 dB	80 dB

Signalling

Out-Band Signalling

Frequency	3825 Hz	
Level	−18 alt. −6 dBm0	
Signalling distortion, for impulses or interruptions lasting at least 30 millisec, when the signal level is within ±6 dB and the signalling frequency within ±10 Hz of nominal, does not exceed	6 ms	

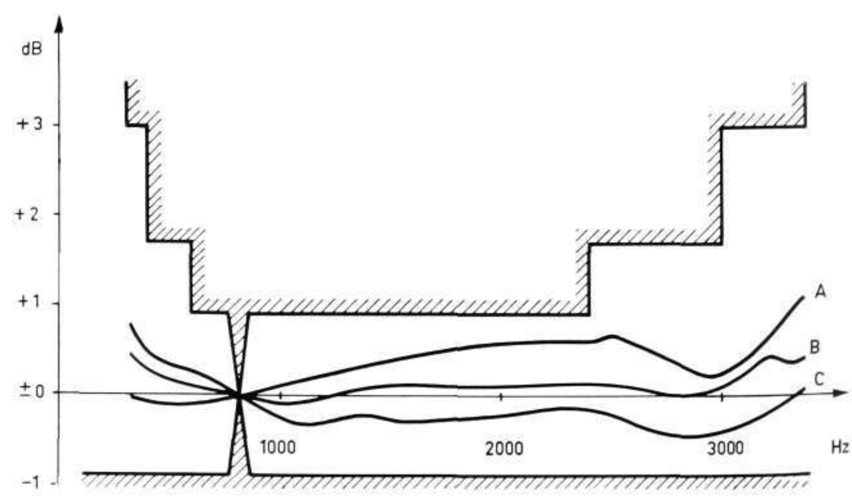

Fig. 29

Variation with frequency of overall loss relative to 800 Hz for individual channels looped at group frequencies

Tolerance limits according to CCITT Blue Book, volume III, Recommendation G.232 A

The curves show the spread for 12 channels

- A Maximum
- B Average
- C Minimum

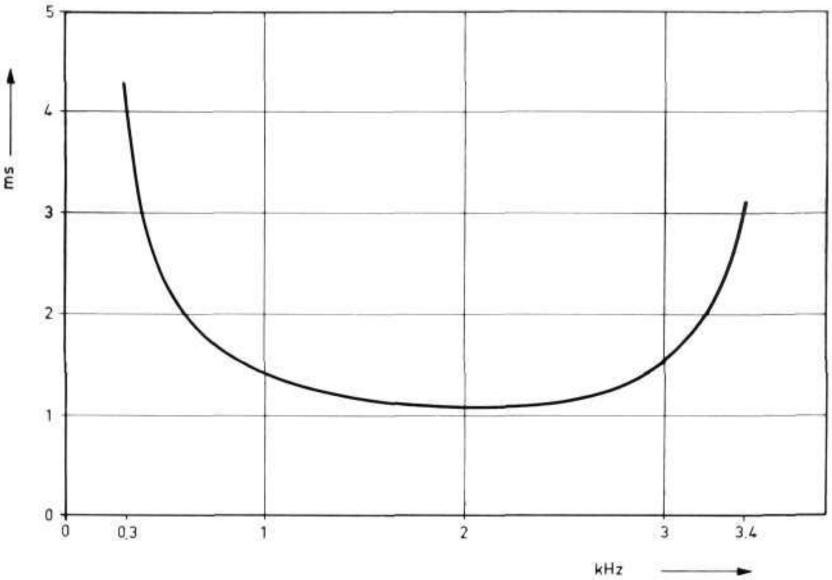

Fig. 30
Group delay as a function of frequency for a channel looped at group frequencies
Mean value for 12 channels

In-Band Signalling

Frequency	2280 alt. 2400 Hz
Level	–6 dBm0
Distortion, for impulses or interruptions lasting at least 20 millisec, when the signal level is within ±9 dB and the signalling frequency within ±15 Hz of nominal, does not exceed	5 ms

Carrier Generation

Incoming carrier basic frequency	12 kHz
at level/impedance	0 dBm/75 ohms
Outgoing frequencies with feeding capacity for translating equipment serving up to 300 channels	
Carrier frequencies	
channel carriers	12, 16 and 20 kHz
subgroup carriers	84, 96, 108 and 120 kHz
group carriers	612 kHz
	420, 468, 516, 564 and
Signalling frequencies	
out-band	3825 Hz
in-band	2280 Hz alt. 2400 Hz

Power Consumption

Shelves

(Supply from 21 V d.c. battery)	
Channel translating shelf	10 W
Channel and group translating shelf stack	55 W
Carrier generating shelf	20 W
Group translating shelf	
excl. carrier generation	5 W
incl. carrier generation	17 W

Bays

	Supply from		
	battery		mains
	24 V	36, 48 or 60 V	110, 127 or 220 V
Channel and group translating bay Equipped with: 4 channel and group translating shelf stacks 1 carrier generating shelf	320 W	290 W	320 W
Group translating bay Equipped with: 4 group translating shelves with carrier generation 15 group translating shelves without carrier generation 2 pilot receiver shelves	375 W	340 W	375 W

Equipment for Level Supervision and Regulation

Å. BRENÉ, TELEFONAKTIEBOLAGET L M ERICSSON, STOCKHOLM

UDC 621.395.44
621.395.66
LME 8471

A new universal equipment for level supervision and regulation has been developed for the M4 equipment construction practice. It is built up round a centralized pilot receiver for each modulation stage. The equipment is fully electronic and contains no moving mechanical parts.

The transmission of frequency bands over long distances inevitably involves certain variations of the overall loss. The consequent attenuation distortion may vary owing to rearrangements of traffic on other routes, through connections, variations in cable temperature, aging of amplifying elements, etc. Even though certain variations are automatically compensated by level regulating equipment on the h.f. line, residual errors will occur which are not constant over the transmitted band and which may accumulate to reach a value requiring correction. According to CCITT recommendations a maximum value of the standard deviation of 1 dB is permissible for an international circuit. This circuit may consist of several line sections each having a maximum deviation of 1 dB. Since it is impossible to predict how the loss will vary over the frequency band, the most suitable point for regulation to be applied is after the line frequency band has been broken up into frequency blocks. Regulation within each block of frequencies is independent of frequency (flat). These frequency blocks in their turn are subdivided into smaller frequency blocks, which are also provided with flat level regulation. By further subdivisions smaller and smaller error components can be corrected. See fig. 1.

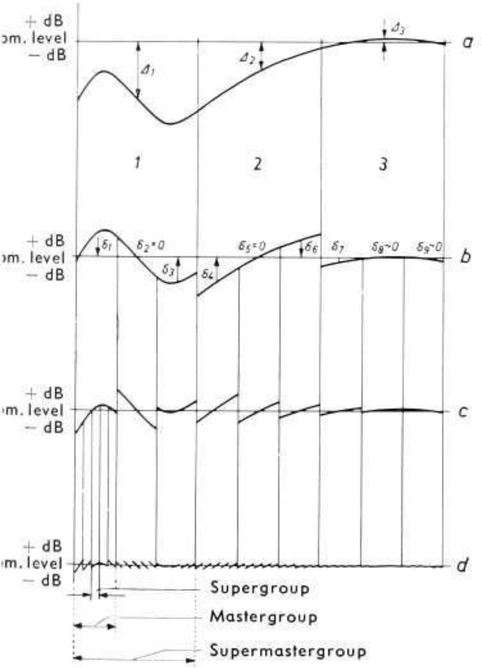

Fig. 1

Example of level regulation

- a Incoming line frequency band, level deviation from nominal
- b Supermastergroup level deviation from nominal after supermastergroup level regulation
- c Mastergroup level deviation after mastergroup level deviation
- d Supergroup level deviation after supergroup level regulation

General Principles

Immediately after the formation of a frequency block the reference pilot assigned to that block is injected. This reference pilot can then be used for automatic regulation or supervision of the respective frequency block. For a 12 MHz carrier system the CCITT has recommended the following reference pilots:

Frequency block	*Assigned pilot*	*Injected into*
basic group B	84.08 kHz	Channel transl. equipment
basic supergroup	411.92 kHz	Group transl. equipment
basic mastergroup	1,552 kHz	Supergr. transl. equipment
basic supermastergroup	11,096 kHz	Mastergr. transl. equipment
15-SG assembly	1,552 kHz	Supergr. transl. equipment
2700-channel line group (not specified by CCITT)	8,248 kHz	Supermastergr. transl. equip.

To receive these different pilot frequencies two pilot receiver variants have been designed, one for 84.08 kHz, the other for 1,552 kHz. The two design versions only differ in the selective part of the assemblies. To enable the pilot receivers to handle the other pilot frequencies, modulators are included in which the incoming pilots are caused to modulate a carrier frequency appropriate for each case (see table below).

Pilot receiver 84.08 kHz		*Pilot receiver 1,552 kHz*	
Pilot frequency	Carrier frequency	Pilot frequency	Carrier frequency
84.08	—	1,552	—
411.92	496	8,248	6,696
		11,096	12,648

The pilot receiver checks in turn the levels of the reference pilots of the different frequency blocks. In the event of level deviations requiring regulation the pilot receiver operates a memory circuit in the automatic level control associated with the frequency block concerned. This level control then adjusts the level of the frequency block by regulating the gain in the respective receiving translating equipment. This gain regulation is obtained by appropriate variation of the d.c. current through a thermistor. In the event of excessive level deviations an alarm is given. The central alarm equipment of the bay concerned extends an alarm, an indication of the level fault being given by an indicator lamp associated with the respective frequency block. The equipment can be used either for level supervision only or for combined level regulation and supervision. (See fig. 2.)

The above method using a common pilot receiver has been made possible by the advent of electronic memories which are acceptable from the point of view of reliability as well as economy. This method has several advantages over the method using individual pilot receivers for each frequency block. One of the advantages is that the pilot receiver can be simply arranged to be self-checking by checking the level of the pilot from the local pilot supply and checking the trigger limits of the decision circuit by means of stabilized d.c. voltages. These checks obviate all routine maintenance of the equipment. In addition, since the level regulating unit is provided with a memory circuit, the regulating equipment included in the transmission path will maintain the gain at a constant value in the event of pilot failure, short-duration interruptions of transmission, etc. Another advantage is the fact that all regulation steps are equal and each step is preceded by a check ascertaining whether the level deviation still exists. Regulation speed is independent of the magnitude of the level deviation. All the above-mentioned factors have a favourable effect on the stability of the system.

Operation

The following description of the operating principles refers to equipment handling groups and supergroups. Fig. 3 shows this equipment schematically. The same method of operation is applied in equipment handling mastergroups, supermastergroups and 2700-channel line groups, using the same type of apparatus containing, of course, different frequency-dependent parts.

By means of electronic equipment the different groups and supergroups are automatically connected in turn to the centralized pilot receiver.

Each frequency block is connected for 2.5 seconds. The block next to be checked is connected from a test outlet of the demodulator concerned, via a static relay *SR*, to the input of the pilot receiver. If a group is checked, it is passed via an amplifier stage to a crystal filter *4*, which selects the 84.08 kHz reference pilot. If a supergroup is checked it is passed through a modulator *3*, which by means of a 496 kHz carrier produces a band from which the 84.08 kHz can be selected by the crystal filter.

The filter suppresses interference from speech and signalling frequencies, thus preventing these from affecting regulation. Its discrimination characteristic is shown in fig. 4. After separating out, the pilot frequency is amplified in two identical amplifiers *5* and *6*, and rectified in a pilot rectifier *7* before being applied to an electronic level sensing device, the decision circuit *8*. This comprises four Schmitt trigger circuits, each of which is set to an individual voltage threshold. These voltage thresholds have been fixed at such values that any level deviation exceeding +0.5 or −0.5 dB will cause one of the two Schmitt triggers arranged for regulation to respond. Should the level deviation

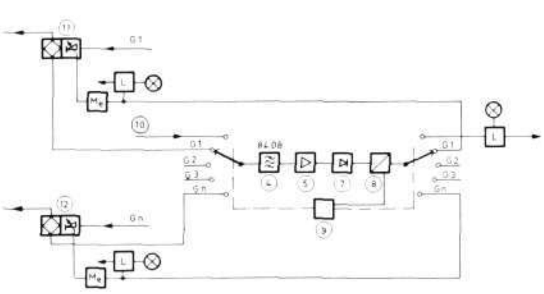

Fig. 2

Principle of scanning several frequency blocks by means of centralized pilot receiver

④ Pilot filter 84.08 kHz
⑤ Amplifier
⑦ Rectifier
⑧ Decision circuit and logic circuit
⑨ Timing control
⑩ Injection of outgoing 84.08 kHz pilot
⑪ Group demodulator
⑫ Group demodulator

Me Memory
L Alarm holding circuit

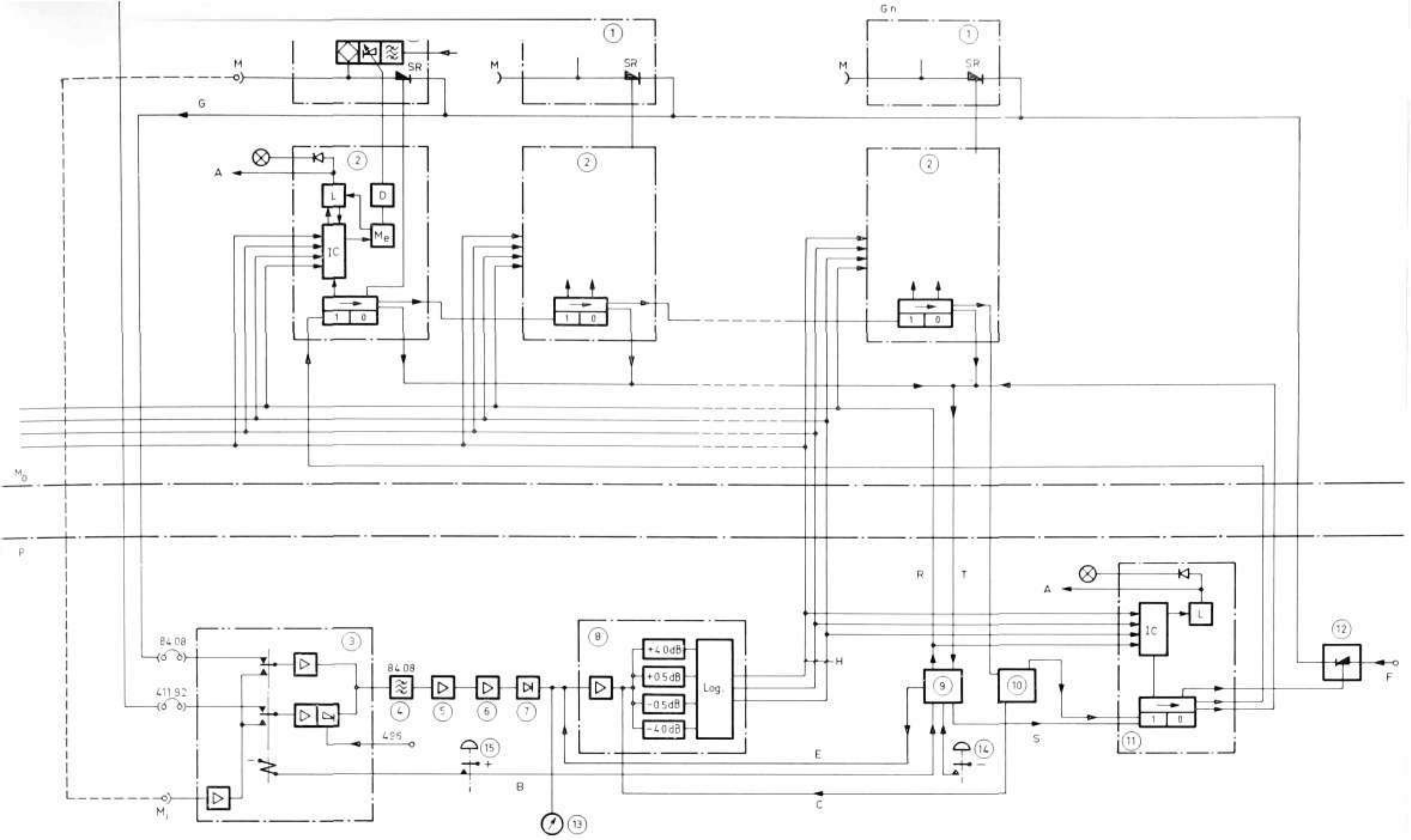

Fig. 3

Regulation and supervision of group and supergroup levels with common pilot receiver

- ① Demodulator with regulating circuit and static relay (SR)
- ② Automatic level control
- ③ Pilot modulator
- ④ Pilot filter 84.08 kHz
- ⑤ Amplifier
- ⑥ Amplifier
- ⑦ Rectifier
- ⑧ Decision circuit (d.c. amplifier, Schmitt triggers and logic circuit)
- ⑨ Timing control
- ⑩ Threshold monitor
- ⑪ Alarm indicator
- ⑫ Static relay for outgoing pilot
- ⑬ Indicating instrument
- ⑭ Start button
- ⑮ Switch for manual checking

- A Alarm extension
- B Blocking of regulation stepping pulse
- C Control of Schmitt triggers
- D Drive stage
- E Short circuit of decision circuit input
- F Injection of outgoing 84.08 kHz pilot
- G Basic groups
- H To automatic level control (alarm, level < nom. and level > nom.)
- IC Input circuits
- L Alarm holding circuit
- Log Logic circuit
- M Maintenance test point for received frequency block
- Me Memory circuit
- Mi Input jack for connection of optional frequency block (manual checking)
- Mo Translating (receive) equipment
- P Pilot receiving shelf
- R Regulation stepping pulse
- S Starting pulse
- SG Supergroups
- T Timing pulse

exceed the alarm limit, which can be set to ± 2 dB or ± 4 dB, also one of the two Schmitt triggers arranged for alarm will respond, operating a logic circuit, which in its turn extends an alarm. At the same time regulation is clamped, so that amplification in the transmission path is unchanged.

In case of a level deviation of between ± 0.5 dB and the preset alarm limit, i.e. a deviation requiring regulation, the memory circuit in the automatic level control *2* is actuated by a regulation stepping pulse from the timing control *9*. The memory circuit consists of five bistable toggles combined into a reversible binary counter. The output signal from the counter is a d.c. current whose magnitude is dependent on the state of the counter. This current is passed through a thermistor in the demodulator *1* and regulates the gain in the receive direction. The counter in the memory provides 32 forward or backward steps by which it can increase or decrease the gain in accordance with the input stepping pulses applied to it by the timing control.

Only one regulation step can be provided during each scanning cycle.

The range of adjustment is ± 4 dB related to the nominal level of the incoming reference pilot. As no contacts are included in the signal path optimum reliability is obtained. In the event of a level deviation beyond the preset alarm limit the level control sends out shelf, bay and station alarms. In addition, an individual lamp will indicate the faulty frequency block. This alarm indication is held until the fault has been cleared. At the same time regulation for the frequency block involved is clamped to prevent incorrect level adjustment. Should a prolonged, gradual level change cause the counter to reach one of its end positions, an alarm is given and the alarm lamp for the frequency block involved is lit.

The outgoing reference pilot, generated by the common frequency supply of the terminal and injected in the send path immediately after the formation of the basic group and supergroup, is also checked once during each scanning cycle by means of an alarm indicator *11* and a static relay *12*. If this pilot level deviates from its nominal value by more than 0.5 dB, an alarm is given. Thus a check is obtained on the level of the outgoing pilot as well as on the function of the common pilot receiver.

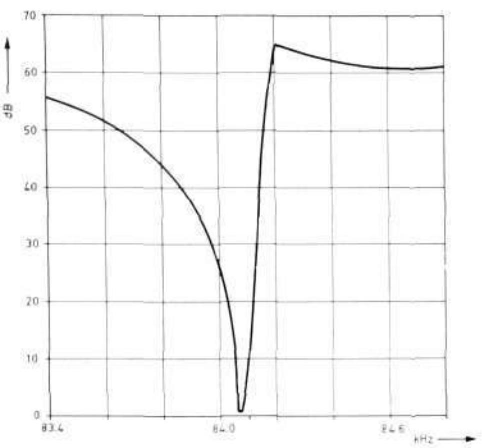

Fig. 4

Attenuation characteristic for pilot filter 84.08 kHz

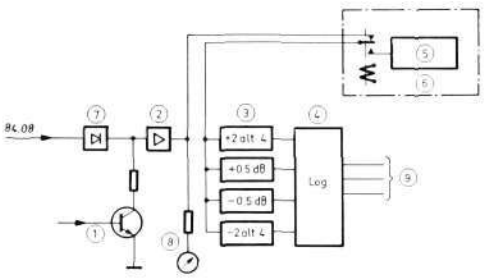

Fig. 5

Decision circuit with rectifier and logic circuits

① Transistor for short-circuiting amplifier input
② DC amplifier
③ Schmitt trigger circuits
④ Logic circuits
⑤ Voltage standard
⑥ Threshold monitor
⑦ Rectifier
⑧ Indicating instrument
⑨ To level controls (alarm, level < nom. and level > nom.)

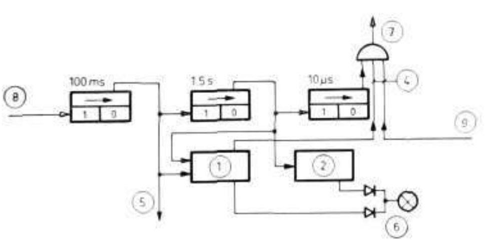

Fig. 6

Timing control

① Incorrect scanning
② Interrupted scanning
③ Starting pulse to alarm indicator
④ In hibiting of regulation stepping pulse
⑤ Control pulse for short-circuiting decision circuit
⑥ Scanning fault indication
⑦ Regulation stepping pulse out
⑧ Timing pulse in
⑨ From manual testing and threshold monitor

To increase the reliability of the decision circuit a threshold monitor *10* is automatically connected once during each scanning cycle to check the four Schmitt triggers by means of zener-controlled d.c. voltages.

The pilot levels of the different frequency blocks can be read from a built-in indicating instrument *13*. To this end a test lead is inserted between the maintenance test point associated with the desired frequency block and the pilot receiver input jack.

When the test button *15* is pressed, the stepping pulse to the automatic level control is blocked and the pilot level of the frequency block under test can be read from the instrument.

Scanning

When the start button *14* is pressed, a negative trigger pulse is applied from the timing control *9* to the alarm indicator *11* (which serves to supervise the level of the outgoing pilot). This trigger signal drives the monostable flip-flop included in the alarm indicator into its unstable state, where it remains for 10 seconds. In this state the static relay *12* and the input gate circuits *IC* of the alarm indicator are opened.

The pilot level is checked. To be able to indicate an alarm condition an additional pulse is required to be applied to the input gate circuits. This pulse (stepping pulse) is derived from the trigger pulse and is emitted about 1.5 seconds after the monostable flip-flop has been driven into its unstable state.

When the monostable flip-flop in the alarm indicator reverts to its stable state, it applies a negative pulse to the level control *2* for frequency block *G 1* in the sequence of *n* frequency blocks included in a scanning cycle. At the same time the input gate circuits are closed and level testing ceases as far as the alarm indicator is concerned. The monostable flip-flop in the level control is driven into its unstable state for a period of 2.5 seconds. At same time the input gate circuits *IC* for alarm extension and regulation in the level control are opened, as is the static relay in the demodulator for *G 1*, thereby permitting the level to be tested. In connection with the switching from the alarm indicator to the level control a timing pulse is produced, which is applied to a timing control *9*. Here the timing pulse is converted and delayed, to be fed out as a regulation stepping pulse at the end of the test period. The scanning cycle proceeds in this manner until all frequency blocks have been tested. The last unit in this test sequence is the threshold monitor *10*. This unit consists of four monostable flip-flops which in turn apply stabilized d.c. voltage to the decision circuit for checking the four Schmitt triggers. When the last of the four flip-flops in the threshold monitor is restored to its stable state, it triggers the alarm indicator, which initiates a new scanning cycle.

Pilot Rectifier and Decision Circuit

The rectifier together with the decision circuit constitutes an analogue-to-digital converter. A block diagram is shown in fig. 5. The rectifier converts the pilot signal into a direct voltage, which is passed through a d.c. amplifier and then applied to the level sensing circuit. Where manual checking of the level in any frequency block is desired an indicating instrument can be connected to the output of the d.c. amplifier. The level sensing circuit consists of four Schmitt triggers. Two of these are employed for the regulation of minor level deviations (± 0.5 dB): the other two can be set to indicate deviations of ± 2 dB or ± 4 dB. To eliminate the hysteresis of the Schmitt triggers, a transistor circuit controlled by the timing control and serving to short-circuit the input of the d.c. amplifier between each two consecutive tests has been inserted between the pilot rectifier and the d.c. amplifier. In this manner the Schmitt triggers will always be actuated by a d.c. signal rising from a low value (short circuit) to a value corresponding to the level of the frequency block concerned.

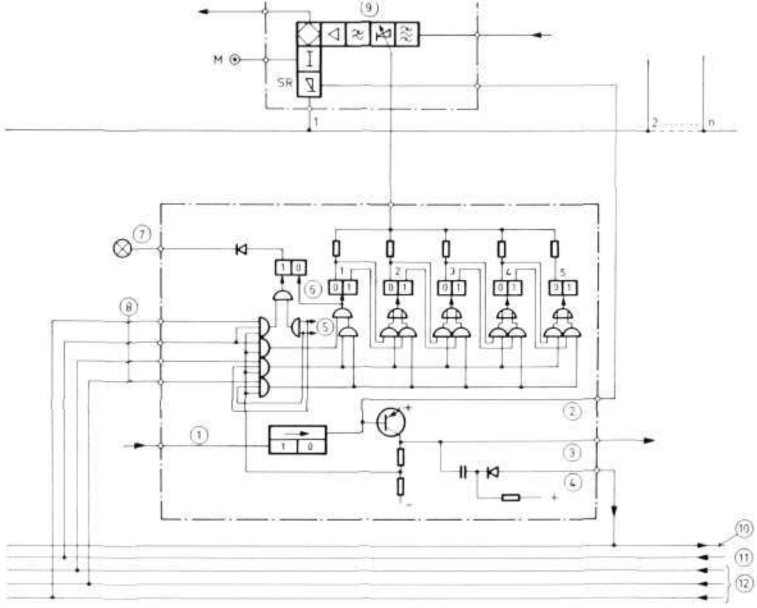

Fig. 7

Demodulator and automatic level control

① Trigger pulse input
② To static relay
③ Trigger pulse output for connection of next frequency block
④ Timing pulse output
⑤ End-position alarm
⑥ Automatic reset
⑦ Level alarm
⑧ Input circuits (alarm, stepping pulse, level < nom. and level > nom.)
⑨ Demodulator with regulating circuit
⑩ To timing control
⑪ From timing control
⑫ From logic circuit in decision circuit

The four Schmitt triggers are connected to logic circuits. At three outputs these logic circuits give digital information on the pilot level. The logic circuit output + 0.5 dB and − 0.5 dB for regulation are inhibited when one of the alarm circuits, + 4 dB or − 4 dB, has been triggered.

Timing Control

The timing control (fig. 6) serves to provide a control pulse causing the d.c. amplifier at the input of the decision circuit to be short-circuited. This control pulse is derived from the timing pulse produced on switching from one frequency block to the next. In addition, it produces a regulation stepping pulse about 1.5 seconds after the beginning of a test period. The timing control also sends out an alarm in the event of incorrect or interrupted scanning. The unit further incorporates a circuit enabling the scanning cycle to be initiated manually. For this purpose a start button is provided.

Automatic Level Control and Alarm Indicator

The automatic level control (figs. 7 and 8) is designed, first, to accept information in digital form from the decision circuit and to convert this into

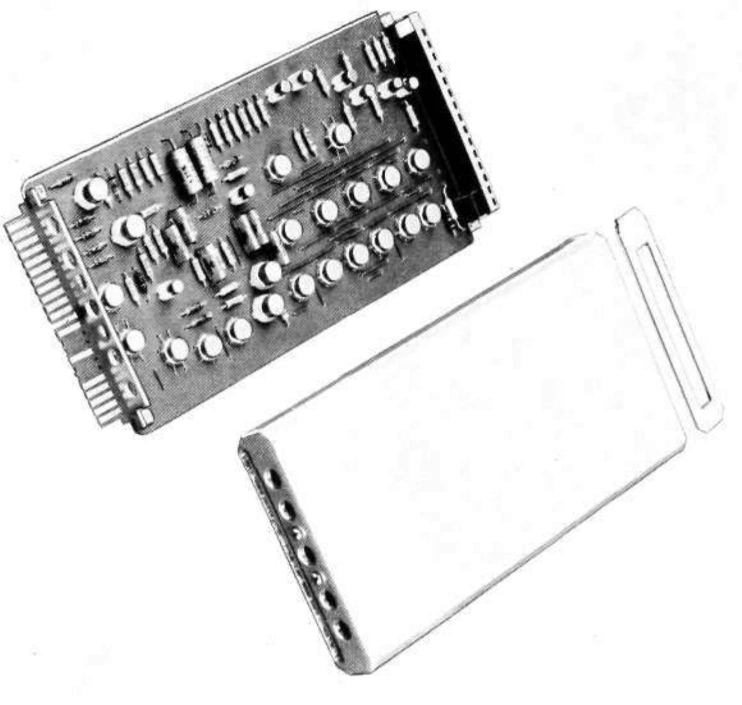

Fig. 8

Level control

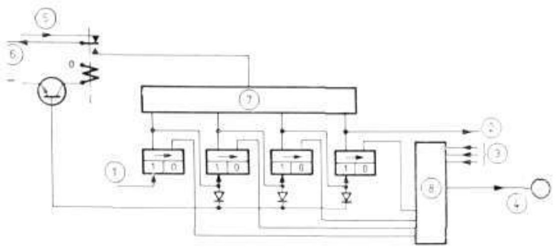

Fig. 9

Threshold monitor

① Trigger pulse input
② Trigger pulse output
③ From decision circuit
④ Fault in decision circuit
⑤ Rectified pilot
⑥ To decision circuit
⑦ Voltage standard
⑧ Logic circuit

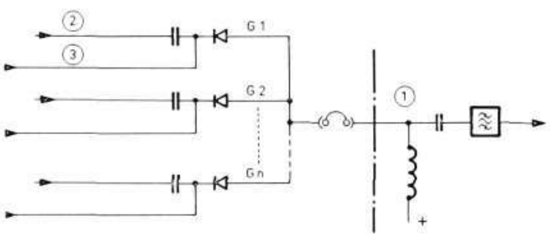

Fig. 10

Static relay with pilot receiver input

① Pilot receiver
② HF signal from hybrid in demodulator
③ DC voltage from level control during test

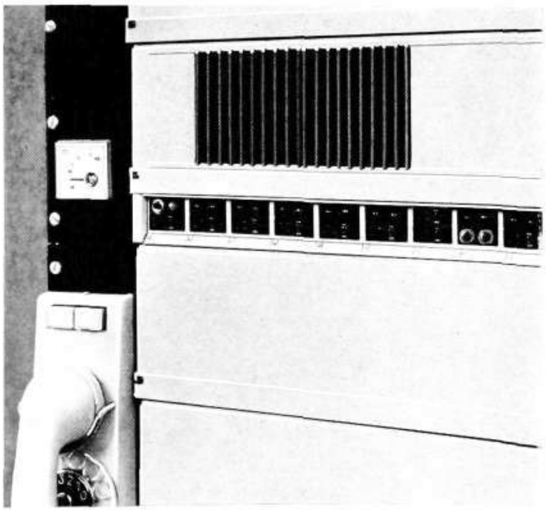

Fig. 11

Pilot receiving shelf with associated indicating instrument mounted in bay. Heat sinks visible through opening in dust cover belong to d.c. converters (21 V to 3.6 V).

the analogue equivalents to be used for the regulation of the level of the associated frequency block in the transmission path. Second, it serves to maintain the regulating current at a constant value between two consecutive test periods. Third, on major level deviations in the transmission path, to receive information from the decision circuit and to convert this into an alarm to be maintained for the duration of the fault. The unit incorporates a monostable flip-flop that forms part of the chain of level controls involved in one complete scanning cycle. The gates and trigger circuits making up the unit consist of integrated circuits. The digital-to-analogue converter consists of a reversible binary counter containing five bistable toggles. These toggles are interconnected via gate circuits. The input pulses "level < nominal" and "level > nominal" decide in which direction regulation will be effected when the stepping pulse is applied.

Each toggle stage is connected to a drive stage. The number of output current units produced in the '1'-state of each of the five toggle stages of the regulation circuit is 1, 2, 4, 8 and 16 respectively. Thus the combined arrangement permits regulation to be effected in 32 equal steps.

Depending on the direction of regulation required, the pulse from the decision circuit is passed via one or the other gate system. When the level is at nominal and under fault conditions regulation is clamped and the condition of the counter remains unchanged, the thermistor current being maintained at a constant value.

When responding to a major level deviation, the decision circuit extends an alarm pulse via its logic circuit to the level control of the frequency block under test. This signal together with the regulation stepping pulse drives the alarm toggle of the level control into the alarm state. This will also occur when the binary counter has reached one of its end positions. At the same time an indicator lamp associated with the frequency block concerned is lit and station alarm is sent out. When after a power failure current is restored to the level control, the binary counter reverts to its centre position (corresponding to nominal gain).

The alarm indicator is similar in design to the level control, but has no memory circuit. In systems where only supervision without automatic regulation is required, a manual level control is used. Here a variable resistor for the regulation of the thermistor current is substituted for the memory and the drive stage. Compensation is provided in the heater circuit for changes in voltage and temperature.

Threshold Monitor

This unit serves to check automatically once during each scanning cycle the trigger levels of the four Schmitt triggers in the decision circuit. Four monotable flip-flops (fig. 9) included in the same scanning chain as the level controls and the alarm indicator connect in turn the zener-controlled d.c. voltages to the decision circuit. In case of a fault in the decision circuit the threshold monitor will block regulation and send out an alarm.

Gain Regulator and Test Relay (Group and Supergroup)

Regulation is effected in the demodulator, which is a transistor modulator design whose feedback path incorporates an indirectly-heated thermistor to regulate the gain. The range of adjustment is ± 4 dB. See fig. 7.

The output of the demodulator consists of a hybrid. One pair of its terminals is connected to the next demodulation stage, the other to a maintenance test point and a test relay. For the basic group and supergroup a static relay is used for this purpose. It normally consists of a diode which is driven into conduction by a d.c. current when the level is checked. See fig. 10.

For other frequency blocks using the 1552 kHz reference pilot a mercury-wetted contact relay is used to meet the demands imposed by crosstalk at higher frequencies.

Mechanical Construction

The pilot receiving shelf contains all the apparatus units common to the decentralized level controls and supervisory equipment of the various modulation stages, as shown in the block diagram, fig. 3. Besides the units shown in fig. 3 the shelf contains the units required for the generation of the 496 kHz carrier by means of the 124 kHz basic frequency, and for d.c. conversion from 21 volts to the 3.6 volts needed for the integrated circuits in the level controls and alarm indicators. The mechanical design is illustrated by fig. 11, which also shows the indicating instrument. This is normally placed in the left-hand bay upright beside the service shelf.

The 84.08 or 411.92 kHz pilot and the 124 kHz basic frequency are obtained from the common frequency supply of the station via connectors on the left-hand side of the shelf. The intershelf wiring connecting the pilot receiver to the apparatus units in the frequency translating shelves or shelf stacks is arranged at the right-hand end of the shelf. Maintenance test points, U-links and alarm lamps for indication of any fault in the scanning cycle, decision circuit and 3.6 V supply are placed in the maintenance strip. This also contains push buttons for alarm location, start of a scanning cycle, connection of the instrument for manual checking and regulation inhibiting.

The shelf for the 1552 kHz pilot is arranged in the same manner.

Technical Data

Testing

Number of supervised groups	$\leqq$ 100
,, ,, ,, supergroups	$\leqq$ 50
Test period per group or supergroup	2.5 sec.
Test period for outgoing pilot	10 sec.
Regulation stepping pulse	10 μsec.

Automatic level regulation

Range of regulation	$> \pm$ 4 dB
Regulation error	$<$ 1 dB
Regulation step	$<$ 0.4 dB
Number of regulation steps	32

Automatic level supervision

Level alarm is given (and regulation simultaneously clamped in applications with automatic regulation) when output pilot level deviation from nominal exceeds a limit that can be preset at	$\pm$ 2 dB or $\pm$ 4 dB

Level reference

Level of pilot generated by local frequency supply.	
Level alarm on pilot level deviation from nominal setting of pilot receiver	$\pm$ 0.5 dB

Power consumption

Pilot receiving shelf 84.08 and 411.92 kHz (operation from 21 V d.c. supply)	
basic equipment	10 W
increase per added frequency block	1 W
Pilot receiving shelf 1552 kHz (operation from 21 V d.c. supply)	
basic equipment	10 W
increase per added frequency block	1 W

Supergroup Translating Equipment for a 960-Circuit System

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UDC 621.395.44
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LME 8421 7544

Together with preceding articles in this issue dealing with the channel and group translating equipment and equipment for level supervision and regulation, this article dealing with the equipment for assembling basic supergroups into line groups forms a complete description of a terminal equipment for a 960-circuit carrier telephone system engineered in the M4 equipment construction practice.

The supergroup translating equipment, which assembles basic supergroups into a 960-channel line group, is accommodated in one shelf stack and forms a mechanical unit. This shelf stack also contains the supergroup carrier generating equipment as well as individual units for regulation and supervision.

Equipment which together with associated entrance cable provides for the interconnection of the 960-circuit multiplex with a radio link has been assembled in a separate shelf.

The equipment fulfils the relevant requirements recommended by the CCITT with ample margins.

Modulation Plan and Block Diagram

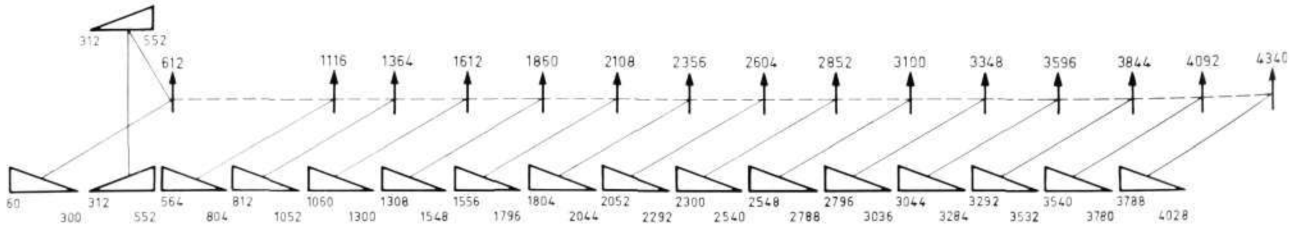
Fig. 1 shows the frequency allocation for the supergroup translating equipment for the formation of a 960-channel line group. In addition to the frequencies standardized by the CCITT the 1552 kHz can be provided to serve as reference pilot for the 960-channel line group (line link pilot).

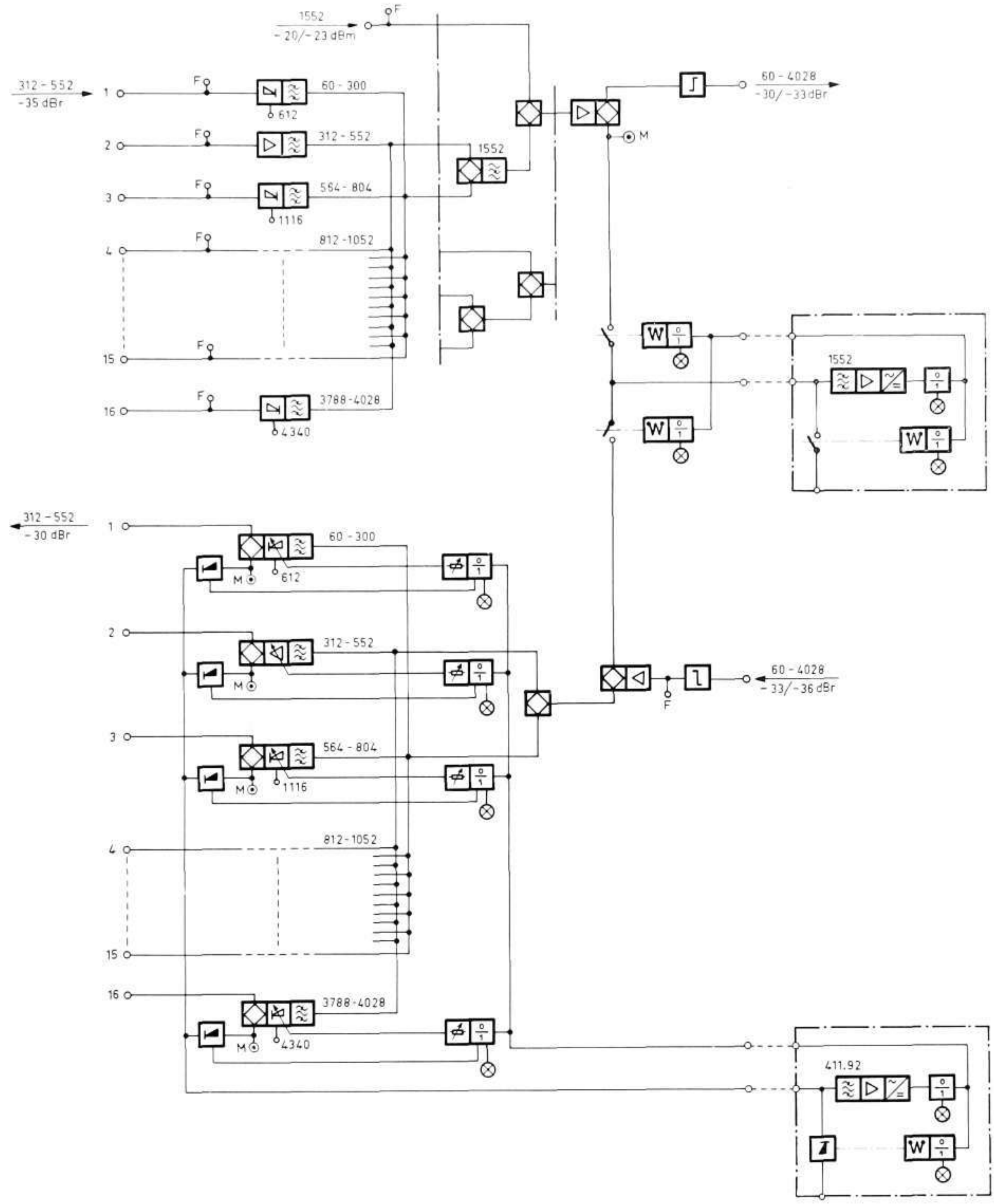
Fig. 2 shows a block diagram with frequencies and levels. A novel design feature is the integration of the supergroup carrier generating equipment into the supergroup translating equipment, the carrier basic frequencies 12 and 124 kHz being supplied by the common frequency supply of the terminal equipment.

The shelf stack also contains equipment for the regulation of the supergroup receive level and for the supervision of the send and receive levels of the 960-channel line group. This equipment is controlled by the pilot receivers for 411.92 and 1552 kHz, both of which are housed in separate shelves.

An extremely compact design has been achieved by the application of new circuit design principles such as the introduction of the active transistor modulator, which has resulted in favourable level conditions and the saving of a number of amplifiers.

Fig. 1
Modulation plan for the translation of 16 supergroups into a 960-channel line group.
Frequencies in kHz





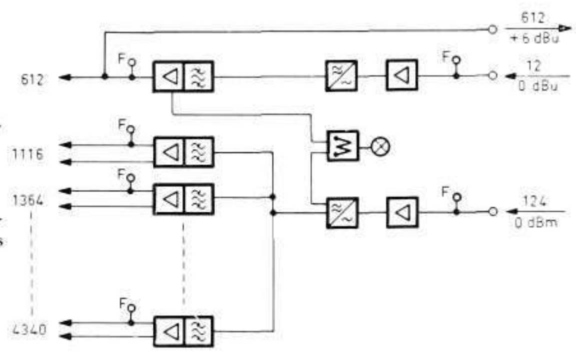


Fig. 2

Block diagram of supergroup translating equipment for 960-circuit systems.

Below: the built-in carrier generating equipment

Right: the pilot receivers 411.92 and 1552 kHz respectively common to a number of supergroups

1—16 Supergroup input and output terminals

M Maintenance test point

F Fault location test point

Frequencies in kHz

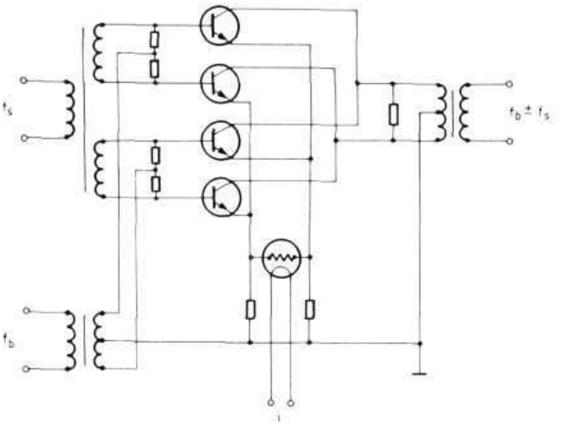


Fig. 3
Double push-pull modulator with regulation facility
f_s Signalling frequency
f_b Carrier frequency

Translating Equipment

Modulators

Active transistor modulators are used throughout the equipment. These are designed as push-pull amplifiers whose operating voltages modulate the respective carrier frequencies. The transistor modulator has several considerable advantages over the diode modulator (see description of channel and group translating equipment), its most salient feature being its gain regulating function.

Modulators 1 and 3 are designed as a double push-pull arrangement. This configuration provides suppression of the direct leak, which eases the demands on the associated filter networks. Fig. 3 shows the circuit configuration.

Modulators 4–16, however, use a single push-pull circuit. In this modulator type the output contains modulation products which in the double push-pull configuration are attenuated by balancing. Thus, among other things, the level of the direct leak is 2.5 dB above that of the wanted sideband. As the filter requirements are determined almost completely by the impedance requirements resulting from parallel connection with other filters, the suppression of the above-mentioned modulation products is not considered a complication.

For supergroup 2 in the 312–552 kHz band a single amplifier stage is provided instead of a modulator.

Fig. 4 shows a typical stop-band attenuation curve for a band-pass filter and a typical pass-band curve for a complete modular unit.

Each modulator in the send path is preceded by a low-pass filter, which suppresses the noise spectrum outside the transmitted band, to prevent it from entering the traffic band during modulation. The low-pass filter at the output of the demodulator in the receive path protects subsequent amplifiers from overloading owing to the direct leak and the other side-band. At the same time the carrier leak is suppressed.

The demodulators are provided with indirectly heated thermistors in the feedback path to provide continuous gain regulation, the range of adjustment being more than ± 4 dB. The thermistors are controlled either by means of a manual level control or by means of an automatic level control in conjunction with a 411.92 kHz pilot receiver.

In the event of major level deviations gain regulation is blocked and an alarm sent out.

Each modulator with associated filters is constructed as a mechanical unit. Fig. 5 illustrates such a modulator assembly. Owing to the relatively large size of the band-pass filters required for the modulators and demodulators for supergroups 1 and 3, these have been divided into two separate mechanical units each, one of which contains the band-pass filter.

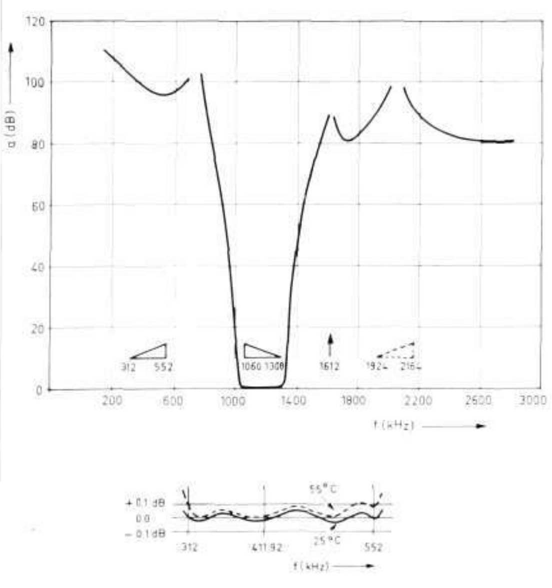


Fig. 4
Frequency characteristic of a supergroup filter

Supergroup Combination and Separation

Parallel connection of the band-pass filters in the send and receive path respectively is arranged by means of symmetrical hybrids. As illustrated by the block diagram, odd-numbered supergroups are paralleled on one side of the hybrid and evennumbered ones on the other.

Normally when such a large number of filters is connected in parallel, a certain mutual interference occurs. This is especially the case in partly-equipped terminals. By inserting a pad between each filter and the hybrid this interference has been reduced to a negligible amount. Thus the equipment can be expanded to any desired extent and supplementary equipment added as re-

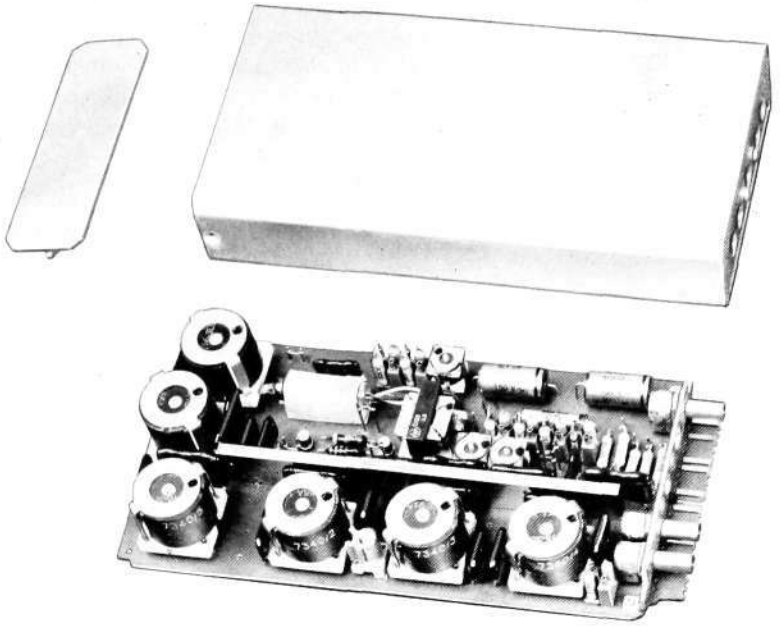


Fig. 5
Demodulator unit

The carrier generating equipment required for the translation of supergroups quired. The attenuator pad is an L section whose series arm is incorporated in the output filter of each modulator and whose shunt arm is a common item included in the hybrid.

Pilot Injection and Protection

Immediately after the formation of the 960-channel line group the 1552 kHz line link pilot can be injected by means of a pilot injection hybrid. If there is through connection of supergroups at the station, a band-stop filter for the 1552 kHz pilot is inserted before the hybrid to protect this frequency against interference arising from additional measuring frequencies (inter-supergroup pilots). This arrangement in conjunction with the through supergroup filter, which suppresses the translated pilot at 308 kHz and 556 kHz, clears the band of disturbing pilot residues.

Amplifiers

The supergroup translating equipment includes only one amplifier in each direction of transmission, namely for the amplification of the 60–4028 kHz line frequency band. For this purpose a standardized wideband amplifier is employed, whose gain can be adjusted by means of soldered straps. A double hybrid arrangement at the output provides a short-circuit-proof test point and permits the pilot to be picked off.

Station Cable Attenuation Equalizers

In the 60–4028 kHz frequency range the frequency distortion introduced by the station cabling cannot be disregarded.

To compensate for this distortion, equalizers are provided on the line side in both directions of transmission. These networks can be adjusted in steps of 0.5 dB.

Allowance has been made for a total station cable attenuation of 3 dB between the output of the supergroup translating equipment and the line link interconnection frame.

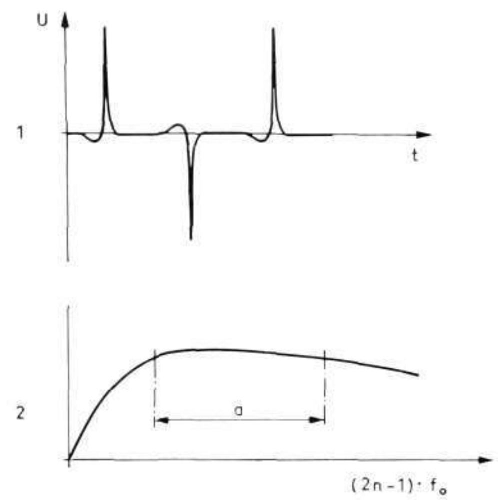


Fig. 6
Harmonic generator

1 Output voltage at normal load
2 Amplitude spectrum
a Operating range

Supergroup Carrier Generating Equipment

The carrier generating equipment required for the translation of supergroups into 960-channel line groups is incorporated in the supergroup translating equipement. Two standardized carrier basic frequencies are required, which are obtained from the common frequency supply, namely

- 12 kHz for the generation of the 612 kHz carrier
- 124 kHz for the generation of the carriers lying, at 248 kHz intervals, between 1116–4340 kHz.

Harmonic Generators

In both cases the carrier frequencies are odd harmonics of their respective basic frequencies. The harmonic generator has, therefore, been designed to produce only these components of the spectrum. The main element of the harmonic generator is a toroidal coil with an iron core which is periodically saturated by the feeding a.c. voltage. When the saturation point of the coil is exceeded the following capacitor will discharge across the ballast resistor. This will occur twice each period, giving rise to a train of short-duration pulses of alternating polarity. Such a pulse train contains only odd multiples of the fundamental frequency.

The amplitude spectrum of the harmonic generator is shown in fig. 6.

Carrier Filters

The carrier filters for selecting the 1116–4340 kHz harmonics of 124 kHz have their inputs connected in parallel and can be provided as required by the number of supergroups to be multiplexed. Each individual carrier frequency is maintained at a fully adequate and constant amplitude irrespective of the variations this will involve in the number of carrier filters connected to the harmonic generator. Each of the filters, a specimen of which is shown in fig. 7, has two single-stage amplifiers at its output, by which method the modulator and demodulator are decoupled from each other. Thus a very high crosstalk attenuation via the carrier supply is achieved.

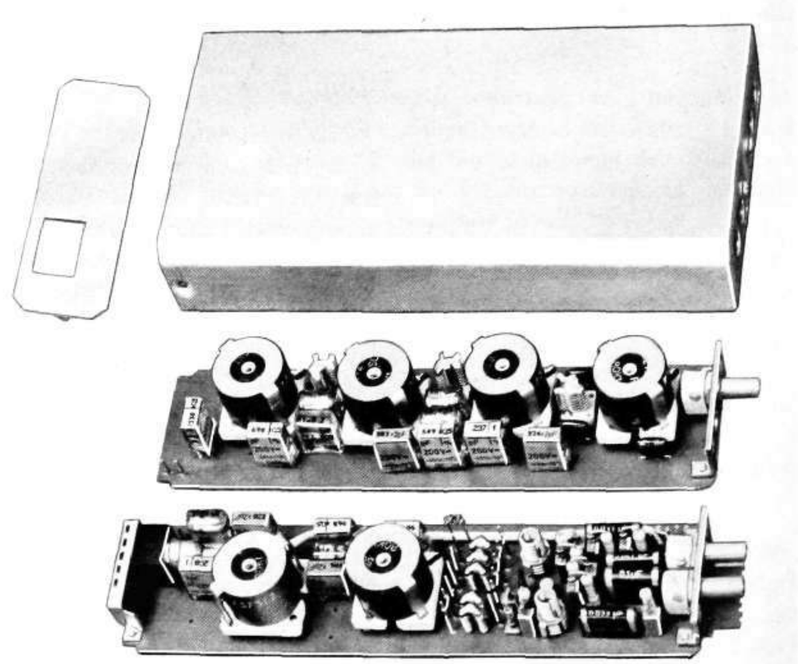


Fig. 7
Carrier filter

For the generation of the 612 kHz carrier use is made of part of the equipment required for the generation of the group carriers. This arrangement differs from that described above in that the feeding circuits to the modulator and demodulator are arranged in parallel. Adequate decoupling is achieved by the low output impedance of the carrier filter 612 kHz. Up to five pairs of modulators and demodulators can be supplied in parallel, i.e. a common supply is provided for up to five supergroups 1, corresponding to 300 channels.

Supervision of Carrier Levels

If the output voltage from a harmonic generator falls by more than 2.5 dB an alarm is automatically sent out. A rectified nominal voltage of 10 volts is derived for level supervision.

The d.c. voltage for supervision of the 612 kHz is obtained from the output of the carrier filter. Thus the 12 kHz harmonic generator as well as the carrier filter is supervised in the same way as in the group carrier generating equipment. The d.c. voltage for supervision of the 1116–4340 kHz carriers is taken from the output of the 124 kHz harmonic generator. For this purpose the 868 kHz harmonic is used. The filter for this frequency and the associated rectifier circuit have been incorporated in the harmonic generator. This simple solution to the supervision problem has been made possible by the high degree of reliability of the subsequent filters and the fact that in the event of failure of a carrier an alarm is sent out for the respective supergroup by means of the automatic pilot receiver.

Tests Points

Two kinds of test points are provided, namely maintenance test points and fault location test points.

Maintenance test points, denoted by *M* in the block diagrams, are provided at all outputs. These test points are short-circuit-proof, i.e. a short circuit at the test point does not noticeably affect the transmission path. They consist of coaxial jacks located in a maintenance test strip at the lower front edge of the respective shelf and are easily accessible when the hinged cover plate with designation strip is opened.

Fault location test points, in the block diagrams denoted by *F*, are provided to enable any faults to be located to a certain unit by logical fault location. They are designed as bridging test points and located at the front of the apparatus units. Access to these test points is obtained by removing the respective shelf dust covers.

Line Entrance Equipment

For the transmission of the line group over short distances, such as a cable extension of a radio relay link, use is made of a line entrance equipment (fig. 8). This is assembled in a shelf and contains equalizers for slope introduced by the entrance cable as well as equipment for the injection and reception of frequency comparison pilots. Supervision of the line group level with the help of the 1552 kHz pilot can be carried out in both directions of transmission when using a centralized pilot receiver.

Cable Attenuation Equalizers

Networks can be included for cable attenuation equalization in steps of 1 dB. Compensation for slope introduced by 2.6/9.5 mm cable standardized by the CCITT can be provided for cable sections of 5.8 km. When using line entrance equipment at both ends of the entrance cable, attenuation equalization can be provided for sections of up to 8.8 km.

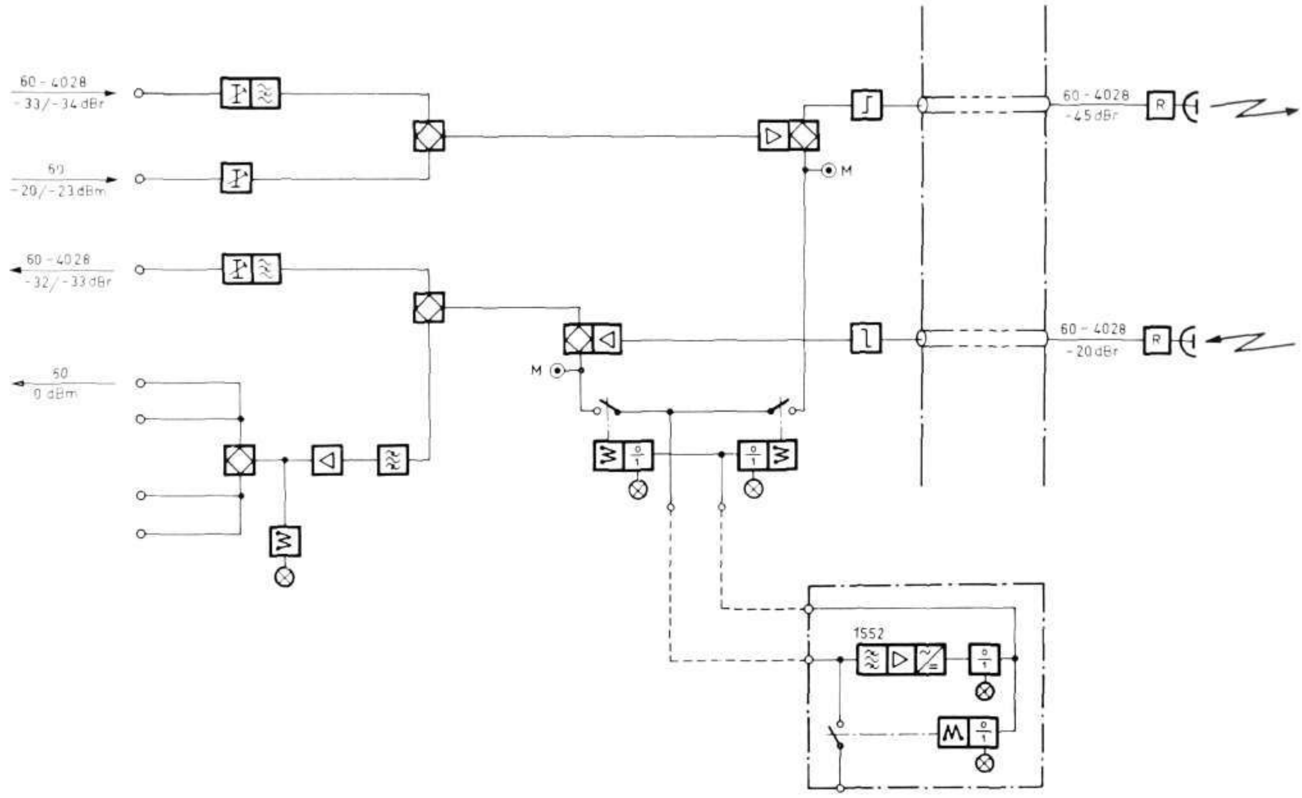


Fig. 8
Line entrance equipment for 960-circuit systems. Block diagram
M Maintenance test point
Frequencies in kHz

Equipment for Frequency Comparison Pilot

The frequency comparison pilot used in a 960-circuit system is 60 kHz. This pilot frequency can be injected by means of a hybrid in the send path and picked off by means of a hybrid and filter in the receive path. After amplification the pilot is distributed to four decoupled outputs at a power level of 0 dBm. For the suppression of the pilot in the transmission path a pilot stop filter can be included in both directions of transmission.

Mechanical Construction

All apparatus units are of the plug-in type. The components are assembled on printed wiring boards, which are enclosed by aluminium cans providing

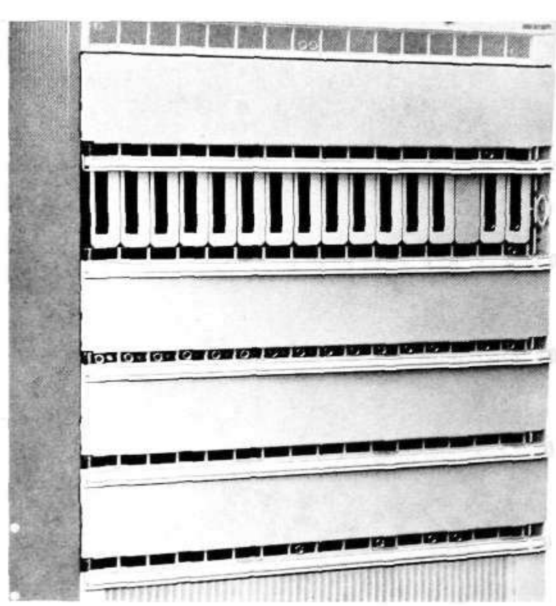


Fig. 9
Shelf stack for assembling 16 supergroups into a 960-channel line group, with built-in carrier generating equipment.
Dust cover removed from one shelf housing supergroup modulators. All hinged cover plates with designation strips opened, giving access to respective maintenance strips.

good electrical shielding as well as protection from mechanical damage. The apparatus connectors consist of flat contact plugs as well as coaxial plugs and sockets.

The complete equipment for assembling 16 supergroups into a 960-channel line group, including the supergroup carrier generating equipment and automatic level controls, is accommodated in a shelf stack 600 mm high.

This shelf stack consists of five shelves of standard dimensions combined into a mechanical and electrical unit (fig. 9).

This design has been chosen to achieve the optimum cabling arrangement, electrically as well as mechanically. Thus the top shelf contains the carrier generating equipment, the second the modulators and the third the demodulators. This arrangement has made possible a substantial reduction of the length of the bulky carrier cabling, the modulators being placed in rows directly under the associated carrier filters.

Connectors for the station cabling are provided on the left-hand side of the shelf stack, for the inter-shelf wiring on the right.

The line entrance equipment is housed in a separate shelf. This also applies to the two pilot receivers for 411.92 and 1552 kHz, described elsewhere.

Three supergroup translating shelf stacks with the associated line entrance shelves and the two pilot receiving shelves can be accommodated in *one bay*. In the centre of the bay is a service shelf containing fuses, etc. A power pack is provided at the bottom of the bay (see fig. 10). If required, the power pack can be duplicated.

Technical Data

Frequency Ranges

basic supergroup	312–552 kHz
960-channel line group	60–4028 kHz

Nominal Levels

basic supergroup	
send direction	–35 dBr
receive direction	–30 dBr
line group	
send direction	–30 dBr
receive direction	–36 dBr
Station cable equalizers provide adjustment to level at line link interconnection frame, namely	–33 dBr

Nominal Impedance

basic supergroup and line group	75 ohms unbal.

Frequency Distortion

in the transmitted and received supergroup band referred to loss at 411.92 kHz, less than	±0.5 dB

Level Regulation Range

for the incoming supergroup in the receive path	±4 dB

Carrier Leaks

measured at sending equipment output do not exceed	-40 dBm0

Attenuation of Intelligible Crosstalk

referred to nominal levels for all combinations of near-end and far-end crosstalk is greater than	85 dB

Power Consumption

Shelf assemblies (operated from 21 V d.c.)	
Supergroup translating shelf stack excl. regulating equipment	28 W
with manual level regulation the additional power drain per supergroup is	0.5 W
with automatic level regulation the additional power drain per supergroup is	1 W
Line entrance equipment shelf	3 W
Bay assembly (operated from mains or station battery)	
Supergroup translating bay, fully equipped with 3 supergroup translating shelf stacks, 3 line entrance shelves, 1 pilot receiving shelf 411.92 kHz, 1 pilot receiving shelf 1552 kHz	240 W

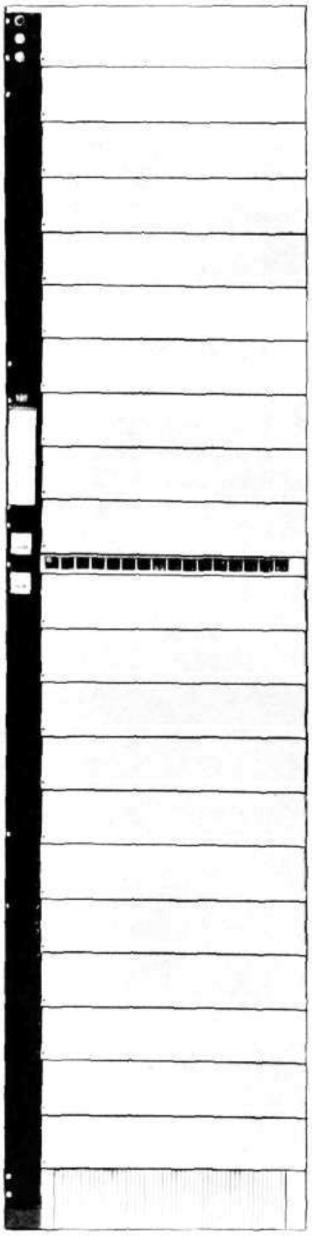


Fig. 10

Supergroup translating bay

The bay contains:
3 supergroup translating shelf stacks
3 line entrance shelves
1 pilot receiving shelf 411.92 kHz
1 pilot receiving shelf 1552 kHz
1 service shelf with fuses, etc.
1 power pack

ERICSSON News from All Quarters of the World

Italian President Visits L M Ericsson

In conjunction with the Italian state visit to Sweden in June this year the President, Sr. Giuseppe Saragat, paid a call at L M Ericsson's main factory at Midsommarkransen in the company of the Swedish Prime Minister, Mr. Tage Erlander. The President of L M Ericsson, Mr. Björn Lundvall, greeted the visitors on their arrival and gave a brief presentation of the group and its activities. They were then taken on a tour of the Exhibition Room by Mr. Eric Lundqvist. The Italian President was so interested – especially in the oldest telephones – that, when Mr. Lundqvist was to demonstrate the old trumpet telephone, the President became tied up in the single wire. After he had been disentangled, the tour could continue.

As a special feature in the programme President Saragat was invited to make a telephone call to Italy, to L M Ericsson's subsidiary company FATME, the Chairman of which, Dr. Giuseppe Marchesi, immediately invited President Saragat to visit the Italian Factory.

Mr. Lundvall presented the President with an ivory-white Ericofon with the President's monogram in gold. And before the end of his visit President Saragat had the opportunity of talking to Italian employees at the factory and was greeted with such southern fervour that the leavetaking ceremony was nearly forgotten.

President Saragat signs his name on a memorial tablet.

The Italian President, Sr. Giuseppe Saragat (right), is greeted by Mr. Björn Lundvall, President of L M Ericsson. Between them is the Swedish Prime Minister, Mr. Tage Erlander.

President Saragat is presented with an Ericofon by Mr. Lundvall.

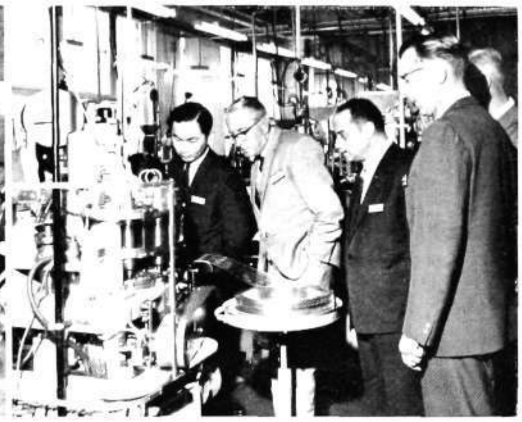
Fusion in France

The fusion which has been planned for some time between Société des Téléphones Ericsson (STE) and its subsidiary Ateliers Vaucanson (SAV) took place on June 14, 1966, as from which date the activities of SAV have been taken over by STE.

STE, the name of which has been changed to Société Française des Téléphones Ericsson, has at the same time increased its share capital by a bonus issue of 10 million francs and a new issue of 304,350 francs. The share capital is now 30,304,350 francs.

In June 1966 STE's shares were introduced on the Paris Stock Exhange, in conjunction with which rather more than 20 % of L M Ericsson's holdings were placed with the French public.

As mentioned in Ericsson Review No. 2, 1966, L M Ericsson has concluded an agreement with United Utilities Inc. (UUI), Kansas City, USA, involving the transfer of the share majority in North Electric Company (NEC), Galion, USA. L M Ericsson will continue to take a very active part in the leadership of NEC. The new board consists of (from left, front row) Messrs. Hans Werthén, LME, William H. Graham, NEC, Paul H. Henson, UUI, Björn Lundvall, LME, and R.M. Alden, UUI, and (back row) John M. Kingsley, Bessemer Securities Corp., Douglas Gleason, UUI, Fred Sundkvist, LME, and J.C. Cluen, United Telephone Company of Ohio.



(Left) The delegates in the Conference Room at Midsommarkransen. (Right) Some of the delegates during a tour of the main factory. (From left) Messrs. Chua Kai Soo, Singapore, J.W. Devon, Ireland, M.A.E. Messiri, United Arab Republic, and R.H. Davis, USA.

Maintenance Conference

The Maintenance Conference held last year with representatives of the Scandinavian telephone administrations was repeated in June this year. On this occasion there were representatives from the administrations of Australia, Britain, Canada, Ethiopia, Ireland, Italy, Jugoslavia, Lebanon, the Netherlands, Poland, Portugal, Singapore, Sweden, Thailand, Tunisia, the United Arab Republic and the United States. Maintenance experts from the Danish, Finnish and Swedish telephone administrations attended as visiting lecturers. The conference was held in English. There were more than 40 foreign delegates and 14 from L M Ericsson.

As at last year's conference, the main interest was in organizational questions and centralized supervision of subscriber-dialled trunk traffic, but terminology, statistics and training were also on the agenda. Quite properly, too, the increasing use of data processing in telephony was also discussed.

The delegates were invited by the Swedish Board of Telecommunications to visit the plants in the Örebro Telecommunications Area. The conference terminated in a visit by the delegates to Turku, Tampere and Helsinki at the invitation of the respective Finnish telephone administrations.

During the lively discussions during the conference many interesting and valuable points were put forward by the representatives of the various administrations. L M Ericsson, therefore, as on earlier occasions, can establish with satisfaction that the goal of the Maintenance Conference has once again been attained–namely, through exchange of experience between supplier and qualified representatives of the Maintenance Divisions of the Telephone Administrations, to obtain new experience which should assist in the production of equipment that is both more reliable and easier to maintain.

The conference will be repeated next year for Spanish-speaking delegates.

During their visit to Turku Mr. V.K. Tähti, Director of the Turku Telephone Administration, addressed the conference delegates on the subject of the Administration's organization.

Record Order for SOCOTEL Equipment

Société Française des Téléphones Ericsson (STE) has recently signed a contract worth 25.8 million kronor for telephone exchange equipment of type SOCOTEL. This is STE's largest order hitherto. The purchaser is the French PTT.

In 1964 and 1965 STE obtained similar orders from the PTT worth 16.4 and 23 million kronor.

The SOCOTEL system was designed in co-operation between French telephone manufacturers and the PTT and corresponds most closely to L M Ericsson's ARK system.

Opening of New Automatic Exchanges

ETHIOPIA

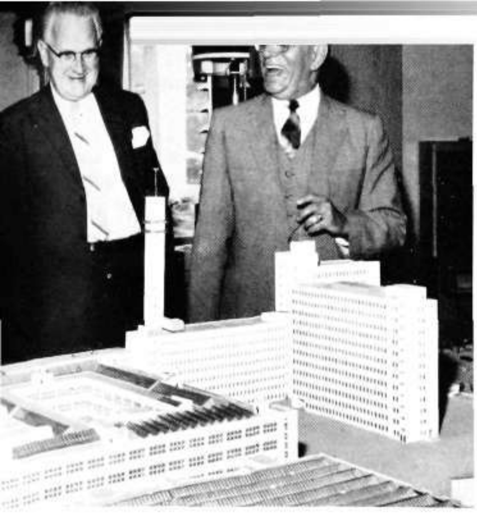
In June a new all-automatic telephone exchange was officially opened at Dessie in Ethiopia with an initial capacity of 1,000 ARF lines. The next step in the investment programme of IBTE (Imperial Board of Telecommunications of Ethiopia) is an extension of the exchanges at Addis Abeba and automatization of the exchanges at Nazareth and Massawa.

After the opening of the Dessie exchange, which was presided over by His Imperial Highness Crown Prince Merid Azmatch Asfa Wossen, the new exchange was demonstrated by Ato Girmaw Ingedayehu, head of the IBTE Telephone Division, to the invited guests of honour, among whom the Minister of Communications, Ato Salah Hinit, and the Director General of IBTE, Herman Ruud.

EGYPT

On August 13 a further stage was completed in the extension and modernization of Cairo's telecommunications through the cut-over of a large new all-automatic telephone exchange of L M Ericsson's modern crossbar system ARF 102. The new exchange is at Shoubra, one of the most densely populated districts in the Cairo area. From its initial capacity of 10,000 lines the exchange will be extended in stages to 40,000 lines.

In the Cairo district alone L M Ericsson has now installed more than 75,000 ARF lines.



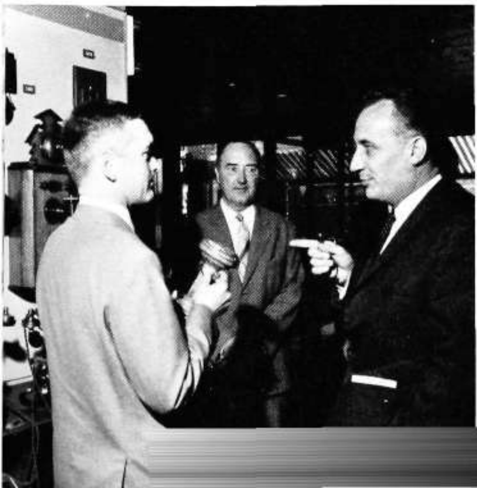
The Chairman of L M Ericsson's Brazilian subsidiary, Ericsson do Brazil, Marshal Nelson de Mello (right), visited the main factory at Stockholm this summer. While viewing the model plant in the Exhibition Room Mr. G. Fernstedt, LME, apparently thought up a good old LM story.

During a visit by (from left) Messrs. Djumbaran and Rockaeli from the Indonesian State Railways it was, of course, the model of the CTC plant that attracted most interest. Mr. Lundqvist, LME, demonstrated.

The United Arab Republic Minister of Communications, Mr. Younes, with his wife visited L M Ericsson at Midsommarkransen in the autumn in the company of the UAR Ambassdor in Stockholm, Mr. Tawfik. (From left) Ambassador Mustafa Tawfik, Mrs. Patricia Lundvall. Mrs. Fadila Younes, Minister Mahm. Younes, Mr. Björn Lundvall and Mr. Eric Lundqvist, (LME).

LME has been visited by the Board of FATME. Some of the members — (from left) Sr. U. Levêque, Dr. G. Marchesi and Sr. L. Baggiani — are here seen with Mr. Björn Lundvall.

In front of the show case containing the oldest models of the telephone are seen (from right) the Bulgarian Minister of Foreign Affairs and Commerce, Mr. I. Beudinow, and Messrs. A. Stein and J. Couturier, LME.



A guest from afar was Mr. Alan Yeo, Vice Chairman of the Singapore Telephone Board. He is here seen with the President of LME, Mr. Björn Lundvall (left).

Some pupils from the UNWRA Technical and Teacher Training School at Siblin, Lebanon, are seen receiving instruction in modern telephone technique. A large part of the equipment was supplied by LME.

Director Luigi Baggiani

Director Umberto Levêque

Director Aldo D'Arrigo

Management Changes at FATME and SIELTE

Sr. Luigi Baggiani retired on pension on June 12, 1966, from the post of President of the Italian manufacturing company of the Ericsson group, FATME, Rome. He will remain on the board of FATME and has been appointed to the board of the holding company SETEMER.

Sr. Baggiani took an engineering examination in 1923 and, after some years in the Air Force, in which he reached the rank of Captain in 1927, was taken on in 1929 as Departmental Manager in the telephone operating company in southern Italy, Società Esercizi Telefonici (SET). In 1934 he joined FATME as Director and became its President in 1947. In 1959 he was appointed member of the board of the Italian Radio and Television Company, RAI-TV, and in 1965 became Chairman of ANIE, the Association of the Italian Electrical Industry. He is "Grand Ufficiale" of the Italian Order of Merit.

When Sr. Baggiani came to FATME, the company had about 200 employees and a limited manufacture, principally of telephone sets and manual exchanges. During his leadership it grew at a rapid pace and, in 1942, FATME had some 1,000 employees and its manufacture included automatic public and private telephone exchanges. During the war FATME was heavily damaged and 70 % of the machines and most of the stock were confiscated. The number of employees fell to about 200 and at the end of the war the activities had almost entirely stopped. Headed by Sr. Baggiani an energetic reconstruction program was started, and by the end of 1946, the company once again had 1000 employees. The development within the automatic telephony field thereafter continued and the factory started to produce long distance equipment as well. The facilities for expansion of the existing factory had been completely exhausted and in 1959 it was decided to build a modern telephone factory outside Rome. Sr. Baggiani devoted much valuable work to the planning and erection of a new factory, which was completed at the end of 1964 and opened in 1965. FATME now has 2400 employees and is the largest factory in Rome, as well as being the largest telephone factory in central and southern Italy. The manufacture convers the greater part of the telephony field and is done on the most modern methods and with the most modern epuipment.

On his retirement from the presidency of the company Sr. Baggiani received warm greetings both from the management and personnel, who in many ways gave expression to their great appreciation and gratitude for what he had done for FATME and its employees during more than 30 years of intense and successful work. His many friends wish him success and satisfaction in the important appointments to which he will now devote his time, interpersed with well earned leisure.

The board has appointed to the presidency of FATME Sr. Umberto Levêque, previously president of the sales and outside plant construction company of the Ericsson group in Italy, SIELTE, Rome. After taking an engineering examination in 1930 he joined Società Ericsson Italiana, which later became SIELTE. In 1938 he was appointed Departmental Manager, in 1954 Executive Vice President and in 1962 President. He is a member of the boards of SIELTE and FATME. Sr. Levêque is Commander of the Order of Merit of the Italian Republic.

The board has appointed Sr. Aldo D'Arrigo to the presidency of SIELTE. He was taken on by SIELTE in 1946, became Departmental Manager in 1963 and Executive Vice President earlier this year.

Organizational Change

Mr. Per Ahlström was appointed head of the Erga Division of Telefonaktiebolaget L M Ericsson as from October 1, 1966. He succeeds Mr. Sten Ake Nilsson, who will retire on pension at the beginning of next year. Mr. Ahlström has been appointed Vice President of the company from the same date.

Mr. Ahlström was born in 1928, graduated from the Chalmers' Institute of Technology in 1952 and joined L M Ericsson in 1953, where since 1962 he has been head of ERGA's Telephone Set Section.

Sweden's Mach 2 delta wing all-weather interceptor, the Saab 35F Draken, is now fitted with an infra-red detection unit mounted beneath the nose for target location at very low altitudes, which is unaffected by enemy electronic countermeasures. The unit is built in Sweden by L M Ericsson under licence from Hughes.

UDC 621.395.44
LME 8400

ERIKSEN, E.: *A New Generation of Transmission Equipment.* Ericsson Rev. *43*(1966): 3, pp. 74—82.

The article describes the guiding principles that have been used in the work of designing a new generation of terminal equipment for carrier systems. The requirements which must be placed on the mechanical design so as to be able to make best use of the latest progress in component development are dealt with in particular. One objective has been to design equipment that can be flexibly used in the formation of small and large terminal stations and that permits easy expansion and rearrangement and also requires a minimum of maintenance.

UDC 621.395.44
62.002.2
LME 60 84

AXELSON, K.: ***The M4 Method of Construction Used in Mechanical Design.*** Ericsson Rev. *43*(1966): 3, pp. 83—93.

The article describes the M4 method of construction from the mechanical point of view, how the problems of reduction of volume while retaining flexibility were solved, how the design has been carried out to obtain simplest installation work and to a certain extent what experience has been gained during the development period.

UDC 621.395.44
LME 8424 8442

JOHANSSON, S.-O.: *Carrier Terminals for 300- to 2700-Circuit Systems, System Design.* Ericsson Rev. *43*(1966): 3, pp. 94—101.

The article gives an outline of the system design for large-capacity terminals to be included in carrier systems using coaxial line links or radio links.

Further details of the component subsystems are given in separate articles.

UDC 621.395.44
621.376
LME 8421 7544

OUVRIER, G.: *Supergroup Translating Equipment for a 960-Circuit System.* Ericsson Rev. *43*(1966): 3, pp. 132—140.

Together with preceding articles in this issue dealing with the channel and group translating equipment and equipment for level supervision and regulation, this article dealing with the equipment for assembling basic supergroups into line groups forms a complete description of a terminal equipment for a 960-circuit carrier telephone system engineered in the M4 equipment construction practice.

UDC 621.395.44
621.395.66
LME 8471

ent for Level Supervision and Regulation. Ericsson
125—131.

ment for level supervision and regulation has been
4 equipment construction practice. It is built up
lot receiver for each modulation stage. The equip-
c and contains no moving mechanical parts.

Corrigenda in Ericsson Review No. 3, 1966

Page 98, line 24 should read:

440 kHz: mastergroup translating equipment...

Page 135, line 1 should be deleted

UDC 621.395.44
621.376
LME 8421 7544

OJ, R. & RASK, B.: *Channel and Group Translating Equip-*
icsson Rev. *43*(1966): 3, pp. 102—124.

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UDC 621.395.44
621.376
LME 8421 7544

ASARNOJ, R. & RASK, B.: *Channel and Group Translating Equipment*. Ericsson Rev. *43*(1966): 3, pp. 102—124.

The channel and group translating equipment is engineered in L M Ericsson's new construction practice for transmission equipment and has been designed in accordance with the principles described in the introductory articles in this issue of Ericsson Review.

The article describes the electrical design of the equipment and its mechanical assembly into shelves and shelf stacks. Finally a few practical applications of these in different bay arrangements are shown and a summary of technical data is given.

UDC 621.395.44
621.395.66
LME 8471

BRENÉ, Å.: *Equipment for Level Supervision and Regulation*. Ericsson Rev. *43*(1966): 3, pp. 125—131.

A new universal equipment for level supervision and regulation has been developed for the M4 equipment construction practice. It is built up round a centralized pilot receiver for each modulation stage. The equipment is fully electronic and contains no moving mechanical parts.

UDC 621.395.44
621.376
LME 8421 7544

OUVRIER, G.: *Supergroup Translating Equipment for a 960-Circuit System*. Ericsson Rev. *43*(1966): 3, pp. 132—140.

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A/S Norsk Kabelfabrik *Drammen*, P.B. 500, tel: 83 76 50, tgm: kabel

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AB Rifa *Bromma 11*, tel: 08/26 26 10, tgm: elrifa, telex: 10308

AB Svenska Elektronrör *Stockholm-Tyresö 1*, tel: 08/712 01 20, tgm: electronics, telex: 1275

Instruktionsteknik AB *Stockholm 44*, tel: 08/68 08 70, tgm: instruktec

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L M Ericssons Signalaktiebolag *Stockholm Sv*, tel: 08/68 07 00, tgm: signalbolaget

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CONTENTS

On cover: The Speaker's and (left) the Secretary's keyboards for the new voting system in the Swedish Parliament.

Maintenance and Operating Experience with Transistorized Channel Translating Equipment

B. FORSBERG, THE BOARD OF TELECOMMUNICATIONS, STOCKHOLM

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This article presents the results of investigations made by the Swedish Telecommunications Administration on transistorized channel translating equipment of L M Ericsson design. Comparisons are also made with the characteristics of earlier equipment using tubes. The article is based on a paper presented at L M Ericssons maintenance conference, June 3rd, 1965.

The function of channel translating equipment, it will be recalled, is to shift speech frequencies in the range 300–3400 Hz to a higher position in the frequency spectrum. After modulation, 12 speech channels form a basic group in the standardized band 60–108 kHz with the channels inverted: this is CCITT's basic group B. This frequency band is normally the first stage towards building up the frequency allocation of larger carrier systems, and hence channel translating equipment is the most extensively needed part of the terminal equipment in all larger systems.

The Swedish Administration started commissioning fully transistorized channel translating equipment during 1961. This involved the introduction of several items and components of entirely new design. An investigation of their behaviour under service conditions was naturally of significance for future extensions of the Swedish carrier network.

The presentation which follows, and which deals with service results for a limited part of an extensive multi-channel equipment, is based mainly on two sources of information. The first consists of service reports obtained from the operating divisions. The other type of information treated consists of the results of a special program of measurement carried out over a number

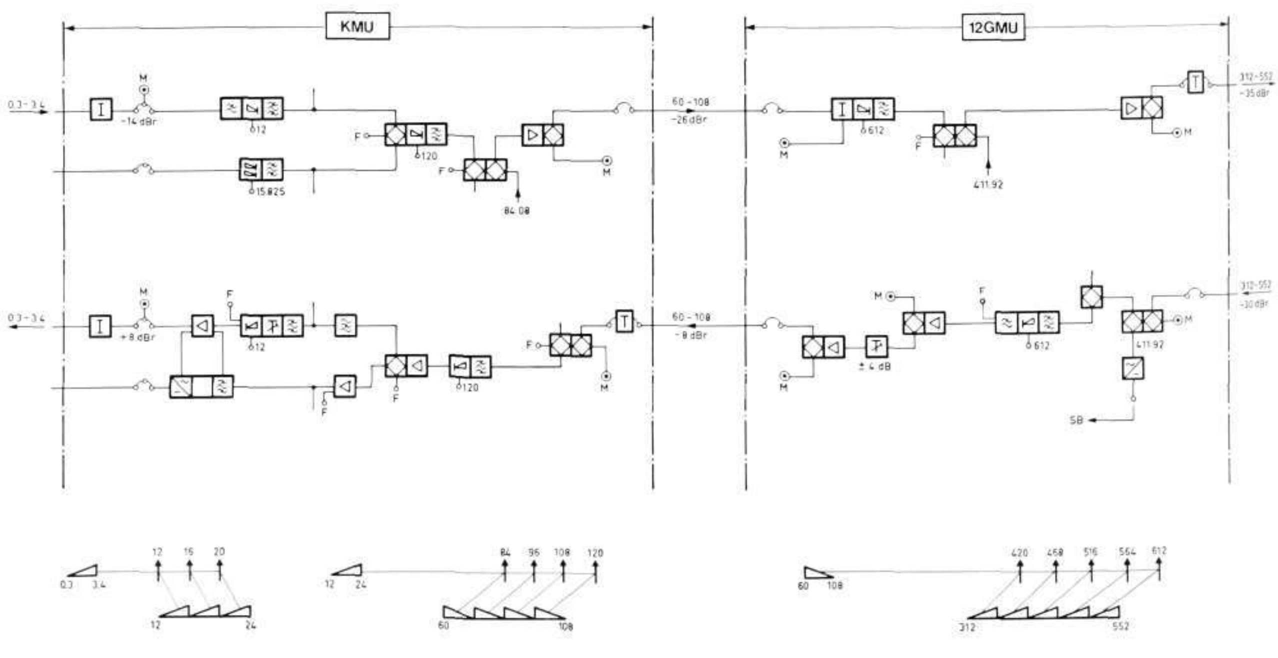


Fig. 1
Terminal equipment up to the basic supergroup
KMU Channel translating bay
12-GMU Group ,, ,,
M Maintenance test point
F Fault location test point
All frequencies in kHz

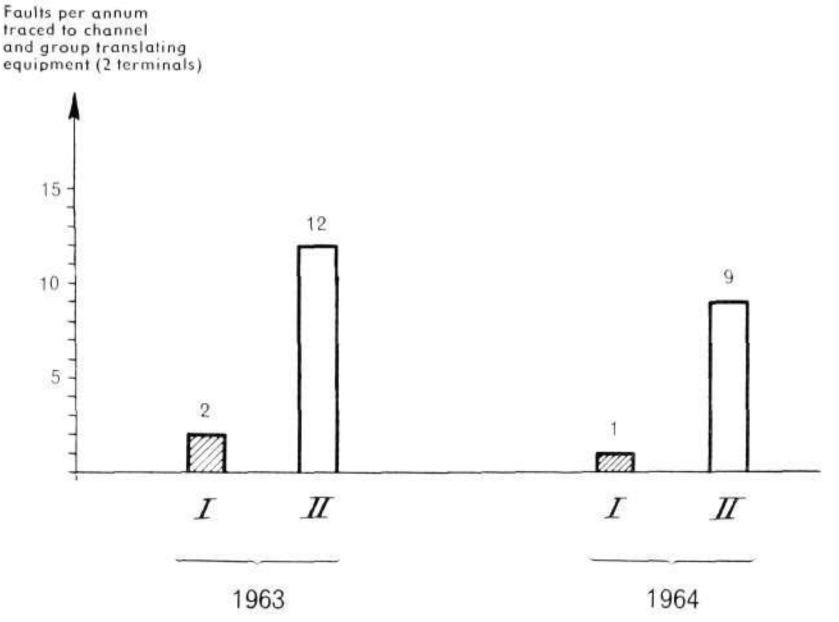


Fig. 2
Comparative fault statistics

Each column indicates the number of faults per annum per 60 telephone channels, with the same type of channel and group translating equipment in both terminals.

Type I = fully transistorized channel and group translating equipment, LME type M3

„ II = channel and group translating equipment using tubes, LME type M2

Both types of equipment use out-band signalling of a frequency 3825 Hz.

of years on randomly selected fully transistorized channel translating equipment and to a restricted extent transistorized group translating equipment. Fig. 1 is a block diagram of the equipment involved.

Knowledge Gained from Service Reports

In assessing the service characteristics of new types of equipment, a comparison with corresponding characteristics of earlier types is usually of great help. With a view to this, fault records of 1963 and 1964 have been examined. Information covering about 5 % of all equipment in service has been gone through, and those supergroups provided with the same type of channel and group modulating equipment at the two terminal stations of the supergroup link have been selected for attention.

Fig. 2 shows the failure rate for two different types of channel and group translating equipment of L M Ericsson's manufacture. Type I is a fully transistorized equipment with components mounted on printed wiring cards. Type II is an earlier design which takes up more space and uses vacuum tubes as amplifying elements.

During both the years under examination, the transistorized equipment (type I) had a significantly lower fault rate than that using tubes (type II). Some interesting comparisons between the two types of equipment can be made by classifying the faults into two groups as follows:

- Group 1 — those faults which could be corrected in a simple routine manner
- Group 2 — those faults involving less simple fault location or repair.

In the transistorized equipment, the simpler faults (Group 1) are mainly restricted to occasional faults in plug-in signalling relays. These have contacts which are sealed into glass tubes and whose contact surfaces are wetted by mercury. The glass tubes are protected by an outer container and are furthermore filled with hydrogen under high pressure in order to reduce electrical erosion of the contact surfaces. Investigation of faulty relays from the first deliveries showed that too much mercury could find its way onto the contact surfaces of the moving contact spring, thereby providing an unwanted path when the contacts should be open. These faults could be temporarily cured by gently tapping the relay. However, to avoid a repetition of this type of fault, relays with the tendency mentioned were replaced by others of a new type which, although using the same basic design, has been improved in this respect. For some years all new deliveries of equipment comprise the improved relay.

Type of unit	Equipment type M2[a] (136 Supergroups in operation)		Equipment type M3[b] (94 Supergroups in operation)	
	No. of units repaired	No. per supergroup per annum	No. of units repaired	No. per supergroup annum per
Modem + filter	100	0.81	11	0.12
Amplifier	27	0.20	8	0.08
Signalling sender	4	0.03	5	0.05
Signalling receiver	26	0.19	4	0.04
Pilot converter			2	0.02
Carrier distribution unit			1	0.01
Regulated loss network			3	0.03
Telephone unit			1[c]	
Mains supply unit	d		1	0.01

[a] Equipment type M2 = equipment with tube amplifiers
[b] ,, ,, M3 = fully transistorized equipment
[c] Fault does not affect traffic, only maintenance
[d] Type M2 uses battery operation or centralized supply bay

Fig. 3
List of units in channel and group translating equipment of L M Ericsson manufacture repaired during 1964.

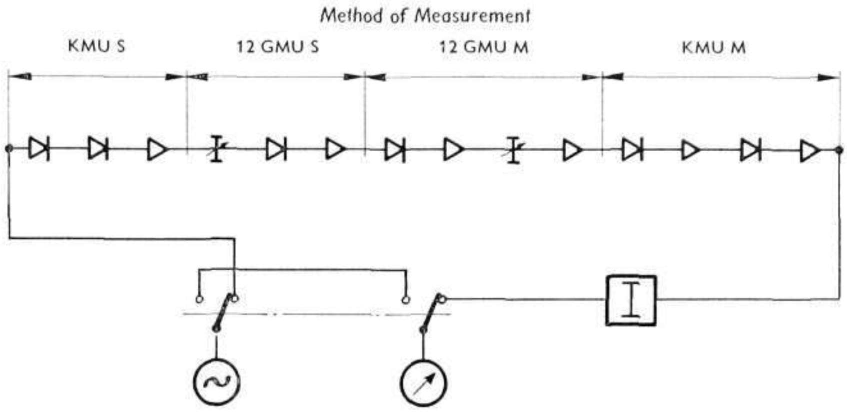
The relays are not meant to be adjusted, and since it has not yet been possible to observe any contact wear whatever, a very long life is to be expected.

Improper functioning of the signalling relay nevertheless as might be expected occurs more often in tube equipment than in transistorized equipment. In the type II channel translating equipment, the signalling relay contacts are of the conventional dry type with access for inspection and adjustment, so that contact faults result amongst other things from corrosion of the contact material. The latter type of equipment also requires other routine attention such as tube replacement.

To give a clearer idea of the faults in Group 2, repeater stations' repair orders have been studied for all channel and group translating equipment of the types mentioned which had been in service for at least a year. A summary of the result is given in figure 3. Among other things it can be seen that the number of repairs per supergroup per year was $3^1/_2$ times as great for the earlier tube equipment than for the transistorized. Fault location and replacement of faulty units has been made very much easier in the transistorized equipment by the fault-finding test points provided in the units and by the plug-in connexion of the units themselves. Reliable service from this method of connexion, however, demands reliable contact devices. Our experience of plug-in connexions using gold as the contact material has without exception been good. Investigation of faulty contacts in the transistorized channel translating equipment also indicates that reliable methods have been used during manufacture for soldering to the printed wiring cards.

Knowledge Gained from the Special Investigations

Questions of the greatest interest for an operating engineer are in what way and how rapidly equipment ages. Amongst other things the answers will help him to decide what maintenance methods should be used in order to counteract a gradual degradation in the service quality of telephone circuits with time. Special measurements, covering a period of 2 or 3 years and still in progress, have therefore been made in certain stations on the above-mentioned transistorized channel translating equipment of L M Ericsson manufacture. As is the case for most long-term tests, the investigation requires much time and the measurement results can of course be dealt with in different ways. For this presentation, a simplified treatment was aimed at and was in fact necessary because of the time available.



Measurement Results

No. of channels checked (n)	Measured changes in level Δ cN after 24 months				
	$+1cN$	$0cN$	$-1cN$	$-2cN$	$-3cN$
24	7	7	7	7	7

$$M = \frac{\Sigma \Delta}{n} = -0.3cN$$

Fig. 4

Investigation of variation in level in transistorized channel and group translating equipment

Test period 24 months

- Modulator or demodulator
- Amplifier
- Adjustable loss (setting unaltered)
- Oscillator
- Level measuring set
- Attenuator for measurement

S Sender

M Receiver

In all transmission equipment a good stability of level is aimed at. The special measurements of level made on the channel and group translating equipment on a sample basis during 2 years show that the level stability in this equipment is good. Only small changes have been measured, of the order of a hundredth of a neper (apart from faulty units). The results of measurements and the measuring technique used are indicated in fig. 4. The measuring accuracy is of the order of ± 0.01 N and the greatest change measured was -0.03 N. The frequency response curve relative to 800 Hz over the transmission band 300 to 3400 Hz has also been checked during a longer period. Changes have been small and the tolerance limits required on delivery were still met after 3 years for all channels tested. The measurement results are given in figure 5: measurement accuracy is about ± 0.01 N.

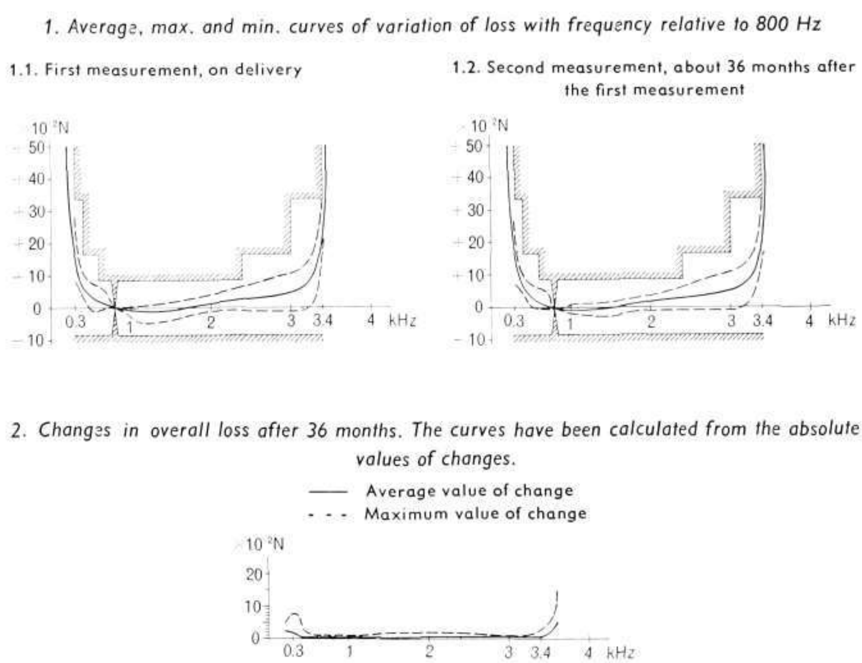
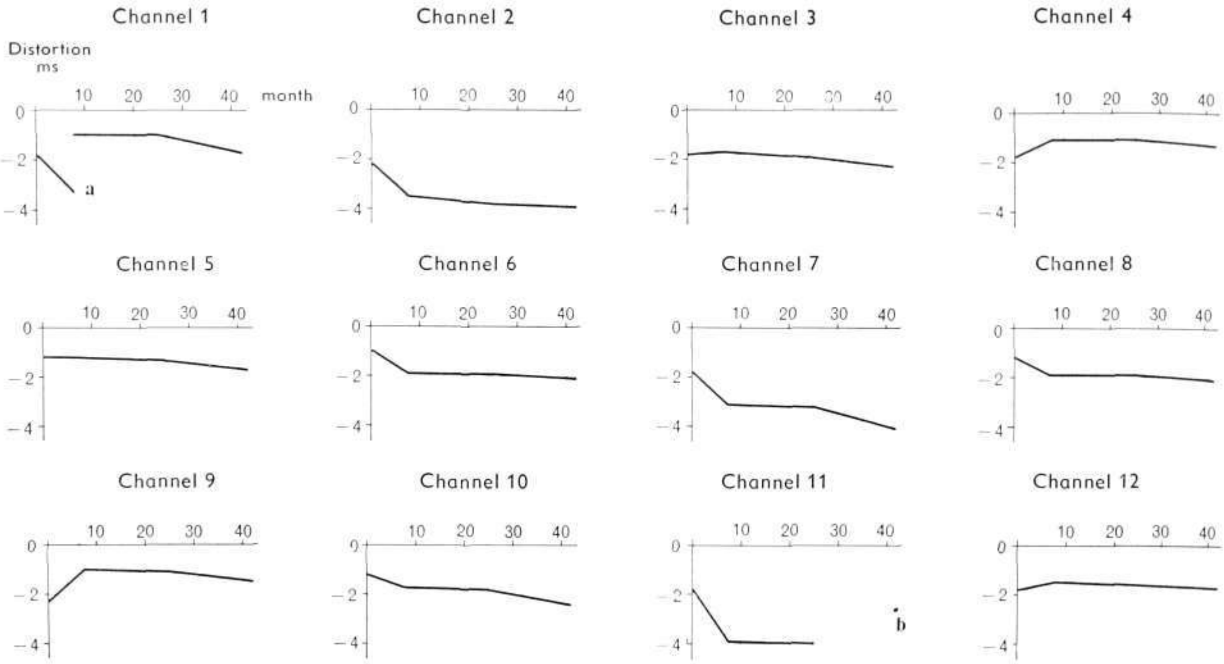


Fig. 5

Aging of transistorized channel translating equipment. Attenuation frequency distortion for 24 channels loop-connected at basic supergroup (sender + receiver)

Test period 36 months

Limits shown in 1.1 and 1.2 are 1/3 of those given in CCITT Red Book volume III, diagram No. 1.



Summary of results for whole group

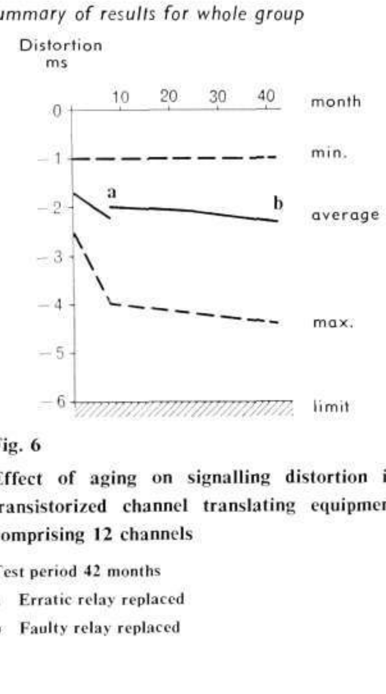


Fig. 6

Effect of aging on signalling distortion in transistorized channel translating equipment comprising 12 channels

Test period 42 months

a Erratic relay replaced

b Faulty relay replaced

The quality of signalling transmission is of considerable interest. Checks of 10 Hz impulse distortion in the signalling path have therefore been carried out on the channel translating equipment over a period of $3^1/_2$ years without making any adjustments to the signalling units. The measurement results for 12 channels tested at normal signalling level are given in fig. 6. The check included both v.f. signalling sender and receiver in the corresponding channel including its relay. The points for the individual channels represent the average value of three measurements at 10 Hz but with different impulse ratios, namely 50/50 ms, 60/40 ms and 70/30 ms (the figures indicate the break and make times respectively). Besides giving the average values of distortion at the various times, the summary also indicated the maximum and minimum values. The average value for distortion of the length of a received pulse on delivery was −1.7 ms and after 42 months −2.3 ms. Distortion figures with a minus sign signify that the contact closure was shorter by the given number of milliseconds. Measurement accuracy was about ± 1 ms (of which reading accuracy was about ± 0.5 ms). On delivery the limit for distortion is ± 6 ms.

As regards the quality of speech transmission, important factors in this are given by measurements on noise and crosstalk. The variation with time of thermal noise has been studied in three stations and the results are shown in fig. 7 and 8. Measurements were made on transistorized channel and group translating equipment with sending and receiving sides looped at the supergroup distribution frame. Figure 7 shows the values of psophometrically weighted noise power at a point of zero relative level for each of the channels in a supergroup. The measurements indicated an increase of the noise level in each channel of some 10 to 15 pW over a period of two years. The high initial measured value for channel 2 in group for equipment delivered 1961 was due to interference from the mains supply unit in the bay. This interference was eliminated by improved screening, as can be seen from the second series of measurements. Fig. 8 shows the statistical distribution of measured values of noise power on delivery and after 2 years. The figure shows (1) that the average value increased by 14 pW to a final value of 50 pW, (2) that after 2 years all individual values are still below the delivery guarantee limit of 100 pW.

Besides the long-term tests just described on changes in thermal noise in a system without input loading, measurements of intermodulation noise in channel and group translating equipment have also been made. For these tests, 59 channels in a supergroup were each loaded with a white noise signal

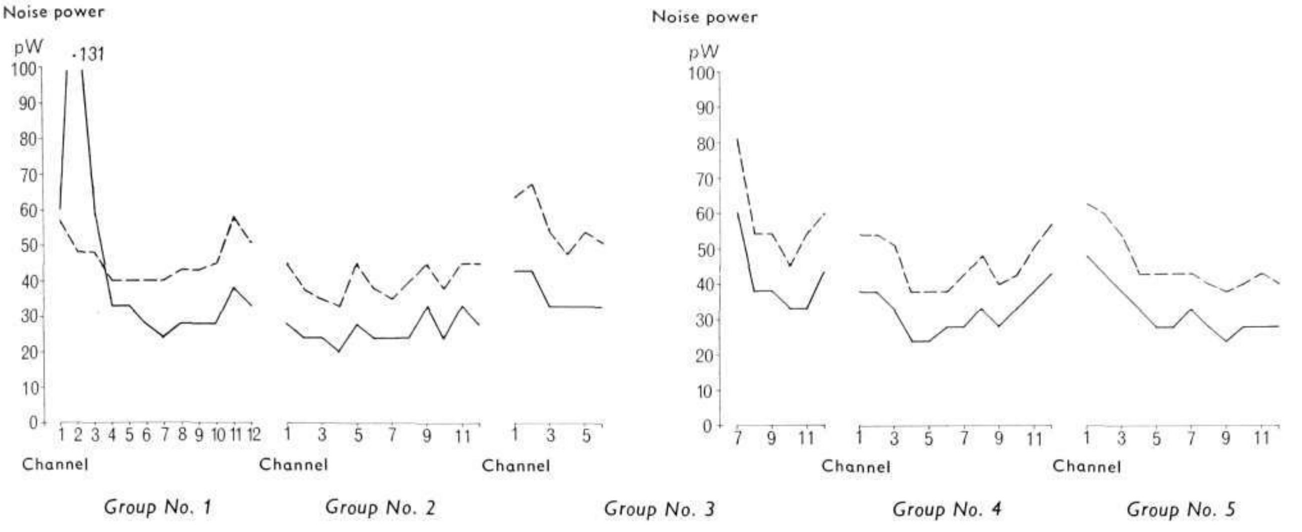


Fig. 7

Aging effects in transistorized channel and group translating equipment, measured loop-connected at basic supergroup

Weighted thermal noise in respective channel
—— First measurement 06.11.61
– – – Second measurement 10.10.63

at −15 dBm0; the average increase in noise power in the remaining channel (i.e. the intermodulation noise) was 14 pW with a standard deviation of 7 pW. The highest value did not exceed 30 pW.

Intelligible crosstalk between channels within a group has also been checked on delivery and after about 3½ years in service. The results are shown in fig. 9. The measurements have been carried out both with and without semi-continuous out-band signalling applied (3825 Hz, level −18 dBm0). The measurements have been made using a single frequency applied to the interfering channel and a selective measuring set connected to the disturbed channel. For values of crosstalk ratio up to 80 dB, the measurement accuracy was about ± 1 dB; for higher values somewhat worse. All values were better than those guaranteed on delivery, namely 75 dB. This applies both without and with outband signalling applied, although in the latter case the values obtained were somewhat lower; this is probably due to intermodulation.

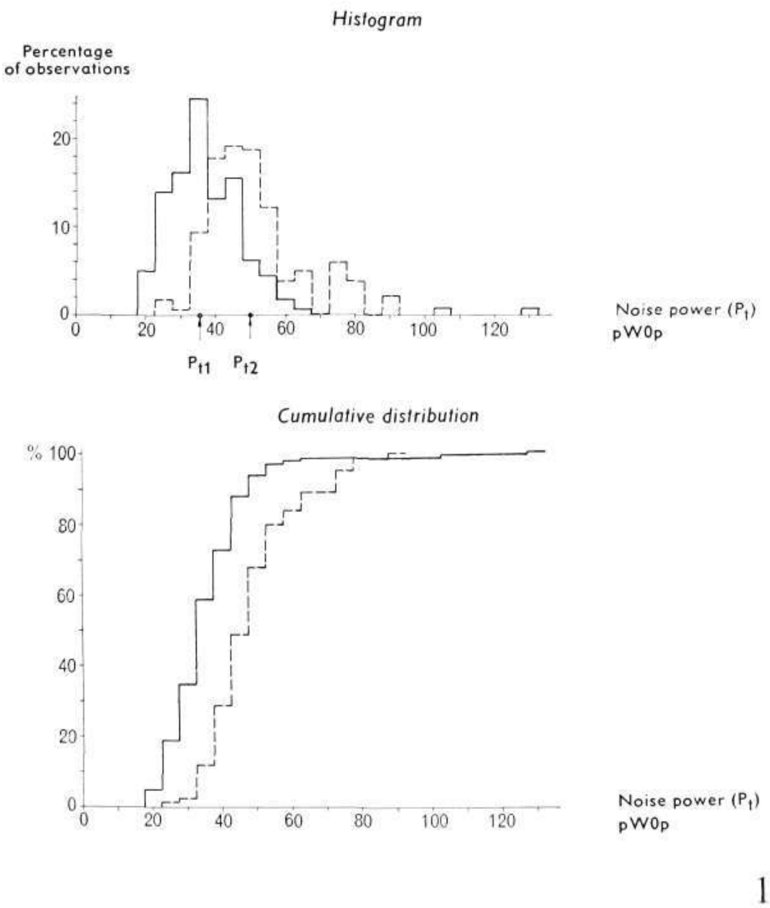


Fig. 8

Aging effects in transistorized channel and group translating equipment, measured loop-connected at basic supergroup

Noise distribution for 180 channels

—— First measurement (on delivery)
mean power P_{t1} 36.2 pW
standard deviation 9.3 pW

– – – Second measurement (after 2 years)
mean power P_{t2} 50.2 pW
standard deviation 13.8 pW

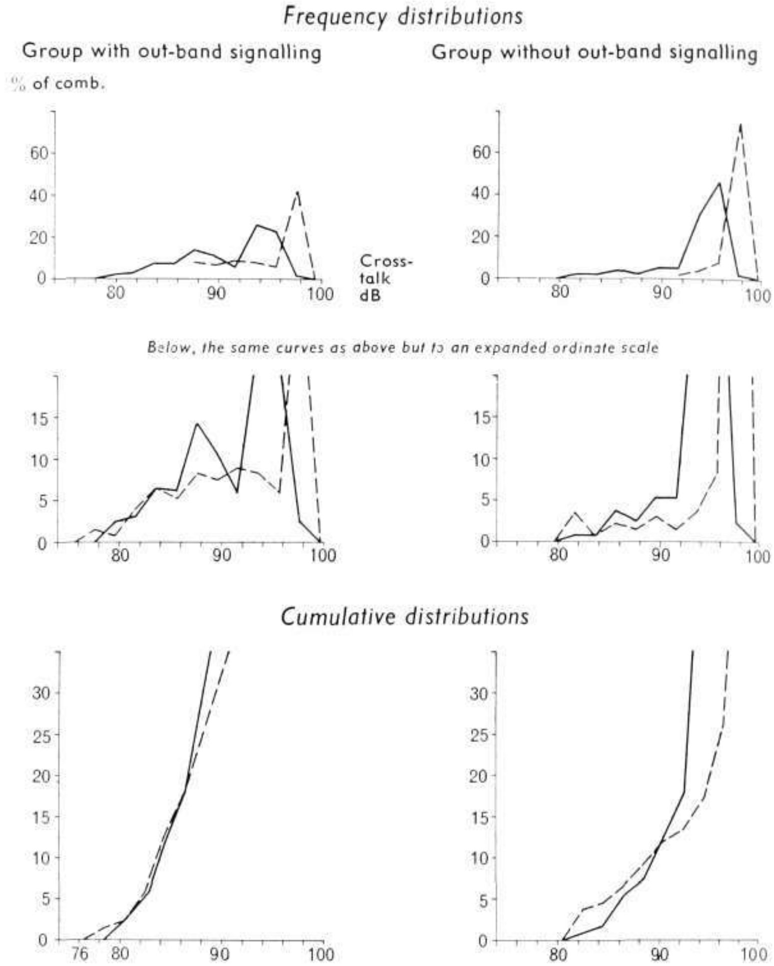


Fig. 9

Aging effects in transistorized channel and group translating equipment. Intelligible crosstalk between 12 channels in loop-connected supergroup

Channels of same group

—— First measurement

– – – Second measurement (after about 41 months)

All values are for crosstalk ratio. The vertical axes of the diagram are scaled in per cent of the total number of measurement combinations within a group (132).

The carrier leak from the channel modulator lies only 175 Hz from the out-band signalling frequency, so that this leak can interfere with signalling transmission if its level is not sufficiently low. The channel modulators in the transistorized equipment under study have been designed for low carrier power which helps to keep down the leak. This alone would not however prevent aging of the modulator diodes from causing an unacceptably high unbalance voltage, i.e. giving rise to disturbing carrier leak. The carrier leaks in two supergroups (channel and group translating equipment) have been investigated $3^1/_2$ years after being placed in service. Since carrier leaks from higher modulation stages (3-channel sub-group and group) can in certain cases add to channel carrier leaks, the tests were made in the basic supergroup range (312–552 kHz).

Measurement Results

Average value	–47 dBm0
Worst value	–36.5 dBm0
Guaranteed limit on delivery	–28 dBm0

The measured results indicate that the carrier leak is still at a comfortably low level and that the stability of the modulator balance is good.

Summary

The fault statistics and aging tests described here show how the introduction of transistorized channel translating equipment has led to good and stable transmission quality and lower failure rate than the corresponding tube equipment could provide. The equipment also more readily permits simplified maintenance routines with consequent lower maintenance costs.

L M Ericsson's Crossbar Systems, Their Development and New Traffic Facilities

S. ELLSTAM, TELEFONAKTIEBOLAGET L M ERICSSON, STOCKHOLM

UDC 621.395.344
LME 8302 7363

L M Ericsson has played an internationally leading part in the development of present-day crossbar technology. The superior qualities of L M Ericsson's crossbar systems, such as high speed, high operational reliability, low maintenance cost and great capability of being adapted to present and future technical requirements have led to the introduction of our crossbar systems by more and more telephone administrations in their networks. The first public crossbar exchange using L M Ericsson's crossbar system working on the advanced by-path and link principles was put into operation in Helsinki in 1950. Since then, our crossbar systems have been subjected to continual development in regard to greater traffic facilities and mechanical improvements to the crossbar switch and other components. This article presents a survey of the development of L M Ericsson's public local telephone system ARF, rural system ARK and transit system ARM and at the same time gives a brief presentation of new traffic facilities. The systems are described in more detail in a new series of brochures.

ARF 50 and ARF 51

As mentioned earlier, the first local exchange of L M Ericsson's crossbar system *ARF 50* and working on the link principle with common markers for interworking with 60 V step-by-step systems was put into operation in Helsinki in 1950. In this city there are now 25 such exchanges in operation. In other countries too, *ARF 50* has been adopted as the standard system. The registers in this system are associated with each switching stage.

The system has been progressively improved. In 1954, the facility of connecting two markers per 1000-line group was incorporated and jack units were introduced on switch and relay racks so that these racks could be plugged into the exchange cabling. Different system types for various traffic capacities have also been introduced, and moreover, the system has been continuously developed so that it now includes transistorized engaged testing and increased possibilities of alternative routing.

In 1958, a 48 V type designated *ARF 51* was developed for interworking with *BPO* step-by-step systems.

ARF 100 and ARF 101

A new system *ARF 100* was put into operation in Denmark in 1953. This system has central registers, more advanced grouping and greater possibilities of alternative routing, thereby making it particularly suitable for use in large multi-exchange networks.

Three years later, this system was replaced by *ARF 101* where two markers per 1000 line group could be connected to the *SL* stage instead of one, thereby

Fig. 1
Interior of a large city exchange of L M Ericsson's system ARF 102 in operation at Padova, Italy

offering a complete exchange series having different traffic capacities. The system is mechanically further developed due to the use of jack units for plugging in switch racks to the exchange cabling.

ARF 102

The first crossbar exchange of system *ARF 102* was put into service in Venice, Italy in 1960 and was the first in the world to use compelled sequence multi-frequency code *(MFC)* signalling.

In this system the called subscriber functions of the final selector relay set have been incorporated in the link circuit relay set *SR* and in the incoming junction line relay set *FIR* which simplifies interworking with other telephone systems.

New Facilities

The new facilities which have so far been introduced in system *ARF 102* will now be briefly mentioned.

Compelled sequence multi-frequency code signalling has been worked upon by L M Ericsson for a long time. The basic ideas were developed in 1954 and the first field trials were made in the Netherlands in 1957. This signalling system is included as standard and offers the following advantages:

- *Rapidity*. Six to seven digits per second can be transferred.
- *Reliability*. The system is self-checking and insensitive to disturbances in transmission as there are no margins on signal duration.
- *Unlimited application*. The system can be used on all types of 2-wire and 4-wire lines.

- *Optimum number of signals* in both directions for numerical and other information concerning the calling and called subscribers. The system is thus adaptable to all present and future traffic facilities. Additional advantages from the traffic routing point of view are obtained as it is possible to repeat certain digits.
- *Wide operating range* sufficient to economically cover all types of traffic encountered in practice.
- *Simple transit registers* with short holding time owing to the use of end-to-end signalling.
- *Self-checking*, thereby avoiding transmission of incorrect information and facilitating fault location.

Identification of the A-subscriber is mainly used in connection with toll ticketing. Even if toll ticketing is not so widespread at present it will certainly be required to an increasing extent in association with fully automatic international traffic. The registers of system *ARF 102* are arranged for receiving and storing the *A*-subscriber's number and for sending this forward by *MFC* signalling to a trunk register.

Push-button dialling pulses from the subscriber's set will become more and more widespread in the future. The new register block which will be described below can be supplemented with code receivers for reception of push-button dialling pulses from the subscriber's telephone set. As its standard for public exchanges, L M Ericsson uses a multi-frequency signalling system in which each digit is characterized by two tones. These tones are selected from two groups, each consisting of four frequencies.

Division of subscribers into different classes is required more and more in today's telephone network so as to be able to offer different services. It is possible to have up to 40 different classes of service in system *ARF 102*. Examples of *A*-(calling)subscriber classes of service are: push-button telephone set, two-party line, subscriber barred from making trunk calls, immediate price information to subscriber when there is toll-ticket charging, coin box set, test line call, etc. Examples of *B*-(called)subscriber classes of service are: incoming calls barred, no call charging, direct in-dialling to *PABX* extension etc.

Fig. 2
Telephone set for push button dialling

A new register block has been developed which as mentioned above enables push-button telephone sets to be connected. This register block is built up using new principles, with separate analysers for digital analysis and translation. Relays are used as digital store, which offers advantages when the rapid push-button dialling is used. The new register block offers the great advantage that different types of code sender for different signalling systems can easily be connected. This can be used when interworking with exchanges having a different type of signalling than compelled *MFC* and is of great importance for future developments when new and even more rapid signalling systems can be introduced.

A three-stage group selector unit having greater multiple capacity has been developed to meet the need in large multi-exchange networks. Initially, the group selector unit can consist of two stages *A* and *B*, and when required a third stage *C* is added. The smallest unit consisting of only *A* and *B* stages has 160 inlets and 400 outlets served by a common marker organization. By adding one to four separate *C* stages each having 100 inlets and 400 outlets, the multiple capacity is successively increased from 400 to 700, 1000, 1300 and 1600. The *C* stage is controlled by a common marker which is permanently connected to the marker organization of the *A* and *B* stages. A connection through all three stages is made by conditional selection. The fully built-out unit permits choice of about 200 routes with an availability of between 5 and 80 with up to five alternative route attempts.

A 4-wire group selector stage has been developed to obtain better transmission properties when distributing trunk traffic from the trunk exchange to the different local exchanges in a metropolitan network. Individual balancing of the lines to the different local exchanges can therefore be arranged.

Direct in-dialling to PABX extensions has become increasingly important, and on request system *ARF 102* can be supplied initially with this feature or it can be added later. We recommend the use of a linked numbering plan in connection with direct in-dialling i.e. *PABX* extensions to which direct connection can be made are given numbers in the public number series. This is in agreement with most administrations' wishes. This feature, which means that a subscriber on the public exchange can dial directly to any extension on a *PABX* without the intervention of an operator, is of course dependent on the design of the different *PABX's*.

Centralized absent subscriber service offers many advantages. A very advanced system has been developed for *ARF 102*, with operator service, announcing machines etc. of different types connected to the main exchange in a multi-exchange area. The system is provided with decentralized electronic stores (ferrite cores) for marking of absent subscriber service for the individual subscribers connected to the other exchanges in the network, for rerouting calls to the central absent subscriber service equipment at the main exchange.

Lines connected for absent subscriber service can be divided up into fourteen classes, for example:

- changed number
- vacant number
- subscription ended
- information given by different groups of operators and/or announcing machines
- tracing of malicious calls.

Subscribers connected to absent subscriber service can make outgoing calls without operator assistance.

Terminal Exchanges Type ARF 102

System *ARF 102* has also been modified so that the subscriber stage can be used as combined group and final selector stage. This type is intended for use in terminal exchanges with an initial capacity of up to about 900 subscriber lines. The final capacity is the same as for the normal *ARF* system as the group selector can be introduced when required.

This application, which permits subsequent introduction of the group selector stage, means that the *ARF* system becomes more economic for small exchanges.

ARK 30 and ARK 50

The first rural exchange of type *ARK 30* was put into service in Liseleje, Denmark, in 1951 and the system has since then been widely used in many countries including Finland, Yugoslavia and Italy.

In 1962, a new, rural system *ARK 50* was introduced which differs from the *ARK 30* system in the following respects:

- ☐ Compelled sequence multi-frequency code signalling has been introduced which reduces the setting up time and in general gives the advantages enumerated above concerning this signalling system.

- ☐ In addition to the route to the primary centre, the larger of the exchange types can be provided with three direct (early choice) routes to other exchanges.

- ☐ Subscribers can be divided into 6 different service classes, which number can be easily increased if necessary.

- ☐ System *ARK 50* is more flexibly designed and requires less space as double-sided racks are used.

- ☐ Two markers can be connected in the case of the larger of the exchange types.

With a view to further simplifying installation and testing of *ARK 50*, the mechanical design has been modified so that all racks are provided with jack units for connection to exchange cabling. At the same time the intermediate distribution frames *(IDF)* have been replaced by *BDH* racks, where the exchange cabling is connected, and the *IDF* jumpers now consist of replaceable cables provided with plugs.

In this way, the installation is simpler and more rapid, handing-over testing is more complete and layout more compact, at the same time enabling extensions to be appreciably easier. For standardized lay-outs, moreover, a large amount of exchange cabling can be factory-made in the form of cables with plugs.

The registers for a rural network with *ARK 50* are concentrated to the higher ranking primary centres. Where necessary, the terminal exchanges can be provided with small local registers which can take care of local calls if all junctions to the primary centre are busy. In certain cases, however, it can also be necessary to provide the *ARK* exchange with complete registers.

One type of the standard system *ARK 50* has been developed which identifies the *A* subscriber for toll-ticketing purposes.

ARM 100, ARM 201 and ARM 503

In 1952, the first transit exchange of system *ARM 10* was put into service in Rotterdam.

A new system *ARM 201* with a different grouping and marker organization was put into service in Aarhus, Denmark in 1953. Route markers and test blocks were introduced in a later type and this led to a more flexible and easily extendable system.

In the years 1962 and 1963 the time required for markers to make their tests was reduced and a new exchange type *ARM 201/4* having a greatly increased traffic-handling capacity was introduced.

The first international exchanges of a modified system *ARM 20* with 100-line instead of 200-line grouping and 10-pole through connection were put into service in Copenhagen and Rotterdam in 1959.

In 1954, the first exchanges of system *ARM 501* were put into service in Finland and Italy. In this system, a large number of the analysing functions were carried out in the register. The system was superseded in 1961 by *ARM 503* which had in all essentials the same marker organization as system *ARM 201*. This meant that the same type of repeaters and registers could be used in *ARM 201* and *ARM 503*.

Toll-ticketing equipment for automatic toll ticketing has been developed. A complete *ARM* network with toll ticketing has been in operation in Egypt since 1964, and the system is being successively introduced in Mexico.

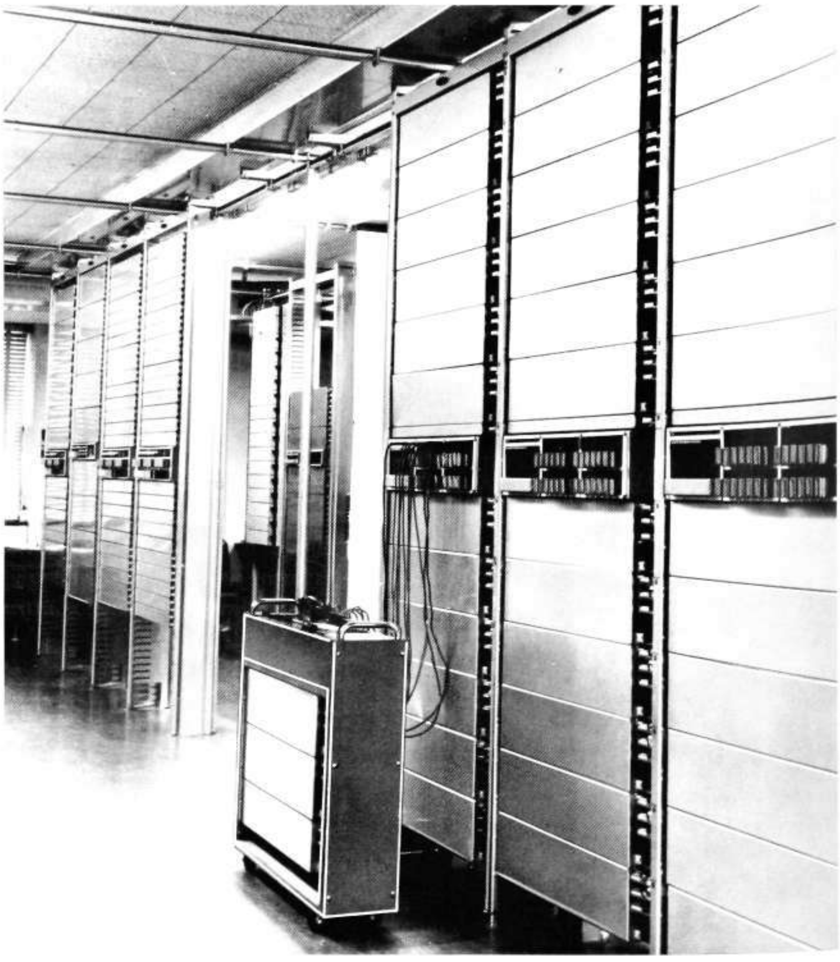


Fig. 3
Crossbar system ARM 20 in Montreal, Canada

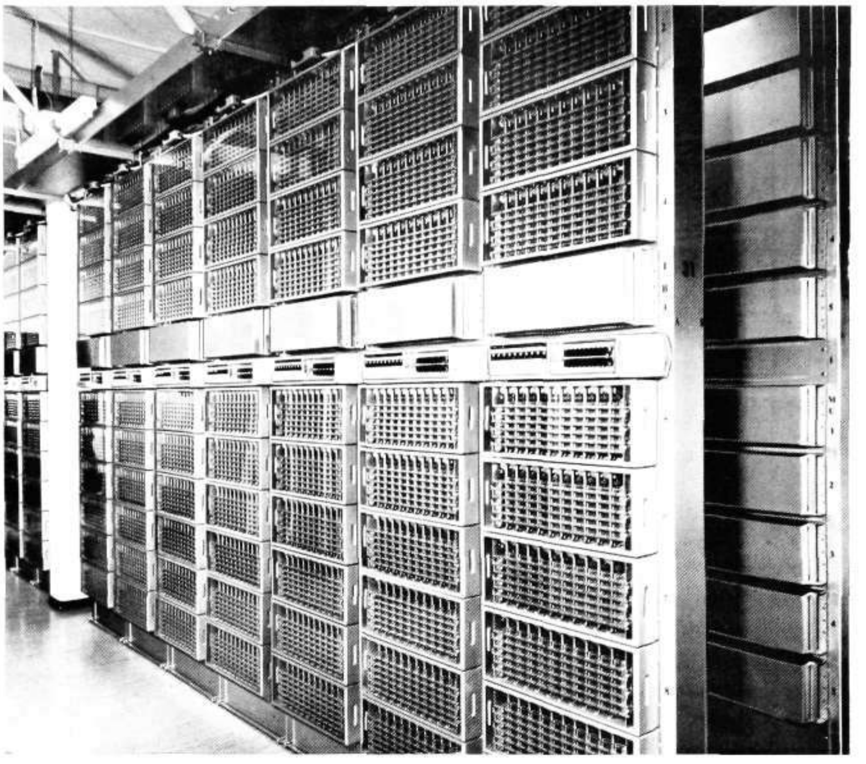


Fig. 4
Crossbar system ARM 20 in Randers, Denmark

This equipment uses common ferrite core matrices. Each call to be charged on toll ticketing is allocated a part of the store in this matrix in which information on the calling and called subscribers' numbers, time of commencement of call etc. is stored. Read-out is made at the end of the call, from which the call duration is worked out.

Feed-out can be arranged in different ways, depending on requirements. For example, read-out can be made directly to a card punch, tape punch or magnetic tape. Immediate service, i.e. immediate price information, can be given by arranging immediate sorting out of the card or by simultaneous write-out on an electric typewriter.

In large national networks it is important to centralize the toll-ticketing equipment. A method has also been developed, for example, for transfer of primary data from the terminal exchange or primary centre to trunk exchange by using *MFC*. Centralization of common data handling for a whole country or a large zone is obtained by feeding-out data from trunk exchanges after completion of calls to a central computer via a tape recording equipment and data link. In this way the data-handling equipment is fully engaged and card punching and various card transports, sorting etc. are avoided.

Signalling principles have also undergone successive improvements and can be adapted to requirements in any particular case. L M Ericsson's compelled multi-frequency code signalling for register signalling, the advantages of which have been touched on previously, has gained increased popularity.

Interworking with Other Systems

ARF, *ARK* and *ARM* systems have been successively supplemented with equipment for interworking with different types of step-by-step and register-controlled systems. Today, as a result of previous operational experience, L M Ericsson can offer equipment for interworking with any telephone system existing on the world market.

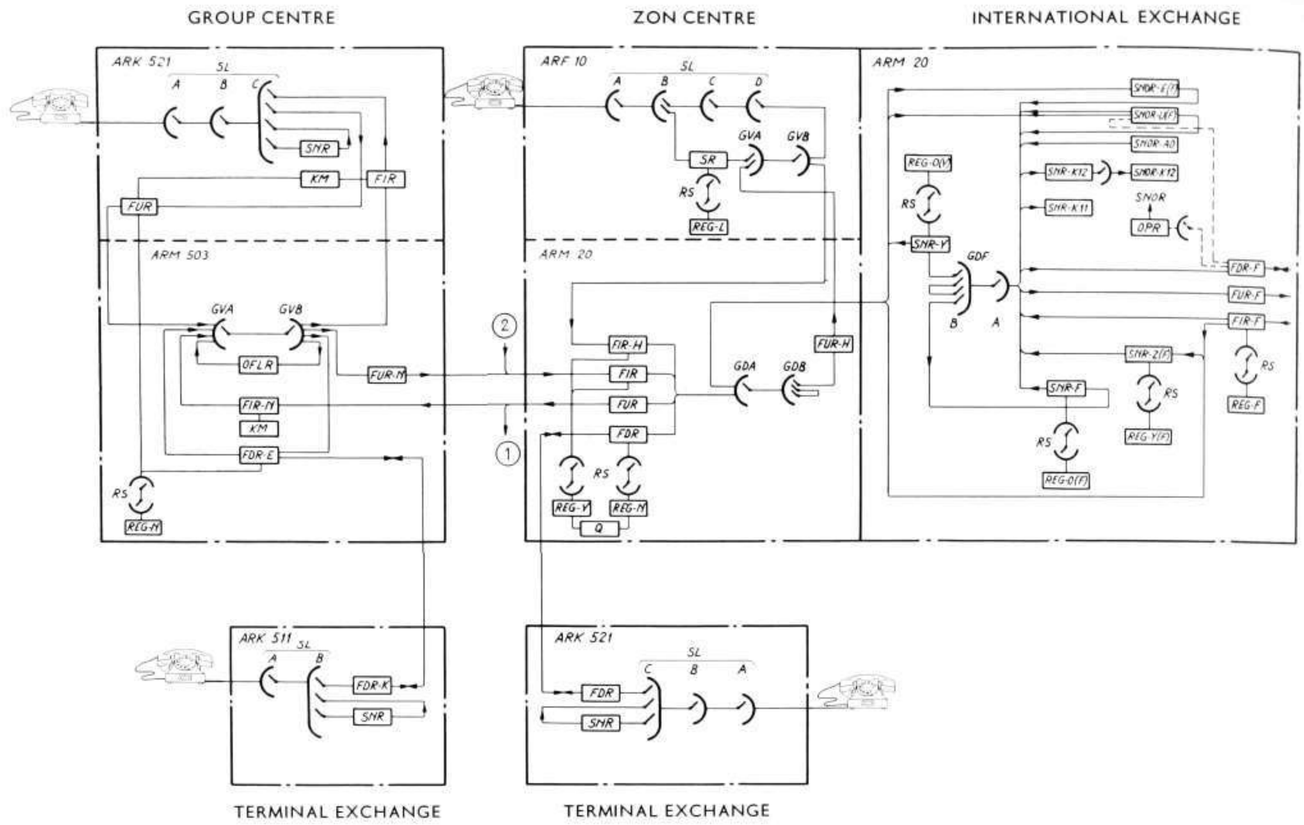


Fig. 5
Model trunking diagram

FDR	Both-way trunk line relay set
FDR-E	Do. to terminal exchange
FDR-F	Do. to internat. exchange
FDR-K	Do. to group centre
FIR	Incoming trunk line relay set
FIR-F	Do. from internat. exchange
FIR-H	Do. from ARF exchange
FIR-N	Do. from zone centre
FUR	Outgoing trunk line relay set
FUR-F	Do. to internat. exchange
FUR-H	Do. to ARF exchange
FUR-N	Do. to zone centre
GDA, GDB	Group selector stage
GDF	Do. for internat. traffic
GVA, GVB	Group selector stage
KM	Code receiver
OFLR	Relay set for overflow traffic
OPR	Operator position
Q	Queue equipment
REG-F	Register for incoming internat. traffic
REG-L	Reg. for local traffic
REG-N	Reg. for zone traffic
REG-O(F)	Operator's reg. for internat. traffic
REG-O(Y)	Operator's reg. for national traffic
REG-Y	Reg. for incoming and transit traffic
REG-Y(F)	Reg. for outgoing subscr.-dialled traffic
RS	Register finder
SL	Subscriber stage
SNOR-AO	Assistance operator's cord circuit
SNOR-E(F)	Do. for outgoing internat. traffic
SNOR-U(F)	Do. for internat. traffic (universal equipment)
SNOR-K 12	Do. for incoming internat. traffic
SNR	Cord circuit relay set
SNR-F	Operator's cord circuit for outgoing internat. traffic
SNR-K11	Do. for incoming internat. traffic
SNR-K12	Do. for incoming internat. traffic
SNR-Y	Do. for national traffic
SNR-Z(F)	Do. for outgoing subscr.-dialled traffic
SR	Link circuit relay set
①	To other centres
②	From other centres

Maintenance and Centralized Service Supervision

The systems have been adapted for more simple maintenance methods and for widespread centralization of the maintenance work. For example, a new alarm system for remote alarm transmission has been developed.

All systems have also been designed to the requirements of L M Ericsson's maintenance philosophy of centralized service supervision which mainly aims at continuous, automatic supervision and registration of service quality.

Automatic Registration of Call Charging Pulses

An electronic system has been developed for automatic registration of call charging pulses, which can replace the subscribers' meters in our crossbar exchanges and in other conventional electromechanical systems. The system provides the possibility of full automation and centralization of the registration of call charging.

Information on the number of charging pulses for each subscriber is received and stored in an electronic store consisting of ferrite cores. In this equipment up to about 65,000 charging pulses per subscriber can be stored before it is necessary to read out. Read-out can be made at suitable intervals and transfer of information to a central location carried out using the normal exchange equipment, junction lines and *MFC* signalling or rapid data transfer systems depending on the requirements of the centralized equipment. L M Ericsson has also developed a 600 baud data conversion system suitable for this transfer of information.

Automatic Transmission Measurement

Owing to the individual selection feature of *ARM* exchanges they are particularly suitable for automatic measurement of transmission characteristics from a central point in a trunk network, as the normal switching network can be used for setting up connections to be tested. L M Ericsson has produced a fully automatic transmission measuring equipment for this purpose which uses punched cards or tape for control of measurements and for presenting the measurement results. With separate access switches, this system can also be made suitable for use with transit exchanges of other manufacture.

Mechanical Improvements

With a view to improving operational reliability and life and to make the various components suitable for automatic manufacturing processes, crossbar switches, relays and other units have been subjected to continuous improvements. New elements such as printed circuits with semiconductors, reed relays and mercury-wetted reed relays have been introduced.

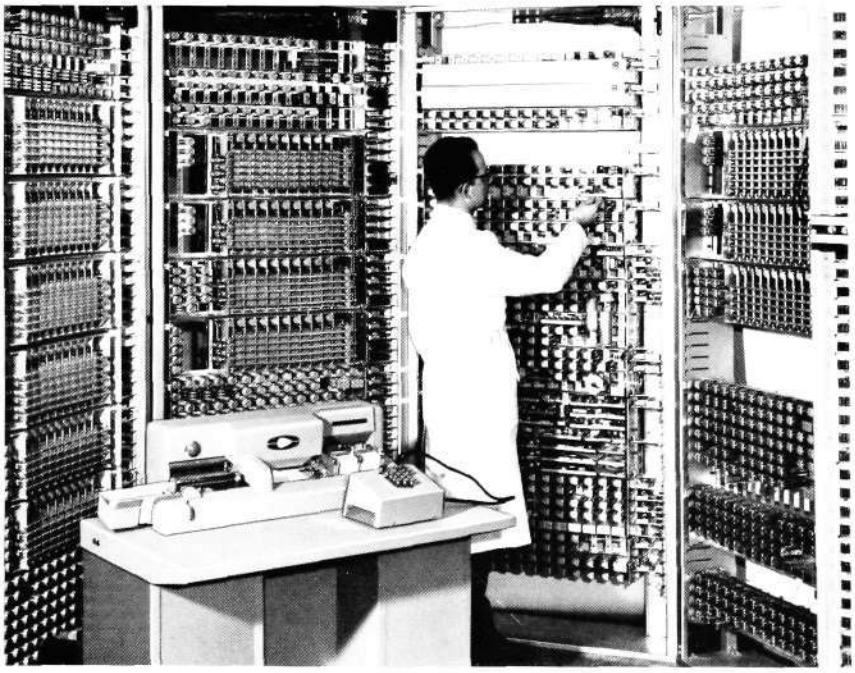


Fig. 6
Automatic transmission measuring equipment, laboratory tests, Stockholm

In the crossbar switch itself, fifteen improvements have been successively introduced, the most important of these being:

- Selecting finger damper has been introduced which has permitted the use of naturally oscillating selecting fingers with short transient time and has eliminated maintenance.
- Contact strip rack insulation has been changed from varnish to separate insulating sheet which has eliminated the risk of flash-over.
- Spherical core face and residual plate have been introduced instead of residual stud in the crossbar vertical which has led to higher holding force and less wear.
- Horizontal damping device of rust-resistant material has been introduced so that simplified adjustment has been obtained.
- The end plates of the crossbar switch as well as the armature of the horizontal have been changed to improve the magnetic circuit of the horizontal and increase the speed of operation.

The standard *RAF* relay has also undergone fifteen improvements of which can be mentioned:

- New springset, to give improved resistance to wear and improved adjustment, has been introduced twice.
- Improved coil insulation using nylon and polyester film to give higher insulation resistance and better resistance to climatic conditions has been introduced.
- The armature system adjusting screws have been replaced by adjustment tongues which stabilize adjustment.

The multi-coil relays, racks, relay sets, jack boxes and terminal strips have likewise been subjected to continuous surveillance for improvement in design.

Future Plans

The development of our crossbar systems progresses continuously, and influenced by proposals from telephone administrations in those countries where our systems have been introduced, new traffic facilities are introduced. The crossbar switch and other components are subjected to successive improvements as new materials become available and the technology advances in general.

Voting Machine for Swedish Parliament

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UDC 654.938
LME 869

L M Ericsson installed a voting machine in the Swedish Parliament (the Riksdag) in the early thirties. After the machine had been operating for more than 30 years, it was found that it was starting to become worn out. The Riksdag decided to replace it by a new and more modern machine, and once again L M Ericsson was entrusted with the order.

The machine has been designed in intimate cooperation with the Riksdag. Account has been taken of the future possibility of a Single Chamber system, in that the various units can be simply interconnected into a system for up to 400 members.

The voting machine collects, records, distributes and photographs the results of every parliamentary division. A keyboard is installed at every member's seat and at the Speaker's and Clerk's desks.

The equipment is self-controlling insofar as, in the event of a wrong count, the result is not displayed but a recount is made automatically. If there is an error after the recount, a lamp lights at the Secretary's position. If any lamp fails during a division, this is signalled to the Secretary's keyboard and in some cases to the Speaker's keyboard as well.

The result of a division (number of Ayes and Noes etc.) is transmitted to the Speaker's keyboard and via a TV installation to four TV receivers in the Legislative Chamber and to a number of TV receivers outside the Chamber.

The vote cast by each member and the result of the division are shown on a record board. The record board is photographed automatically after every division.

The vote cast by each member is also shown on a voting board in the Legislative Chamber.

In addition to the distribution of the results of divisions, the TV equipment is also used for other parliamentary work. A speaker may use it for showing diagrams or other pictures. The press can follow the work of the Riksdag from the press-room, visitors can be given an idea of the procedure before visiting the chambers, changes of the agenda can be displayed, the question to be voted-on can be displayed when the members are summoned to a division, etc.

System Units

The voting machine consists of the following units:

- Central equipment with power supply and intermediate distribution frame
- Speaker's keyboard
- Secretary's keyboard
- Member's keyboard
- Clerk's keyboard
- Voting board
- Record board
- Result panels
- Photographic equipment
- TV equipment
- Cabling

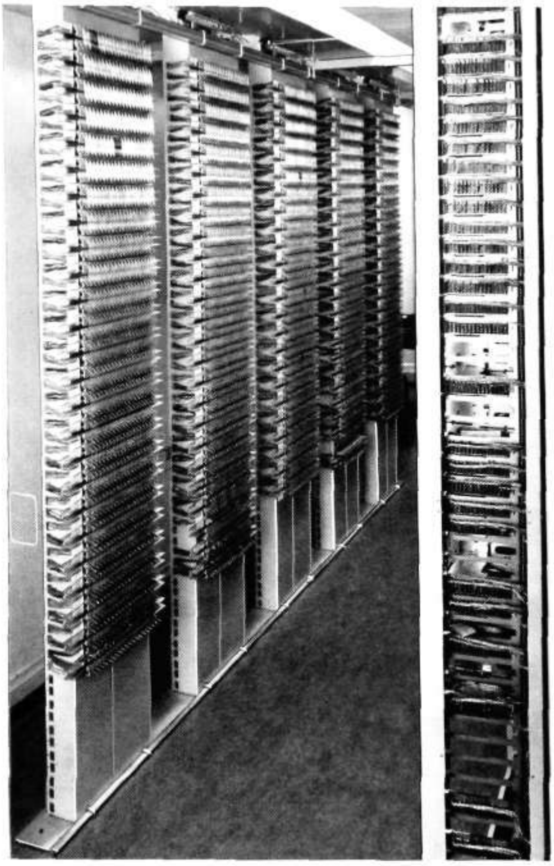

Fig. 1
Central equipment, (left) intermediate distribution frame

Central Equipment

The central equipment for the voting machine is made up essentially of telephone relays (Fig. 1). The choice of an electromechanical system was due chiefly to the suitability of the telephone relay for the circuitry problems of a voting machine. The telephone relay also fulfils all practical requirements of rapidity. The time from completion of voting to presentation of the result is about 4 seconds. (In the previous equipment the time was 40 seconds.)

The relay equipments are assembled in easily handled units which connect to the rack cabling by plug and jack. The racks are of BDH type, height 2.4 metres, and can be provided with doors with locks.

The power supply for the machine comes from two 48V/40A charging rectifiers and two 48V/320Ah batteries with distribution panel.

The batteries are in parallel but are connected across individual fuses, which means that a battery can be disconnected if faulty.

In addition to distribution and battery fuses the distribution panel also contains voltmeters and ammeters.

Keyboards

All keyboards have push-buttons with built-in lamps. When a button has been pressed, the lamp inside the button lights as an acknowledgement that the signal has been received by the central equipment. The Speaker's and Secretary's keyboards have also been designed to avoid faulty operation as far as possible. If the wrong button is pressed, nothing happens. The Speaker may, for example, cancel a voting result before it has been photographed and before the lamp in the PHOTOGRAPHED button has lit.

Speaker's Keyboard

The Speaker's keyboard (Fig. 2) contains the necessary push-buttons and lamps for voting. It also contains a panel on which the result of the division is shown.

The Speaker need operate only three of the eight buttons on his keyboard. When a division is to take place he presses the DIVISION button and, when the members have cast their votes, the VOTING COMPLETED button. He presses the CANCELLATION button when the result of a division is no longer required.

The lamps in the other five buttons inform the Speaker that

- a signal calling for a division has been transmitted
- a member is correcting his vote
- there is a lamp fault in a member's keyboard
- the count has been completed
- the photographing of the record has been completed

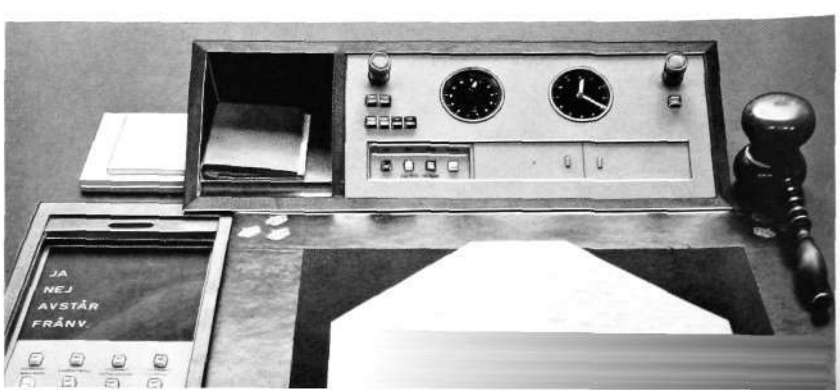

Fig. 2
Speaker's keyboard (left)

Secretary's keyboard

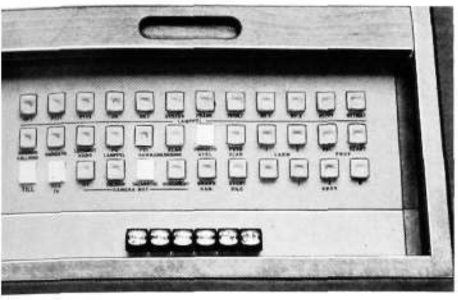

Fig. 3
Secretary's keyboard

The Secretary has a keyboard (Fig. 3) containing push-buttons and lamps for switching-on and testing the system, and push-buttons for the TV equipment. The Secretary decides what picture shall be shown on the TV receivers.

The switching-on of the TV system automatically connects up the camera which is trained on the Speaker. A camera trained on the result board is likewise automatically connected when the counting of votes has been completed.

Members' keyboards

Each member's position is fitted with a keyboard containing four push-buttons with built-in lamps (Fig. 4).

When the Speaker calls for a division, the lamps in the members' CORRECTION buttons light. To register his vote, the member presses the relevant button marked AYE, NO or ABSTAIN. A lamp lights in the button that has been pressed and the lamp in the CORRECTION button goes out. If the wrong button is pressed the member presses the CORRECTION button. The lamp then goes out and the lamp in the CORRECTION button lights up again. He can then record a new vote. If no button is pressed, the member is recorded as absent.

The Deputy Speakers have voting buttons (corresponding to the members' keyboards) on the wall beside their seats when they are not on duty at the Speaker's desk, and on the Speaker's desk. The Speaker has voting buttons only on his desk.

Fig. 4
Member's keyboard

Clerk's keyboard

The Clerk has a keyboard (Fig. 5) for indicating the date, committee and report number, section or subsections. From his keyboard he lights lamps

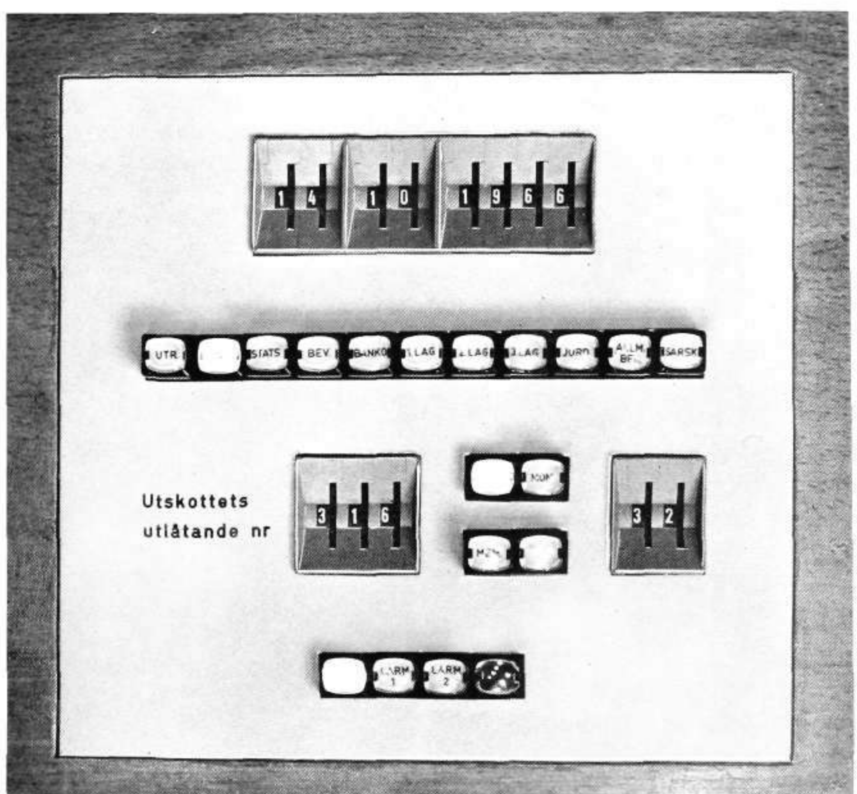

Fig. 5
Clerk's keyboard

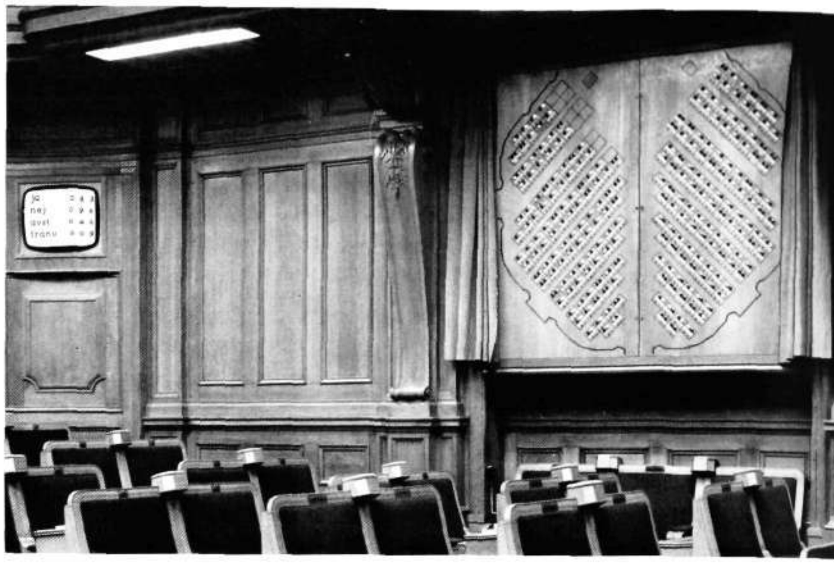

Fig. 6

Voting board; (left) a TV receiver

displaying the required text on the record board, so that the photographic plate automatically registers the text which indicates the subject of the vote. If the vote is on a question which cannot be indicated from the keyboard, a card with the required text can be inserted in a space on the record board before the photograph is taken.

Voting Board

A voting board is placed on the wall in each chamber (Fig. 6). The board is made up in the form of a plan of the Chamber.

Each member is represented on the board by four lamps, a green lamp denoting AYE, red NO, orange ABSTAIN, and white that the member is absent. The AYE and NO lamps have large lenses, the ABSTAIN and ABSENT lamps small lenses.

In front of the voting board is a curtain which is automatically drawn when the voting installation is switched on and off.

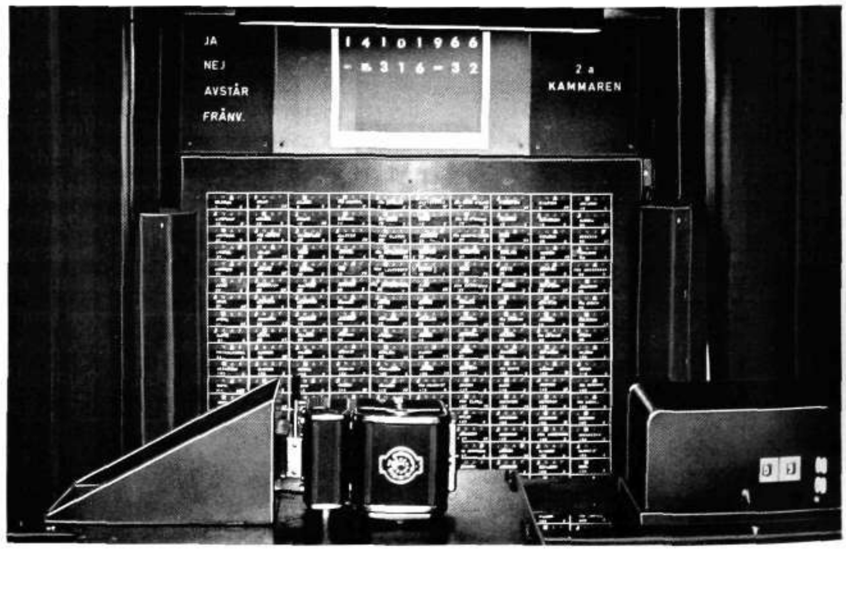

Fig. 7

Record board

In the foreground an electrically operated camera

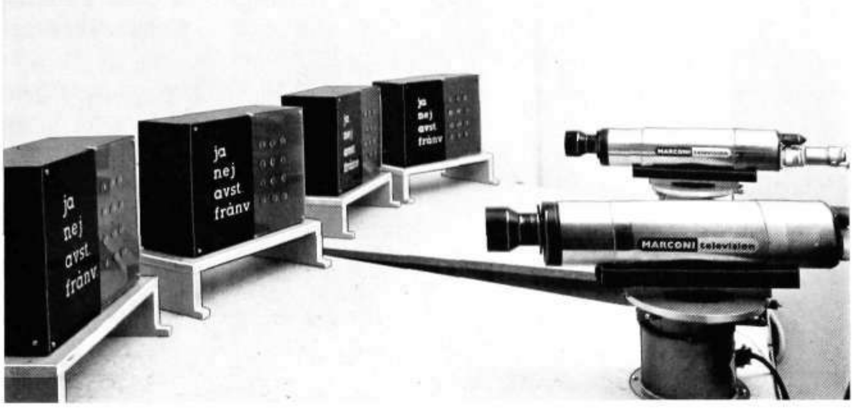

Fig. 8

Result panels and two automatically operating TV cameras

Record Board

The record board (Fig. 7) contains lamps which show the vote cast by each member. The record board is photographed after every division. The board is made up of lamp-holders with duplicated lamps for maximum reliability. The light from the two lamps is focussed by a plexiglass lens on the indication concerned. Eight lamps are thus required for every member.

When a lamp fails, the fact is indicated on the Secretary's keyboard. The probability of both lamps under the same lens failing simultaneously is very small. The members' numbers and names are printed on tape placed under the lamps.

The record board also contains a result panel of the same kind as on the Speaker's keyboard, as well as numerical and alphabetical indicators which show the question to be voted on.

After every division the record board is photographed by an automatic camera. The record board is enclosed in a cabinet.

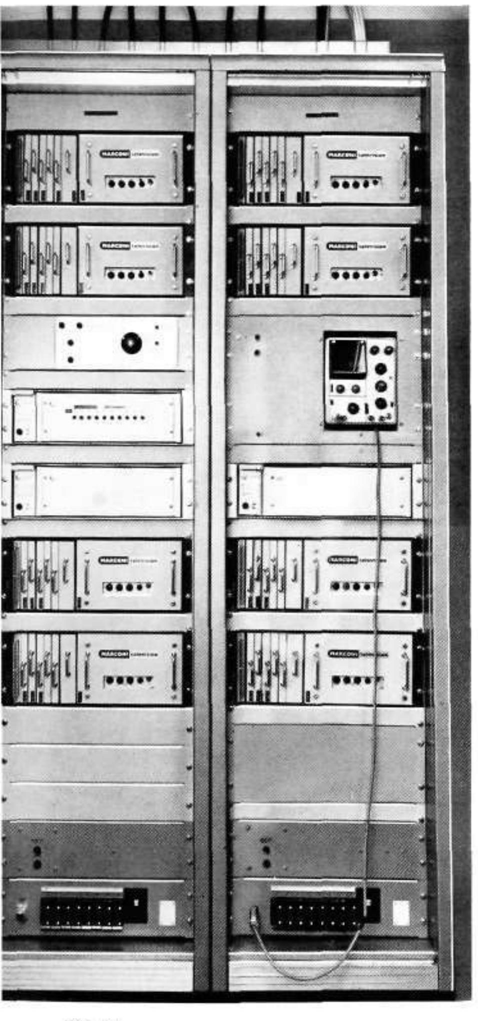

Fig. 9

Distribution equipment for TV installation

Result Panels

Result panels are placed at the Speaker's position and on the record board. There are also two result panels for each Chamber in front of a TV camera in a dark-room. The result panels carry the text AYE, NO, ABSTAIN and ABSENT (Fig. 8). There are also 12 numerical indicators in four rows. After a count, lamps light in these indicators and each indicator shows a number.

Photographic Equipment

An electrically operated Hasselblad camera (Fig. 7) is used for photographing the record board. The camera takes 16 plates. Developing and enlargement are done in a dark-room in the parliament building. The filed photograph is roughly A4 size. The negatives are also filed.

TV Equipment

For each chamber there are four TV cameras and one spare. The TV equipment was delivered by Marconi, England, through Svenska Radioaktiebolaget. Fig. 9 shows the distribution equipment.

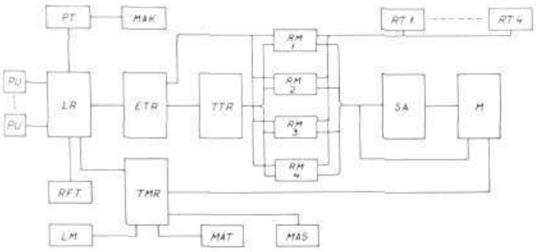

Fig. 10

Block diagram

In addition to the equipment shown in the block diagram there is an equipment for automatic testing of the system.

PU	Member's keyboard
LR	Line equipment
ETR	Units digit relays
TTR	Tens digit relays
RM 1	Result store for AYE votes
RM 2	» » » NO votes
RM 3	» » » ABSTENTIONS
RM 4	» » » ABSENT members
TMR	Speaker's relay equipment
SA	Totalizing relays
M	Lamp supervisory relays
LM	Alarm relays
PT	Record board
RFT	Voting board
RT	Result panel
MAT	Keyboard for Speaker
MAS	» » Secretary
MAK	» » Clerk

One camera is trained on the result panels, one on the Speaker, one on the platform, and one is used for showing documents etc.

In each Chamber there are four 25″ TV receivers, and another ten or so 23″ TV receivers outside the Chambers. The TV receivers outside the Chambers can be used for picture and sound reproduction from both Chambers.

The Secretary can also show the picture of one Chamber on the TV receivers in the other. This may be required, for example, in the case of joint voting.

The existing sound distribution system has been connected to the TV receiver loudspeakers.

Cabling

Ten wires are required to each member's position, five wires per member to the voting board, and eight wires per member and a common return wire to the record board. About 100 wires are required to each result panel. A large number of wires are also required to the Speaker's, Secretary's and Clerk's keyboards.

Coaxial cables are used for the TV equipment and EKKS cable for the sound distribution to the TV receivers.

All cables to the central equipment terminate on an intermediate distribution frame. The wiring between the relay racks also passes via the intermediate distribution frame so as to simplify the alteration of the inter-rack wiring in the event of changing to a Single Chamber system.

Operation

The block diagram for the voting system is shown in Fig. 10.

To switch on the installation, an ON button is pressed on the Secretary's keyboard *MAS*.

When voting is to take place, the Speaker presses the VOTING button on his keyboard *MAT*. This lights all CORRECTION lamps on the member's keyboards *PU*.

A member's vote is registered in *LR* at the same time as lamps light on *PU*, on the voting board *RFT* and on the record board *PT*. The Clerk has in good time set the text indicating the subject of the vote on his keyboard *MAK*.

When the voting has been completed, the Speaker presses the VOTING COMPLETED button on *MAT*. The count then starts, the AYE votes being counted first. In *ETR* the relays operate which correspond to the AYE votes.

Totalling of the AYE votes is done in *ETR* and *TTR* and the result is stored in the result store *RM 1*.

ETR and *TTR* restore, after which counting of the NO votes starts. Now the relays operate in *ETR* which correspond to the NO votes. Totalling of the NO votes takes place in *ETR* and *TTR* and the result is stored in *RM 2*.

The totalling and storage of ABSTENTIONS and absent members is done in the same way. Thereafter the number of votes stored in the result store is totalled in *SA*. A check is made that the total agrees with the number of members in the Chamber. If it does not, all *RM* are restored and a new count is made. If this does not agree either, a lamp lights in *MAS* to indicate that the count is wrong. In such case no result is indicated on the result panels.

If the count is correct, indicators light on the result panels to show the number of AYES, NOES and ABSTENTIONS and of absent members.

The camera in front of the result panels is automatically switched on and the result can then be read on the TV receiver. If any lamp has failed on the result panel on which the TV camera is trained, the camera turns to a parallel panel.

When the count is complete, the record board is automatically photographed, which is seen by the Speaker and Secretary by the lighting of a lamp on *MAT* and *MAS* respectively.

The Speaker can now clear the result panels by pressing the CANCELLATION button.

Supervisory Equipment

The voting machine is equipped with extensive supervisory arrangements. If any lamp on a member's keyboard fails during a session, the fact is signalled to the Speaker. The voting can continue. The Speaker announces that the voting has been registered but that, for example, an AYE lamp has not lit. If a lamp fails on the result panel in front of the TV camera, the camera turns automatically to a parallel panel.

The system incorporates automatic test equipment with which important functions can be tested in accordance with a predetermined program. Selection buttons for these tests are placed on the Secretary's keyboard. Normally these tests are made from this keyboard in the assembly room but, if desired, they can be made from a keyboard in the machine room. In this way observations can be made on the central equipment during the test.

Three tests can be made.

- ☐ Test 1 checks all lamps on the members' keyboards, voting board and record board.
- ☐ Test 2 checks the lamps in the indicators on the result panels.
- ☐ Test 3 extends over a number of divisions. This test checks all totalling circuits in *ETR* and *TTR*.

Faulty lamps and functions are indicated in such a way that the least possible amount of work is needed to remedy the fault.

If a test is to be made also of the television and camera equipment for the record board, this can be done from the Speaker's or Secretary's keyboard. The procedure is the same as for an ordinary division.

In the event of a fault during voting, alarm lamps light at the Secretary's and Speaker's positions. Visual or audible alarms can also be obtained at a number of points, if desired.

TEHG—A Mercury-Wetted Contact Switch

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UDC 621.318.56.066.6
LME 5524 735

Mercury-wetted switches have been developed in the United States since the forties. Their good properties as regards life and reliability, and their speed combined with small dimensions, give them an increasing use in modern switching applications. AB Svenska Elektronrör (SER) has started making these switches under the type designation TEHG. This article describes the construction, operation and properties of the TEHG switch.

Fig. 1
TEHG mercury-wetted contact switch

The switch, which has a break-before-make contact function, employs mercury wetting of the contact surfaces for good and stable contact without bounce. The switch opens and closes circuits carrying currents up to 2 A with operate times of 1–3 ms. The expected life is 10^9 operations at maximum load. The *TEHG* switch is made also in a make-before-break form and with corresponding data. The former type alone will be described in this article.

Construction of the mercury switch

The construction of the switch is shown in fig. 2. It consists of a glass capsule enclosing two fixed contacts of platinum alloy (4) and a moving reed armature (2) in a protective gas atmosphere under high pressure. Connection to the external circuits is effected through contact leads (1) and (6) passing through the glass, both of which are conductors for the electric current and for a magnetic flux. The glass capsule also contains a reservoir of mercury (3) for wetting of the contacts.

The moving reed, made of a nickel-coated nickel-iron alloy, has longitudinal 0.1 mm grooves to form paths for the mercury. It is welded to a tubular stem (6). This serves also as bushing through the glass and is used for refilling of the protective gas to a pressure of 17 atm (1.7 MN/m²). The stem is sealed by a vacuum-tight weld (7) close to the glass capsule.

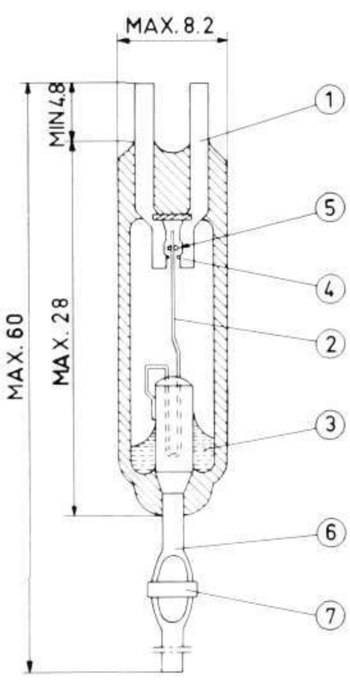

Fig. 2
Sketch of TEHG mercury-wetted contact switch
① Contact leads
② Moving reed (armature)
③ Mercury
④ Fixed contacts
⑤ Baffle wires
⑥ Tubular stem (terminal)
⑦ Weld
Dimensions in mm

Operation

The mode of operation is shown schematically in fig. 3. The moving reed, the armature (2), closes to one of the two fixed contacts (4). These contacts are at the same time formed as magnetic pole pieces and conduct a permanent magnetic flux perpendicular to the armature. The armature is magnetized by an axial relay coil (8) outside the glass capsule and is deflected towards one of the contacts by magnetic action between the armature and the two magnets. The spring force of the armature counteracts the deflection and tends to return it to mid-position. Fig. 4 shows the complete relay with its magnetic system. The two upper steel or ferrite magnets are magnetized to appropriate values. A switch with *TEHG* contacts is therefore always polarized, i.e. is dependent on the polarity of the energizing current. If one of the magnets is more strongly magnetized, a single-side-stable relay is obtained. If the magnets are equally powerful the relay is bi-stable.

Since the contact surfaces are wetted with mercury, a large contact surface is obtained without the need to apply a heavy contact force. This means that

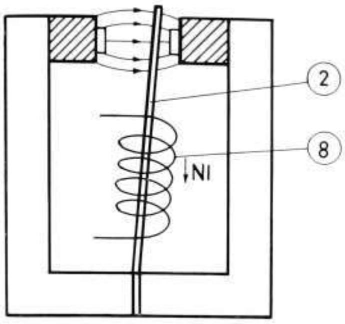

Fig. 3
Simplified representation of relay
② Moving reed (armature)
⑧ Coil

the capsule can be given small dimensions. Transfer of the mercury from the reservoir (3) up to the contacts takes place via the reed. The 0.1 mm longitudinal grooves serve as capillary paths for the mercury. In one type of *TEHG* switch the quantity of mercury on the actual contact surfaces is limited so that one contact opens before the other closes. To avoid splashing of mercury, which would disturb the operation, the tongue has two transverse baffle wires (5). The pole pieces, furthermore, have grooves for collecting beads of mercury, and the parts which are not to be wetted are oxidized. The dynamic transfer action is described in fig. 5. The use of a mercury reservoir means that the switch can be allowed a maximum slope of 30° from the vertical.

Operate time

The time taken for the reed to transfer to the opposing contact from the moment of voltage being applied to the coil is called the operate time. This is dependent on the m.m.f. (ampere turns) of the coil and on the time constant. The operate time is normally 1–3 ms. The time during the transfer action when the reed does not make contact is called the transfer time. This is normally 0.1–0.4 ms but is dependent on the m.m.f. of the coil. Fig. 6 shows a transfer action at 50 Hz. An example of how the operate time varies with the ampere turns of the coil is shown in fig. 7.

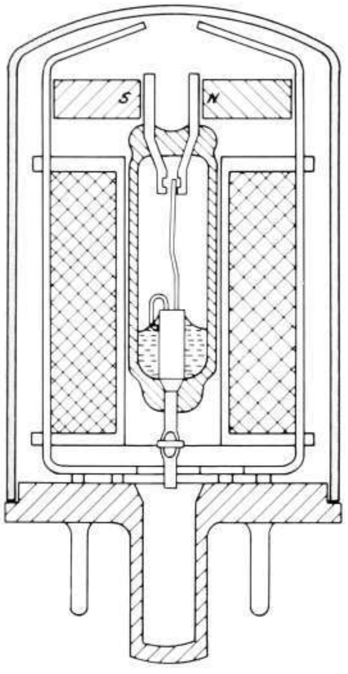

Fig. 4
Mercury-wetted contact relay with switch, magnetic system and casing

Adjustment of sensitivity

The sensitivity is dependent on the strength of the magnetic field. This can be adjusted in a relay by successive demagnetizing of the two magnets. It would be theoretically possible to demagnetize down to a value at which the spring force of the armature predominates. One can thus obtain a maximum sensitivity of 5–10 ampere turns. An increased sensitivity, however, prolongs the operate time.

Contact bounce

Contact bounce arises in ordinary relays at the moment of closure of the contacts. Mercury-wetted contact switches, however, are free from contact bounce. This is because the mercury adheres to the two contact surfaces so that it continues to form a bridge after operation of the switch. Mechanical vibrations are also damped by the mercury.

Symmetry

The symmetrical properties of a relay are of great importance for certain relay functions. The symmetry of the switch is determined primarily by the resting position of the reed between the fixed contacts. The reed must there-

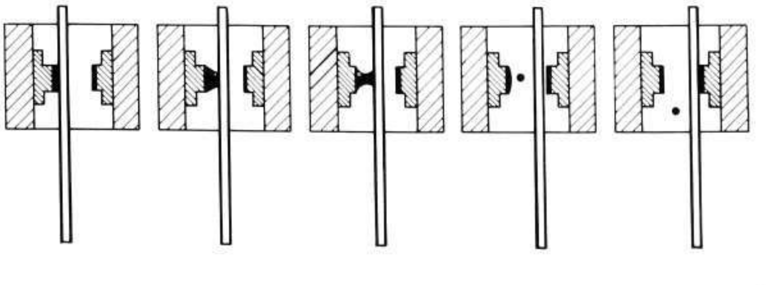

Fig. 5
Dynamics of mercury-wetted contact switch

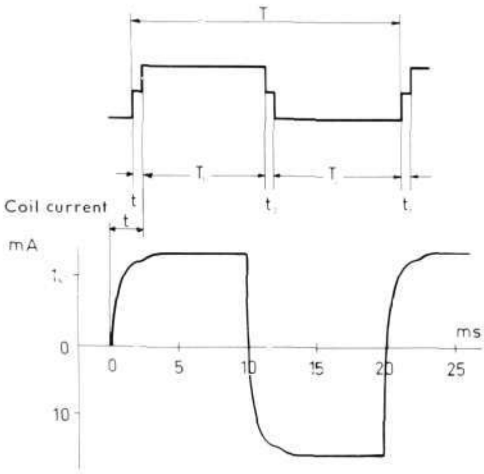

Fig. 6

Transfer action of a relay, 50 Hz, square wave voltage

- T Period, 20 ms
- T_1 Make to contact 1, 10 ms
- T_2 Make to contact 2, 10 ms
- t_1, t_2 Transfer times, 0.1—0.4 ms
- t Operate time

The upper figure represents the oscilloscope picture of the contact function.

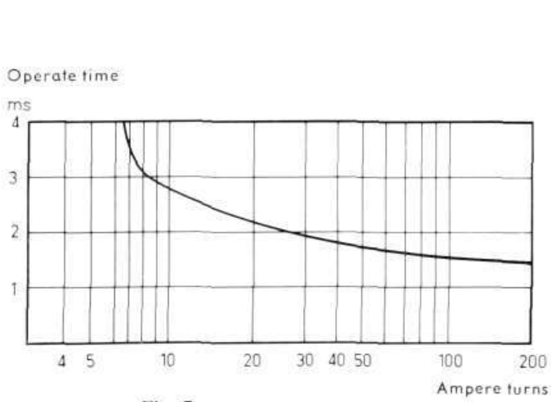

Fig. 7

Example of variation of operate time with number of ampere turns in a coil

fore be as symmetrically positioned as possible. Since the placing of the fixed contacts also contributes to symmetry, a mere visual inspection for symmetry cannot be entirely satisfactory. Measurements by means of field reversals are made under special conditions with such low magnetic forces that asymmetry arises, for example, in the spring tension of the reed.

Breakdown voltage and insulation resistance

With the reed closed to one of the fixed contacts the *TEHG* capsule can be subjected to 3500 V AC peak without arcing. This is achieved through the high gas pressure in the capsule. Arcing, if it occurs, may therefore be due to insufficient pressure. To ensure a high insulation resistance the gas must be extremely pure and free from water vapour. The insulation resistance of *TEHG* is above 1000 mΩ.

Life

The life of the switch is usually defined as the number of operating cycles it can perform under given conditions until failure or a given frequency of failures. The life is dependent chiefly on the resistance of the contact surfaces to wear as a result of opening and closing of a circuit. In the *TEHG* switch the conditions for long life are met by the fact that mercury is added to the contact surfaces. The mercury wetting ensures a continuous area of contact and prevents erosion of the underlying contact metal. The switch therefore has a low and very stable contact resistance during its entire life. At maximum load and with a contact protection circuit the expected life of the *TEHG* switch is at least 10^9 operating cycles.

Contact protection

Owing to the great speed with which the circuit is broken in a mercury-wetted switch a high transient voltage is induced in the inductance of the load circuit, which may cause damage and shorten the life of the switch. Except at very low loads, therefore, it is recommended that mercury-wetted switches should always be protected by a network consisting of a capacitor and a resistor in series. This CR unit must be connected as close to the switch as possible. To calculate the minimum value for these components one may use the expressions

$$C = 0.1 I^2 \ \mu F$$

$$R = 0.1 \frac{U}{I^{\alpha}} \ \Omega$$

where

I = the current through the contact in amperes

U = the contact supply voltage in volts

$$\alpha = 1 + \frac{50}{U}$$

The capacitance C obtained from the formula is often insufficient, and appropriate values must be determined by observing the break-and-make processes on an oscilloscope. At medium amperages standard CR units can often be used (see Ericsson Review No. 2, 1961, *The CR Unit – a Rational Contact Protection Component*). Fig. 8 shows an example of a contact protection circuit.

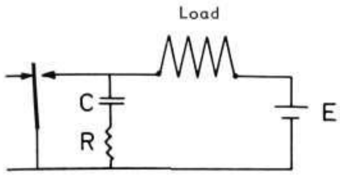

Fig. 8
Contact protection circuit

If the voltage is below 50 V the resistance can be excluded. For voltages above 50 V the resistance must never be lower than 0.5 Ω. To reduce the transients still further a CR circuit must sometimes be supplemented by diodes or similar components to lead off energy stored in the inductive load.

Manufacture at SER

The *TEHG* switch is made by AB Svenska Elektronrör in specially arranged premises since the production involves the use of mercury and high pressures, and complete freedom from dust must be ensured. The personnel must wear masks and goggles, for example, and observe special rules of cleanliness. SER's many years of experience of glass-metal seals and vacuum technique have been essential for this manufacture. Fig. 9 shows the sealing of the reed. To ensure satisfactory symmetry, this is done in an alternating magnetic field. After this sealing operation the capsule is stress-relieve annealed in a reducing hydrogen gas, which eliminates the risk of cracking of the glass and prevents oxidizing of the metallic parts in the capsule. It is then filled with triple-distilled mercury with certain alloying elements added for optimum wetting of the reed. This is followed by vacuum pumping and filling with dry hydrogen gas to a high pressure. After sealing and welding of the tubular stem, a leakage test is made in oil. The capsules are subjected to tumbling in an oven, after which the contacts are operated for 16 hours. They are then inspected under a microscope and subjected to electrical measurements.

Applications

The main applications of the *TEHG* switch are in various types of relays. It is designed for use, among other purposes, in L M Ericsson relays of types *RAG 700*, *RAG 720* and *RAG 740*. One form is shown in fig. 4, which is an enclosed relay with coil and permanent magnets. Such relays are used, for example, in telephone exchanges. A switch can also serve as vibrator with a frequency up to 200 Hz. A biassed switch can be used as rectifier if the coil is fed with alternating voltage of correct phase. Two switches can function as phase detector. The *TEHG* switch can also be used as coaxial relay for switching of signals with frequencies up to 700 MHz.

The normal power consumption for a *TEHG* switch is 20 mW, which places it in a class with sensitive relays. The driving power, however, can be reduced to below 1 mW by introducing a secondary winding. A switch of this kind can be used in an overload protector.

Mercury-wetted contact switches thus have many applications and, through their excellent performance, increase the life and reliability of the system.

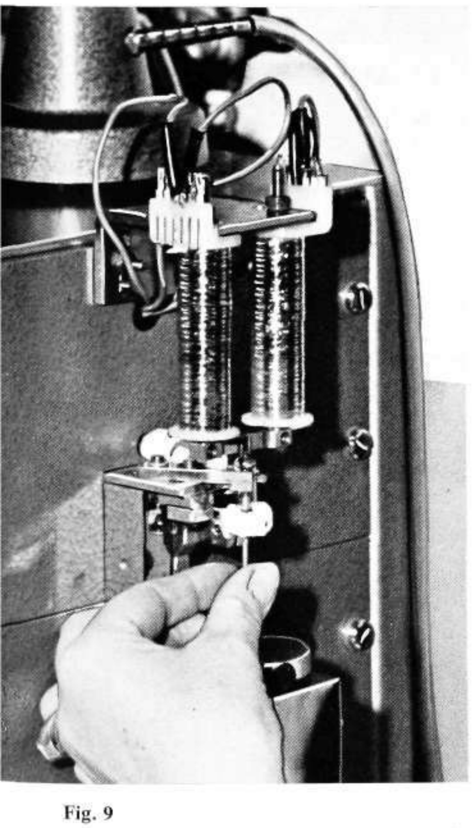

Fig. 9
Sealing of reed armature in a glass capsule

Technical data

Contact function TEHG-1	Form C (break-before-make)
Contact function TEHG-2	Form D (make-before-break)
Contact protection	Under load the contact must be protected by a capacitor and resistor in series
Contact current, max.	2 A

Voltage	
peak value, DC or AC	500 V
Max. load	100 VA
Contact resistance	
typical value	15 mΩ
max. value	50 mΩ
Contact bounce	None
Capacitance	
between armature and one contact (maximum value)	1.5 pF
Insulation resistance	1000 MΩ
Breakdown voltage	
peak value, AC	3500 V
Shock	
(without mechanical damage)	30 g ($g = 9.81$ m/s^2)
Vibration	
(at 10–500 Hz without mechanical damage)	10 g
Temperature range	−38° C to +110° C
Characteristics (depending on permanent magnets and ampere turns)	
min. m.m.f. for transfer	5–10 A (ampere turns)
TEHG-1, transfer time	0.1–0.4 ms
TEHG-2, bridging time	Less than 1 ms
operate time	1–3 ms

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Electrical Components for the M4 Method of Construction

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UDC 621.3.049.7
LME 73 84

When selecting components for the new M4 method of construction the reliability of the components has played a large role. The judgement of the components has been partly based on experiences obtained from the earlier method of construction M3 for which comprehensive operational statistics are available, and partly on the results of thoroughly testing new components and materials. Besides standardized testing to IEC and similar specifications, failure mechanisms of the components have been studied by special methods. This article describes the most important components and gives some of their properties.

New components, better materials and more sophisticated designs have resulted in a very high reliability and at the same time smaller dimensions of most of the components. A further reduction in volume could be possible but would mean larger manufacturing difficulties and risks of variations in quality. The volume has in most cases been reduced to half or one third of the corresponding component volumes in the earlier method of construction. When mounted on printed circuit boards the component height of most of the components has been reduced from 23.5 mm to 15.5 mm.

Failure Rates of Components and Their Stress Dependence

For the components used in the *M3* method of construction, operational statistics for the Channel Translating Bay *ZDG 801* have been made. Mean failure rates according to table 1 have been obtained. It will be seen that these failure rates are very low, and there is no reasonable possibility of confirming these low failure rates by laboratory tests at stresses used in actual operation. The quantity of components used in such tests would be much too large for it to be economically feasible.

Table 1. Repair Statistics for 280 Channel Translating Bays ZDG 801 for the Years 1961—1965: Failures Caused by Component Faults

Component	Number of components in operation	Cumulative operating time Mh	Number of failures	Mean failure rate × 10^9 h^{-1}
Inductors and transformers	790,000	16,100	64	4.0
Resistors	1,710,000	34,900	2	0.06
Capacitors	1,130,000	23,000	38	1.65
Semiconductor components, Ge	398,000	8,100	49	6.0
Total electronic components	4,028,000	82,100	153	1.9
Printed circuit boards	89,600	1,830	8	4.4
Contacts	1,089,000	22,200	0	—

To check that the failure rate really is the wanted low one, testing must be done at appreciably elevated stresses and the probable failure rate calculated using the laws governing the changes of the material properties in the components.

The first "law" is the chemical reaction law, the so-called Arrhenius' law, which popularly expressed says that the chemical reaction rate doubles for each 10°C rise in temperature. The law is generally expressed as

$$v = Ae^{-B/T} \tag{1}$$

where

v = reaction rate $\sim \frac{1}{L}$

L = life

T = absolute temperature

A, B = constants

The second "law" says that the life of an insulating material in a direct electric field is inversely proportional to the n-th power of the applied direct voltage, i.e.

$$\frac{L_1}{L_0} = \left(\frac{U_0}{U_1}\right)^n \tag{2}$$

where

L_1 = life at voltage U_1

L_0 = life at voltage U_0

These two equations can be combined into

$$L_1' \approx L_0 \left(\frac{U_0}{U_1}\right)^n 2^{\frac{T_0 - T_1}{a}} \tag{3}$$

where

L_1 = life at U_1 and T_1

L_0 = life at U_0 and T_0

U = applied direct voltage

n, a = constants to be empirically determined for each material and type of chemical process underlying the failure mechanism.

The value of the constant n is usually 4–6 for paper used in capacitors, 3 for ceramic insulating materials and 6–12 for mica. The constant a usually has values between 5 and 20°C.

The term

$$\left(\frac{U_0}{U_1}\right)^n 2^{\frac{T_0 - T_1}{a}}$$

in equation (3) above is usually called the acceleration factor and can be used not only for recalculating lives between different stresses but also for recalculation of failure rates. When estimating acceleration factors these should be chosen with care so that faulty conclusions about expected failure rates are not obtained.

The failure mechanisms in the component types can be found by testing at elevated stresses and can be eliminated by changes in design. A certain unevenness in the component production, however, results in there always being some weak components left in the component batches. The failure rate of equipments as well as components normally follows the well-known bath tub curve. To reduce the risk of early failures a reliability screening is used for some components by using, for instance, burning-in. The components are subjected to thermal or electrical stress for some hundreds of hours. Components whose reliability is doubtful can then—by comparing the component properties before and after burning-in—be rejected and the reliability of the remaining components in the batch is increased by about one order of magnitude.

Also by direct measurement of certain primary or secondary properties of the components and rejection of the "individualists" a good increase in reliability of the components left in the batch has been obtained.

Semiconductor Components

At the beginning of the 1960's semiconductor manufacturers were able to delight the users of electronic components with silicon diodes and transistors manufactured by the so-called planar process. Here the connections to the transistor electrodes are situated in one plane and the crystal surface is protected against influences from the surroundings by a silicon oxide layer. Better stability is obtained of both the crystal and crystal surface than for germanium semiconductor components, though we have experienced very good operating results with these hitherto as they have been used under suitable operating conditions.

The silicon diodes and transistors have gradually been improved as different development problems have been eliminated. Modern silicon components offer very reliable operation, not only as individual transistors and diodes but also as integrated circuits with transistors, diodes, resistors and capacitors made in one and the same silicon chip.

Transistors

Two transistor types have been standardized for use in carrier frequency equipment using the *M4* method of construction. One type is housed in a *TO-18* can for low power applications and another type in a *TO-5* can for somewhat higher dissipations. The two transistors are shown in fig. 1 together with wire guide and heat sinks.

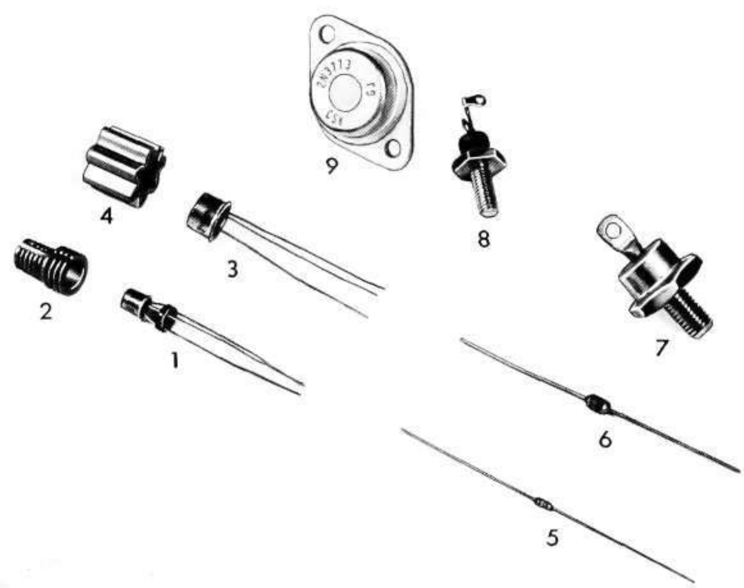


Fig. 1

Semiconductor components

1 Transistor in TO-18 can with wire guide
2 Heat sink for TO-18 can
3 Transistor in TO-5 can
4 Heat sink for TO-5 can
5 Signal diode
6 1A Rectifier
7 10A Rectifier
8 7A Thyristor
9 20A Thyristor

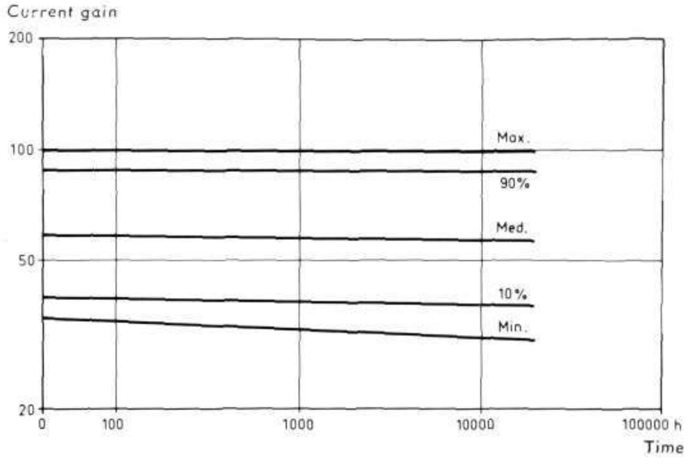


Fig. 2

Change in current gain as a function of time during load testing at 300 mW at + 25 C for 100 silicon transistors in TO-5 can.

When studying the reliability of the transistors, long-term operating tests have been made, see fig. 2, together with short-term overload tests with gradually increasing thermal and electrical stresses, so-called step-stress testing. During the operating tests the silicon transistors have shown very good long-term stability and the maximum change of the current gain is only 10 % for 20,000 hours of operation. As the changes in principle follow a linear relationship with logarithmic time scale it can be assumed that our transistors will function very well during the equipment life.

To obtain reliable function for a long time, it has been decided as a result of investigations, that the junction temperature of the components must not

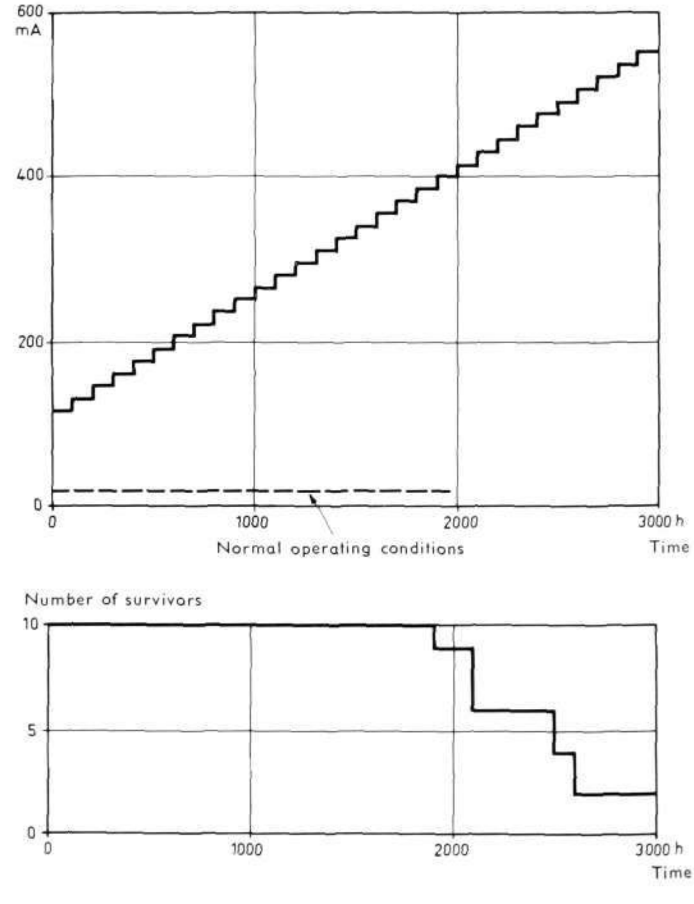


Fig. 3

Step-stress-testing of signal diode at + 100 C

Upper diagram: Increase of load current with time

Lower diagram: Number of surviving diodes with time exceed +130°C. This is very much less than what many manufacturers state but it has been found necessary to keep to this value in order to ensure really long and failure-free function of the equipment.

Diodes

The diodes chosen as standard diodes are shown in fig. 1. The signal diode is made with two heat sinks, one on each side of the crystal which is thereby given very efficient cooling. Tests carried out on this diode type include a step-stress test, the result of which is shown in fig. 3. As the first diode did not fail until after 1900 hours, when the load had increased to 400 mA, i.e. 20 to 30 times the normal operating current, by estimating the life regarding the short circuit failure mechanism, it can be stated that its life should be several orders of magnitude higher than the equipment life.

Thyristors, i.e. controlled rectifiers, are used in some supply units, and these are shown in fig. 1. The time at which current is allowed to pass through the diode can be varied by means of a current to a gate electrode. These components are used for voltage conversion and as protecting devices against over-voltage or short circuit. They are made for mean currents of 7 A and 20 A and can withstand high peak currents.

Integrated Circuits

Digital integrated circuits have been introduced for the generation of carrier frequencies and for some regulating functions. The *TO-5* can that has 8 and 10 connections has been chosen from the available encapsulations. This encapsulation is well known in transistor manufacture and it also allows the mounting of the integrated circuits together with discrete components on the printed circuits.

Magnetic Components

New magnetic components, i.e. inductors and transformers, have been designed for the new component height 15.5 mm. At the same time the other dimensions have been reduced, making the total volume of the new magnetic components only about one third of the earlier ones. This has been possible by the use of new, better ferrite core materials and by making the designs utilize the rectangular mounting space better.

In all cases, in spite of the volume reduction it has been possible to maintain the same performance of the new inductors and transformers compared with the corresponding older and larger ones and in some respects improve them. This is especially so in the case of reliability, which though previously very good has been increased by more extensive use of coil formers with moulded-in soldering tags, thereby making extra soldering points for joining at the winding terminations unnecessary.

With the advent of newer, better ferrite materials for inductors and transformers it has been possible to reduce the effective core volume to about one half of that used previously. Table 2 gives a comparison of some of the most important properties of older and newer ferrite materials.

For inductors intended for use in the frequency range up to about 100 kHz the lower disaccommodation factor *DF*, which is a measure of the decrease of the permeability with time, i.e. the time stability of the inductance, has primarily

Table 2. Comparison of Material Properties of Ferrites Used in the M3 and M4 Methods of Construction

Material	Relative initial permeability μ	Hysteresis material constant* $\eta_B \times 10^3$	Disaccommodation factor** $DF \times 10^6$	Relative temperature coefficient + 20 to + 60°C $TC/\mu \times 10^6$	Relative dissipation factor at 100 kHz $\tan \delta/\mu \times 10^6$
Inductor material					
M3	1 200	< 7.7	< 10	0 —2	< 18
M4	2 000	< 1.2	< 4.5	0.5—1.5	< 5
Transformer material					
M3	2 100	< 3.6			< 15
M4	3 000	< 1.8			< 15

* The hysteresis material constant η_B is standardized by IEC and its definition is given in IEC Publication 125, Amendment 1.

** The disaccommodation factor $DF = \Delta\mu/\mu^2$ is defined as linear in a diagram with logarithmic time scale, and $\Delta\mu$ is the change in μ during a time decade.

permitted the halving of the core volume. At the same time both the hysteresis material constant η_B and the relative dissipation factor tan δ/μ have been reduced and this permits the use of higher effective permeability μ_e in the magnetic circuit, thus compensating for the increase of the copper losses R_0/L accompanying the reduction in dimensions. Core materials with about the same properties as in the *M3* method of construction are used for inductors intended for use at frequencies above 100 kHz. Fig. 4 shows the relative dissipation factor tan δ/μ for the ferrite materials used in the *M4* method of construction. The same factor for earlier materials is shown for comparison purposes.

For transformers the volume reduction has been brought about by using new materials with higher permeability and lower hysteresis losses. The higher

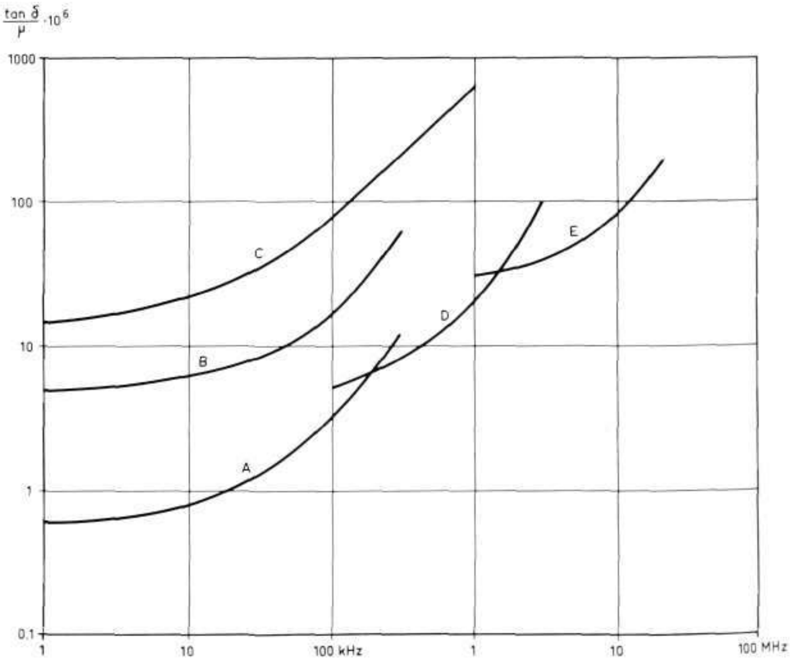


Fig. 4

Typical values of the relative dissipation factor as a function of frequency for

- **A** Ferrite material of MnZn-type intended for frequencies up to about 100 kHz—used in the M4 method of construction
- **B** Ferrite material of MnZn-type intended for frequencies up to about 100 kHz—used in the M3 method of construction
- **C** Carbonyl iron powder with $\mu = 50$—used earlier in toroid cores in the M2 method of construction
- **D** Ferrite material of MnZn-type intended for frequencies up to about 1 MHz
- **E** Ferrite material of NiZn-type intended for frequencies up to about 10 MHz

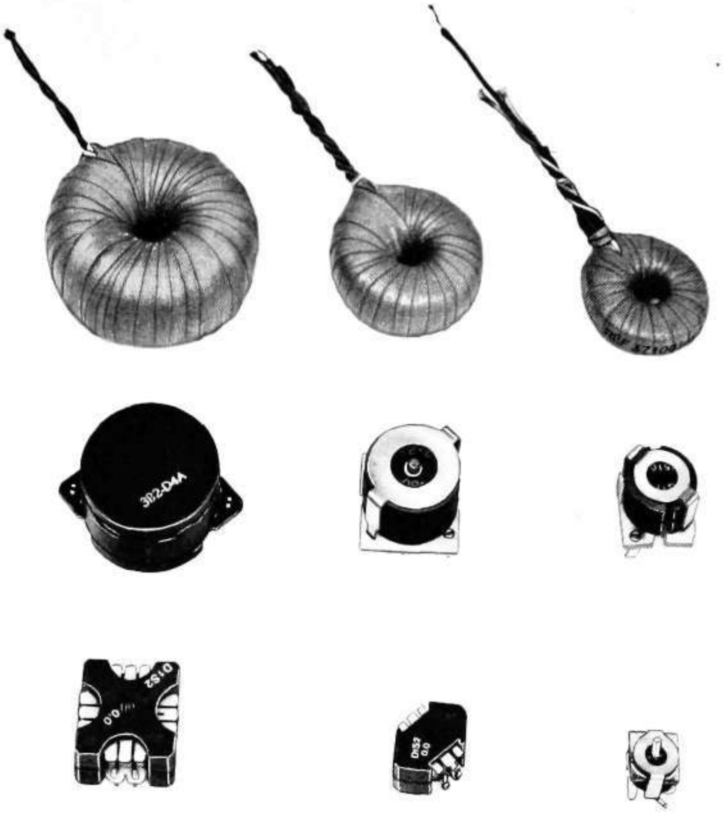


Fig. 5

Inductors of different generations

Top row: Inductors built up with toroid cores of carbonyl iron powder, M2 method of construction

Middle row: Inductors built up with pot cores of ferrite material, M3 method of construction, from left REG 101 (⌀ 36 mm), REG 111 (⌀ 25 mm) and REG 112 (⌀ 18 mm)

Bottom row: Inductors built up with ferrite cores, M4 method of construction, from left REG 316 (X 25), REG 506 (W 17) and REG 123 (P 11/7)

permeability allows a high inductance to be obtained in a smaller volume than before, while the lower hysteresis losses mean that the quality factor of the transformer does not decrease and that the non-linear distortion, i.e. the generation of harmonics is kept low. These viewpoints are of course also of interest for inductors.

The materials which have been chosen for coil formers and as insulation in other cases have been selected so as to avoid corrosion in windings and tappings. The failure types which occur in inductive components mainly consist of open-circuits at terminals, and to reduce these, careful work has been put down in the design of the soldering tags of the coil formers. These permit direct connection of the winding wire to the coil former soldering tags when winding the coil and dip soldering the connections.

Inductors

Fig. 5 shows three different generations of inductors. The top row shows toroid inductors with carbonyl iron cores, used during the 1930's and 1940's. The middle row shows inductors with ferrite cores of the pot core type, used in the *M3* method of construction and the bottom row shows the new inductors, designed for the *M4* method of construction.

The inductor mainly used in the *M4* method of construction is that shown in the middle of the bottom row. It is built up using a new core type called wing core or W-core allowing the use of coil formers with moulded-in soldering tags. Its design uses the rectangular space on the printed circuit board very efficiently. The effective core volume is about half the volume of the pot core (*REG 111*) used earlier but the total mounting volume is only 26 % of the

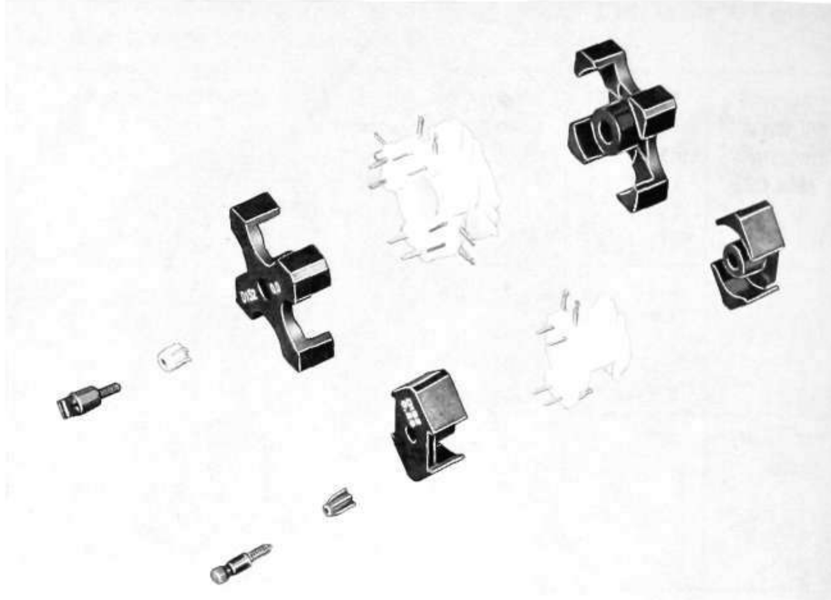


Fig. 6

Assembly of ferrite cored inductors of X-core type (top) and wing core type

corresponding earlier one. The designation of the core is *W 17* and it requires a space on the printed circuit board of 7 × 7 modules (one module = 0.1" = 2.54 mm).

In spite of the great dimensional reduction the properties of the new inductor are in no way poorer than the earlier one: in some cases rather better. This is especially the case for the inductance adjustment range where, by using an improved trimmer core design, a larger adjustment range can be had when there are small air gaps, i.e. at high relative permeability. This makes the coil manufacture simpler and cheaper as wider tolerances can be used in the production than was earlier the case. The new trimming arrangement gives full stability and this has been confirmed by comparing results of aging tests on inductors with such trimmer cores and without. The total inductance change during the service life of the equipment is just a few tenths of a percent.

For inductors with requirements on lower loss resistance and low harmonic distortion the line of X-cores used earlier in transformers of the *M3* method of construction has been supplemented with a smaller, adjustable type, *X 25*. This core has properties that are almost equal to the 36 mm pot core inductor used earlier though it only occupies 31 % of its volume. Like the wing core, the X-core also makes use of the mounting space much better than the pot cores. It needs a mounting area on the printed circuit board of 10 × 10 modules.

The simple construction of the two inductors described is shown in fig. 6. They consist of two core halves, coil former with winding and trimmer core with its nut. The parts are cemented together using an epoxy resin and the inductors are then mounted on the printed circuit boards by means of their soldering tags. The tags are bent on the rear of the boards and soldered. The connection to the boards and the cemented joint have good mechanical strength and the components will withstand not only shock and vibration stresses of those magnitudes found during transport but also those specified for many military applications of electronic equipment. The two inductor types are available with the new improved ferrite material for frequencies up to about 100 kHz and also with cores for higher frequencies up to about 1 MHz and about 10 MHz, see fig. 4.

Table 3 shows for different inductor types a comparison between mounting volume, effective volume (i.e. the effective volume of the magnetic circuit +

Table 3. Volume and Efficiency Comparison between Different Inductors and Transformers

Inductor Transformer (LME code)	Method of construction	Total mounting volume cm³	Effective volume cm³	Effective volume / Total volume
Pot core, 25 mm *(REG 111)*	*M3*	18.5	4.1	0.22
W 17 *(REG 506)*	*M4*	4.8	1.9	0.40
Pot core, 36 mm *(REG 101)*	*M3*	34	12	0.35
X 25 *(REG 316)*	*M4*	10.5	6.0	0.57
X 30 *(REG 301)*	*M3*	21.5	11	0.52
X 36 *(REG 302)*	*M3*	38.5	23	0.59
E 25 *(REG 203)*	*M3*	14.5	3.9	0.27
E 14.5 *(REG 203)*	*M4*	3.0	1.1	0.38

the effective winding volume) and the ratio between these two volumes, which can be regarded as a measure of the design effectiveness. From the table it can be seen that the wing core and the X-core both have appreciably better volume utilization ratios than corresponding pot cores.

Although the magnetic circuits of wing and X-cores are not as fully closed as in the case of pot cores, only an insignificant decrease in crosstalk attenuation is found between two inductors of either of the wing or X-core types placed close to each other compared with that between two pot core inductors of corresponding sizes.

Transformers

The X-core type developed for the *M3* method of construction has been retained for transformers with low attenuation and large bandwidths, but by introducing a better core material it has been possible to use the internationally standardized *X 25*-core with 15.5 mm mounting height with almost the same data as the *X 30*-transformer. The total mounting volume for *X 25* is only half that for *X 30*. Fig. 7 shows these two X-core transformers together with the larger transformer *X 36* intended for special low frequency applications and retained from the *M3* method of construction.

Fig. 7

Ferrite cored transformers of different sizes

Top row from left—mounting height 23.5 mm: REG 302 (X 36), REG 301 (X 30), REG 203 (E 25)

Bottom row from left—mounting height 15.5 mm: REG 316 (X 25), REG 204 (E 14.5)

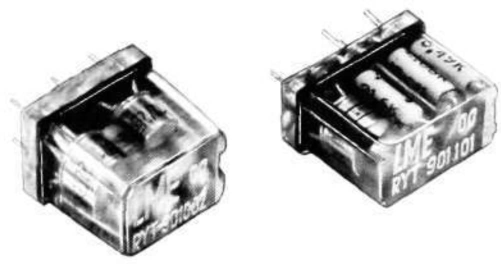


Fig. 8
Circuit blocks, consisting of transistors and resistors, cast in epoxy resin

The figure also shows two E-core transformers, viz. one designed for *M3* with an *E 25*-core and a smaller one with an *E 14.5*-core which only occupies a mounting space of 5 × 6 modules.

Table 3 also shows for the different transformer types the mounting volume, the effective volume and the volume utilization ratio. Of course the X-core types are much better than the E-core types but these latter ones are justified from an economical point of view where electrical requirements do not call for the quality of the X-core transformers.

Resistors

As in earlier designs, carbon film resistors are used as standard resistors in the *M4* method of construction. A resistor with smaller dimensions has been introduced as it has been found that the majority of the resistors are loaded with dissipations below 100 mW. The resistance values are chosen from the internationally standardized series of preferred numbers *E 48* and tolerance ± 2 % is mainly used and thereby the flora of resistance values to be kept in stock is reduced. The smaller resistor allows a vertical mounting and this means a mounting space saving of about 50 % in the apparatus designs.

Stability investigations made show that the quality of the smaller resistor is as high as that of the larger types. The resistance changes when long term testing with rated load at +70°C for 10,000 hours are below a few tenths of a percent for resistance values up to 10 to 20 kΩ. Higher resistance values having a poorer stability will in our equipment not be loaded with more than a fraction of the rated load and at these lower dissipations the same low resistance changes will be found.

Cast Circuit Blocks

In some applications in the *M4* method of construction there is a need for matched component sets which it must be possible to check as functional units. Examples of these are shown in fig. 8. They consist of transistors and resistors which are matched in pairs prior to casting and mounting on printed circuits, giving small differences in resistance between the resistors in a pair and small differences in properties between the transistors in a pair. In order to keep this close matching the resistors are artificially aged before matching. An epoxy resin with low influence on the resistor stability has been chosen for the casting and the results of detailed studies of the casting technique have also been incorporated.

By casting in these component sets, they are obtained as units which can be tested and preproduced before assembly on the unit printed circuits and they can also be delivered as spare parts. A better temperature equality between the components in the set is also obtained.

Capacitors

Capacitors are used in carrier equipment for two different applications, viz. together with inductors as frequency determining elements in filters, and as coupling and decoupling capacitors in amplifier circuits and the like. The requirements on the capacitors are quite different in the two cases. In filter

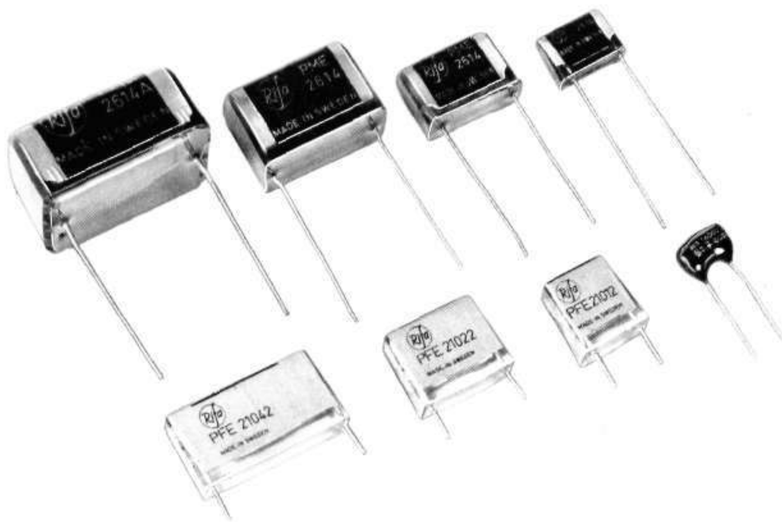


Fig. 9

Capacitors

Top row: coupling and decoupling capacitors of metallized paper type

Bottom row: filter capacitors of polystyrene and mica types

circuits, low losses, close capacitance tolerances and high long-term stability are wanted together with small changes in the resonant frequency for temperature changes. For coupling and decoupling capacitors, the requirements are mainly a low and stable impedance over a wide frequency range and a high insulation resistance.

Filter Capacitors

The main capacitor in our filters is a polystyrene capacitor, see fig. 9. This capacitor is a development of types used earlier. It is made with extended metal foils in contrast to earlier types which had inserted connecting metal strips. It has hereby been possible to reduce the styrene foil thickness somewhat without jeopardizing the breakdown voltage. The connection wires are soldered to the edges of the metal foils giving a low series resistance and low dissipation factor at high frequencies, see fig. 10.

The capacitor is cast in a special epoxy resin and the humidity protection is further increased as a diffusion inhibiting aluminium foil surrounds the larger part of the outer sides of the capacitors. To obtain close capacitance

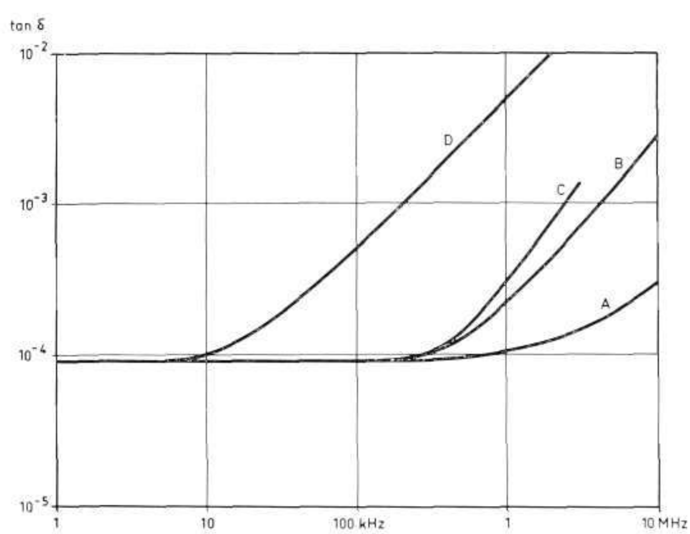


Fig. 10

Frequency dependence of the dissipation factor of polystyrene capacitors

A 1000 pF RJA 361, extended metal foil

B 1000 pF RJA 801, inserted metal strips

C 10000 pF RJA 361, extended metal foil

D 10000 pF RJA 801, inserted metal strips tolerances two capacitor windings matched together are used. The temperature coefficient of the capacitor is about $-100 \times 10^{-6}/°C$ which gives good compensation of the positive temperature coefficient of the inductors. The stability of the capacitor is very good and capacitance changes of maximum 0.2 % are found both in long time usage, after temperature cycling between +70°C and −25°C and after humidity testing for 30 cycles according to the IEC accelerated humidity test.

Mica capacitors are still used for the smallest capacitances. The type chosen is a smaller version of the mica capacitor used earlier but has improved humidity protection obtained by a special process during the manufacture.

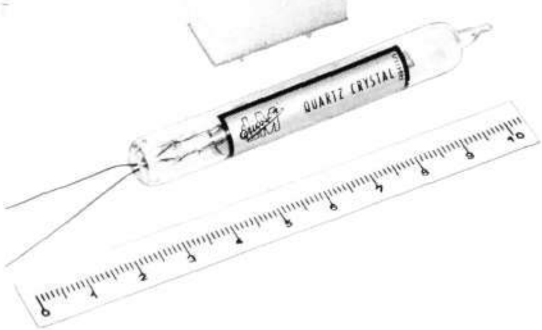


Fig. 11

Quartz crystal for filter applications together with foam plastic mounting holder

Scale graduated in mm

Coupling and Decoupling Capacitors

Capacitors with higher capacitances than those used in filter applications are needed for coupling and decoupling purposes. In the *M4* method of construction a metallized paper capacitor, see fig. 9, and a dry tantalum oxide capacitor have been chosen.

The metallized paper capacitor is made with a dielectric consisting of two layers of paper, one of which is metallized. The risk of decrease of insulation resistance with time is thereby very small and self healing of the type present in single layer metallized paper capacitors does not occur.

The capacitor is impregnated and cast in using a humidity protecting epoxy resin. To further improve the humidity protection an aluminium foil surrounds the major part of the winding and forms a humidity barrier.

The tantalum oxide capacitor is hermetically sealed with a glass feed-through. It is made in four sizes for charges 50, 200, 1000 and 2000 μC. The smallest size can be mounted vertically in the same way as resistors. Tantalum oxide capacitors have much smaller dimensions than the ordinary aluminium wet electrolytic capacitors and can be used up to higher temperatures; +85°C without voltage derating, and up to +125°C at reduced voltages. When using different manufacturers estimates of suitable acceleration factors for recalculation, life testing at +125°C at increased voltage indicates very good life at normal operation, well exceeding several hundred thousand hours. It has also been found from the life tests that the properties of the capacitors are very stable. The capacitance changes have been found to be only one or two percent after operation for 10,000 hours.

Quartz Crystals

The new component height 15.5 mm has brought with it a demand for a new quartz crystal with smaller dimensions. The earlier quartz crystal in a 19 mm glass bulb has been redesigned so that it can be housed in a 10 mm glass bulb. Fig. 11 shows this new crystal together with a foam plastic mounting holder reducing the mechanical stresses on the crystal during transport. This glass bulb is intended for filter crystals within the frequency range 60–160 kHz.

The frequency stability of the new crystal is very high and the typical frequency drift is less than 2×10^{-6} per time decade at temperatures up to +55°C. An improved vacuum technique has been introduced during manufacture so as to obtain high stability of both frequency and loss resistance.

Coaxial Cable

A ductile coaxial cable with 75 ohms characteristic impedance and 5.6 mm diameter has been designed for the *M4* method of construction. The cable, which has double screening is intended both for fixed mounting in bays and the like and also for use in flexible coupling cables. The attenuation which is proportional to the square root of the frequency is 0.02 dB/m at 2 MHz.

Both the near-end and far-end crosstalk attenuations of the cable are high and for two cables, mounted close together attenuation values exceeding 120 dB have been measured for the frequency range up to 15 MHz for lengths up to 70 metres.

During the design of the double screening braid, account has been taken not only of the crosstalk attenuation properties but also to the peelability, making the cable easy to handle when used in the factory and during installation work.

Contacts

The connectors for the printed circuit boards consist of gold plated metal strips bent around the edge of the board and soldered to the foil pattern, see fig. 12, in the same way as in the *M3* method of construction. Two gold plated fork contacts mate against each metal strip at four places, i.e. four contact points are connected in parallel. To increase the wear resistance, the metal strips are made with a rolled gold surface, giving a very smooth, mirror sur-

Fig. 12

Printed circuit board with contacts

At left: a fork contact, a board contact and a coaxial plug can be seen

Fig. 13

Distribution curves for the contact resistance of coaxial connectors RPT 148/RNT 148 and fork and board connectors.

A Initial values

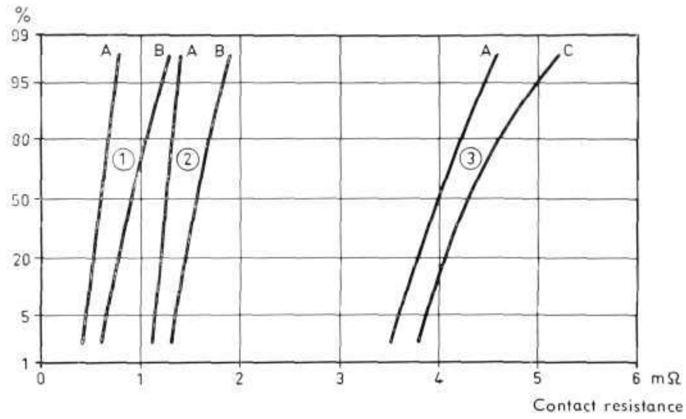
B After 2000 wear cycles + aging for 100 days at + 70 C

C After 200 wear cycles + aging for 100 days at + 70 C

① Coaxial connectors, inner conductor

② Coaxial connectors, outer conductor

③ Printed circuit board connectors



face, much smoother than can be had by electrolytic gold plating. The electrolytically gold plated contact surface on the fork contact is polished by the rubbing against the surface of the metal strip and the wear is very small.

As gold plated connectors are used, very low and stable contact resistance is obtained, which makes the connectors suitable also for low level circuits. Fig. 13 shows a distribution curve for the contact resistance of a number of connectors in unused condition and after wear testing and heat aging. It can be seen that the contact resistance has only increased a few tenths of a milliohm.

Fig. 13 also shows the contact resistance of coaxial connector *RPT 148* (pin contact) and *RNT 148* (jack contact) between the inner conductors and between the outer conductors in unused condition and after wear and aging tests.

The coaxial connector is a development of earlier types used but has smaller dimensions. The contact surfaces are gold plated as in earlier types.

Relays

A relay is needed in signalling receivers for controlling the operation of the exchange switches, and as before a mercury wetted reed relay is used, see fig. 14. The relay chosen is much smaller than the one used earlier and is made for direct mounting on the printed circuit board. The relay sensitivity is of course lower due to the smaller winding space for the new relay, which requires about 50 mW operating power. This is however no longer a problem as modern transistors can give the power needed without jeopardizing reliability. The life of the relay is high—more than 10^9 operations—and the contact load may go up to 2 A, 500 V, but max. 100 VA. The contact resistance is highly stable, variations of this resistance during the relay life not being more than a few milliohms.

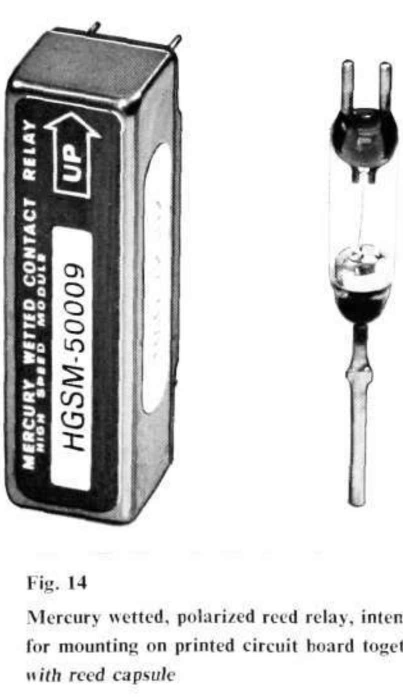


Fig. 14

Mercury wetted, polarized reed relay, intended for mounting on printed circuit board together with reed capsule

ERICSSON *News* from

All Quarters of the World

New Type of Telephone Exchange

Telefonaktiebolaget L M Ericsson has received important orders for transit centres of an entirely new type, in which program control and electronics are introduced on a large scale for the first time.

An order from the Dutch PTT is for a new transit centre for Rotterdam to a value of around 10 million kronor. It will serve as switching centre for traffic between the city of Rotterdam, the surrounding district and the remainder of the country, be a transit point for the 18 district centres of the country, and control the switching of subscriber-dialled international traffic to and from the southern parts of the country. It is to be ready for operation by the end of June 1968. Its ultimate capacity is estimated at around 30,000 trunk lines.

Another order comes from Finland and is for a transit centre at Helsinki for automatic and semiautomatic telephone traffic, both national and international. It will have an initial capacity of 4000 incoming and outgoing lines and is expected to be in operation by the middle of 1969.

A third order has been received from the Royal Swedish Air Force Administration, valued at over 10 million kronor, for equipment for electronic exchanges for general telecommunications on the Air Force Administration network.

The equipments for these orders are based on an entirely new telephone system for large local exchanges, a stored-program-controlled system developed by L M Ericsson in close cooperation with the Swedish Telecommunications Administration. The joint working group—the Electronics Committee—which evolved this system was created in 1956 in order to study questions relating to the design of automatic switching systems based on electronic components. The new system employs code switches for setting up of the connections, and the setting-up procedure—as also signalling and supervision of connections—is controlled by an electronic computer.

Programme testing in the combined computer-and-control room of the AKE exchange. Communication between man and machine is effected by means of typewriters, tape punch and tape reader.

A computer-controlled telephone exchange

The computer-controlled telephone system operates in the same way as a process-controlled production system, the product in this case being telephone calls. The requirement of high reliability is met by duplication of the computer. The two computers work synchronously and, on failure of one of them, the other takes over the entire job.

A computer-controlled system of this kind offers great advantages in the form of flexibility, since the mode of operation of the switching equipment can be easily adapted to meet new marketing requirements, new subscriber desires and telephone habits, and changes in the structure of the telephone network. Such alterations at present involve costly reconstruction of the actual switching equipment, which often leads to a deterioration of service.

The new system can provide several interesting new forms of service at a reasonable cost, e.g.

- push-button dialling
- automatic transfer of calls to another line if the subscriber is engaged or does not answer
- subscribers can get through to certain predetermined long numbers by dialling only two or three digits
- enquiries to other numbers during a call
- transfer of calls to other number
- temporary switching of all incoming calls to another number
- automatic interception
- centralized control and supervision of the exchanges

The first exchange is being built at Tumba

The development work on the new system has now advanced so far that the first equipment has been installed for 4800 subscriber lines in the Telecommunications Administration's zone centre at Tumba outside Stockholm. Programming of the computer system is under way and, after final tests, the entire equipment will be ready for operation by the beginning of next year.

This new switching technique, and the possibilities it offers of new subscriber services and of rationalized telephone operation, has already aroused attention in many parts of the world.

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Inauguration of Liberia's New Telecommunication System

As reported in Ericsson Review No. 1, 1963, the Liberian government placed orders with L M Ericsson in 1961 and 1962 for equipments for a nationwide telecommunications project. The installation of these equipments was completed in the spring of 1966 and they have now been handed över to the Administration.

After earlier being virtually devoid of telecommunications, Liberia today has one of the most modern automatic telecommunications systems in the world.

L M Ericsson has installed carrier terminals, telephone exhanges and local line plant at altogether 22 places (see map). The largest towns and the main points within the country have been connected to the capital, Monrovia, via radio links built by RCA. Liberia has thus acquired a telephone network of a quality which permits international calls even from remote and inaccessible places in the country.

Liberia is one of the most vigorously expanding countries in Africa. This has been due chiefly to the development of the rich iron ore deposits and of crude rubber production. The industrial development for exploitation of the country's raw material resources has also led to a great expansion in the road and electricity supply networks.

Five years ago Monrovia was a typically African city with a population of 70,000. Today the population is 250,000 and large new buildings give the city a modern European air.

The first call after the inauguration of the exchange in Buchanan was put through by Superintendent Williams to President Tubman. On his right is Deputy General Postmaster Cooper.

Turku University Hospital Orders New PABX

O/Y L M Ericsson A/B, Finland, recently received an order for a large PABX type AKD 791 for the Turku University Hospital. The order is especially welcome as this will be the first installation of this type of PABX in Finland.

The initial capacity of the PABX will be 900 lines, 80 connecting circuits and 84 exchange lines, and various special services will be provided, such as automatic call-back, paging in three areas, and trunk discrimination.

Electronic CTC System for Swedish State Railways

This autumn L M Ericsson received an order for an electronic CTC system (ECTC) from the Swedish State Railways. When fully developed the system will control from the CTC office in Stockholm some 70 stations along 220 km of double track and 350 km of single track. The ECTC system includes two computers for supervision of the process in the CTC office. The order also comprises an electronic train describer system and equipment which allows automatic control of the entire plant. An additional computer is required for these latter functions. The computers are of the same type and were designed by L M Ericssons Signalaktiebolag. The equipment will be successively installed during the years 1967–1969.

Norwegian Broadcasting Corporation Purchases DIRIVOX

In November 1964 Elektrisk Bureau, Oslo, received a preliminary enquiry from the Norwegian Broadcasting Association for a DIRIVOX installation of 270 lines. In conjunction with this enquiry representatives of LMS—previously Erga Division—visited Oslo in order to demonstrate DIRIVOX in cooperation with Elektrisk Bureau. The Norwegian Broadcasting Corporation already had an 80-line ITT system, but the Corporation's experts were so impressed with the DIRIVOX system that in April, 1966, Elektrisk Bureau received a new, more specified enquiry from the Corporation. The communication requirement had now grown to 400 lines, for later extension to 800 lines.

The name-call services of DIRIVOX proved to be one of the trump cards in the decision. The Corporation's experts on electroacoustics and telecommunications engineering also judged DIRIVOX to be superior to competitive makes in construction, function, sound quality, natural speech control, and special services.

Expansion of AB Alpha

L M Ericsson has decided to expand AB Alpha's present factory in the new industrial area of Kristianstad. The new factory building will have a floor area of 13,000 sq. m. and will in due course take over the plastics manufacture now being carried on at Sundbyberg.

The number of employees will then be doubled. The new factory building will connect on to the present factory. The cost for the project is estimated at 7 million kronor.

DKB Changes Name

L M Ericsson Driftkontroll AB has changed its name to L M Ericsson Data AB.

The change of name is due to the increasing emphasis of the company on data processing equipment. L M Ericsson Data AB is today the second largest Swedish supplier of punched card and data processing machines.

Since 1942 the company has been entirely owned by L M Ericsson. Its headquarters are at Solna, with branch offices at Gothenburg and Malmö. The company at present employs some 400 persons.

L M Ericsson was visited in the autumn by Mr. César Moya, Undersecretary of State, and Sr. Leopoldo Benitez, Director of the Ecuador Ministry for Public Works and Telecommunications. (From left) Mr. Björn Lundvall, LME, Dr. César Moya, Sr. Leopoldo Benitez, and Mr. Arne Stein, LME.

At the end of October Crown Prince Carl Gustaf was given a day's leave from the preparations for Älvsnabben's round-the-world-trip in order to make a tour of the province of Blekinge. In the company of the provincial governor, Mr. Thure Andersson, he visited a number of factories in the province, among which L M Ericsson's Karlskrona works where he was shown round the factory and given a brief account of the growth of L M Ericsson in Sweden by the factory manager, Mr. Erik Olsson. (From left) The Provincial Governor, Mr. Thure Andersson, the Crown Prince, and Mr. Erik Olsson are seen studying the work of Mrs. Anita Lundberg on a rotary assembling machine for microphone insets.

The head of the Venezuelan Air Force, General J. Miliani, on a visit to L M Ericsson at Midsommarkransen. (From left) General J. Milliani, General J. C. Rosâli, Venezuelan Air Force and Mr. E. Lundqvist, LME, who showed the visitors around the Exhibition Room. In the background Col. N. Wachtmeister and Major G. Blomberg of the Swedish Air Force.

Mr. Bjarni Benediktsson, Prime Minister of Iceland, visited L M Ericsson's head factory at the end of October. The program for his visit included an address in the Exhibition Room and a tour of the factory under the guidance of Mr. Eric Lundqvist. (From left) Mr. Eric Lundqvist, the Prime Minister, Mr. Bjarni Benediktsson, Mr. Malte Patricks (LME), Mr. Herman Kling, Swedish Cabinet Minister, and the Swedish Ambassador to Iceland, Mr. Gunnar Granberg.

The recently launched m/s Svea is here seen on her maiden voyage. This vessel, which cost 30 million kronor, will run on the Sweden-England route. Of the equipment on board, the Gothenburg office of L M Ericsson Telematerial AB supplied a DIRIVOX system, a P.A.B.X. AKD 860 and an electric clock system.

The VI International Fair was held at Bogota between September 1 and 20. Cia Ericsson Ltda. exhibited a number of products, among which a panel illustrating the successive functions of the code switch AKD 741 at normal switching rate particularly attracted the interest of the public. Another appreciated feature was the artistic arrangement with suspended and illuminated Ericofons in different colours, as shown in the photograph. This was reviewed in the press under the name of "Telephone rain".

Gösta Gerdhem In Memoriam

Gösta Gerdhem died on November 28, 1966. He was born in Stockholm in 1896.

He graduated as a civil engineer in 1922.

From his father, K. W. Gerdhem, one of the Swedish pioneers in telephony abroad—among other places in Moscow and Mexico—around the turn of the century, he had got telephony in his blood. It was therefore natural that the son, Gösta, entered the service of the L M Ericsson group, starting in the Railway Signalling Division—he had earlier worked in the Swedish Railways Signalling Service.

Within a year or so, however, his commercial talents took him to the subsidiary company at Vienna, and thereafter to Bukarest, where he was director of L M Ericsson's sales company from 1929 to 1933. In 1934 he returned to Sweden as head of the Swedish Sales Division in Stockholm.

After the opening of the new factory at Midsommarkransen in 1940 Gösta and I shared the responsibility for the parent company's activities there—he, naturally, on the commercial and administrative side. I have a happy memory of our work together.

In 1942 L M Ericsson took over the fire-ravaged site at Ulvsunda from Platen-Munters and Gösta was appointed head of the new company, ERMI, for the production of electricity meters and electrical instruments. He entered with gusto into the planning of the new building and its equipment and into the building up of the new company's internal organization. Under his leadership ERMI grew so quickly that a new building had soon to be erected.

His knowledge of languages and his ability to find the right word at a sticky stage in negotiations—usually combined with a good story—were of great help in his international work.

He was interested in people in general. This he showed especially in the establishment of, and in his relations with, ERMI's labour-management committee. After 1955 he had the responsibility within the parent company for a number of special commercial and other questions. He was also acting director of L M Ericsson's company for the manufacturer of locks, ERMEX, in Solna.

All who were in close contact with him will feel the loss of a friend with a ready fund of humour and a constant readiness to enter into their problems, and this applies not least to

Hans Thorelli

Organizational Changes

Mr. Ingmar Boberg

Mr. Ingmar Boberg was appointed President of L M Ericssons Signalaktiebolag (SIB) as from October 1, 1966. He superseded Mr. Håkan Insulander who, after 22 years as president, had retired from that position at his own request. Mr. Insulander remains in SIB, however, as consultant.

Mr. Karl-Erik Wahlqvist was appointed to succeed Mr. Boberg as Sales Manager as from the same data.

The previous head of AB Alpha, Mr. Stig Jacobsson, has been appointed Director of Production of Sieverts Kabelverk as from October 1, 1966. As from the same date Mr. Sten-Ake Nilsson, previous head of the Erga Division, was appointed Acting President of AB Alpha.

New Appointments

Mr. Lars-Erik Thörnberg

Mr. Lars-Eric Thörnberg, Executive Vice President of AB Ermi, Karlskrona, was appointed President of Ermi on December 1, 1966.

Mr. Thörnberg was born in 1922. His career with L M Ericsson started in Ericsson do Brasil, where he was Treasurer from 1959 to 1962. He has since been with AB Ermi and was appointed Executive Vice President in 1963.

Mr. Adolf Drougge retires from the presidency on pension but will remain with the company for a further three months for special assignments.

New Type...
Cont. from p. 189

An automatic telephone exhange of today is controlled by a "brain" which sets up connections and directs the telephone traffic. This brain has hitherto functioned on the classical basis of electromechanical components, selectors and relays. Sweden has long held a leading position in this field, founded on the pioneering achievements of the Swedish Telecommunications Administration in the early twenties when the first crossbar exchanges were designed and built. In the last two or three decades crossbar switching has become the dominating system in large parts of the world, including the United States, where the Bell companies began to take an interest in the Swedish achievements at an eraly stage and themselves developed similar exchanges. Ericsson crossbar exchanges, the design of which started in the forties, have gained great successes on the world market and have been installed in numerous countries throughout the world.

UDC 621.382.3
621.376.3.004.5
LME 8421 7544
726

FORSBERG, B.: *Maintenance and Operating Experience with Transistorized Channel Translating Equipment*. Ericsson Rev. *43*(1966): 4, pp. 146—152.

The article presents the results of investigations made by the Swedish Telecommunications Administration on transistorized channel translating equipment of L M Ericsson design. Comparisons are also made with the characteristics of earlier equipment using tubes. The article is based on a paper presented at L M Ericssons maintenance conference, June 3rd, 1965.

UDC 621.395.344
LME 8302 7363

ELLSTAM, S.: *L M Ericsson's Crossbar Systems, Their Development and New Traffic Facilities*. Ericsson Rev. *43*(1966): 4, pp. 153—162.

L M Ericsson has played an internationally leading part in the development of present-day crossbar technology. The superior qualities of L M Ericsson's crossbar systems, such as high speed, high operational reliability, low maintenance cost and great capability of being adapted to present and future technical requirements have led to the introduction of our crossbar systems by more and more telephone administrations in their networks. The first public crossbar exchange using L M Ericsson's crossbar system working on the advanced by-path and link principles was put into operation in Helsinki in 1950. Since then, our crossbar systems have been subjected to continual development in regard to greater traffic facilities and mechanical improvements to the crossbar switch and other components. The article presents a survey of the development of L M Ericsson's public local telephone system ARF, rural system ARK and transit system ARM and at the same time gives a brief presentation of new traffic facilities. The systems are described in more detail in a new series of brochures.

UDC 654.938
LME 869

SANDELL, O.: *Voting Machine for Swedish Parliament*. Ericsson Rev. *43*(1966): 4, pp. 163—169.

L M Ericsson installed a voting machine in the Swedish Parliament (the Riksdag) in the early thirties. After the machine had been operating for more than 30 years, it was found that it was starting to become worn out. The Riksdag decided to replace it by a new and more modern machine, and once again L M Ericsson was entrusted with the order.

The machine has been designed in intimate cooperation with the Riksdag. Account has been taken of the future possibility of a Single Chamber system, in that the various units can be simply interconnected into a system for up to 400 members.

UDC 621.304.97
LME 73 84

HARRIS, P. O.: *Electrical Components for the M4 Method of Construction*. Ericsson Rev. *43*(1966): 4, pp. 175—188.

When selecting components for the new M4 method of construction the reliability of the components has played a large role. The judgement of the components has been partly based on experiences obtained from the earlier method of construction M3 for which comprehensive operational statistics are available, and partly on the results of thoroughly testing new components and materials. Besides standardized testing to IEC and similar specifications, failure mechanisms of the components have been studied by special methods. The article describes the most important components and gives some of their properties.

UDC 621.318.56.066.6
LME 5524 735

TORSTENSSON, L.: *TEHG—A Mercury-Wetted Contact Switch*. Ericsson Rev. *43*(1966): 4, pp. 170—174.

Mercury-wetted switches have been developed in the United States since the forties. Their good properties as regards life and reliability, and their speed combined with small dimensions, give them an increasing use in modern switching applications. AB Svenska Elektronrör (SER) has started making these switches under the type designation TEHG. The article describes the construction, operation and properties of the TEHG switch.

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SIELTE, Soc. per Az. *Roma,* C.P. 4024 Appio, tel: 780.221, tgm: sielte

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A/S Norsk Kabelfabrik *Drammen,* P.B. 500, tel: 83 76 50, tgm: kabel
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AB Ermi *Karlskrona 1,* tel: 0455/23010, tgm: ermibolag
AB Rifa *Bromma 11,* tel: 08/26 26 10, tgm: elrifa, telex: 10308
AB Svenska Elektronrör *Stockholm-Tyresö 1,* tel: 08/712 01 20, tgm: electronics, telex: 1275
Instruktionsteknik AB *Stockholm 44,* tel: 08/68 08 70, tgm: instruktec
L M Ericsson Data AB *Solna,* tel: 08/83 07 00, tgm: ericdata
L M Ericssons Signalaktiebolag *Stockholm Sv,* tel: 08/68 07 00, tgm: signalbolaget
L M Ericsson Telemateriel AB, *Stockholm-Tyresö 1,* Fack, tel: 08/712 00 00, tgm: ellem, telex: 1275
Sieverts Kabelverk AB *Sundbyberg,* tel: 08/28 28 60, tgm: sievertsfabrik, telex: 1676
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Société Marocaine des Téléphones Ericsson *Casablanca,* 38, rue Mohamed Sedki, tel: 788-75, tgm: ericsson

Rhodesia, Botswana and Malawi

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

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Zambia

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gm: erica-

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Guayaquil, Casilla 376, tel: 16892, tgm: ericsson

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Cyprus

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

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

Iraq

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Gadelius & Co. Ltd. *Tokyo C,* P.O.B. 1284, tel: 403-2141, tgm: goticus, telex: 22-675

Jordan

The Arab Trading & Development Co., Ltd. *Amman,* P.O.B. 1, tel: 259 81, tgm: aradeve

Korea

Gadelius & Co. Ltd. *Seoul,* I.P.O. B. 1421, tel: 22—9866, tgm: gadeliusco

Kuwait

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

Lebanon

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

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Libya

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

Mauritius

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

Morocco (Tangier)

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

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