ERICSSON Review

1
1959

ERICSSON REVIEW

Vol. XXXVI 1959

RESPONSIBLE PUBLISHER: HUGO LINDBERG

EDITOR: SIGVARD EKLUND, DHS

EDITOR'S OFFICE: STOCKHOLM 32

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

CONTENTS

page

MISCELLANEOUS

ERICSSON REVIEW

Vol. XXXVI No. 1 1959

RESPONSIBLE PUBLISHER: HUGO LINDBERG

EDITOR: SIGVARD EKLUND, DHS

EDITOR'S OFFICE: STOCKHOLM 32

SUBSCRIPTIONS: ONE YEAR $ 1.50; ONE COPY $ 0.50

CONTENTS

On cover: Cables ready for forming at Gothenburg automatic transit exchange.

L M Ericsson Equipment for Carrier Channels of Program (Music) Quality, Type ZAB 1

J PYDDOKE & H SCHILLING, TELEFONAKTIEBOLAGET L M ERICSSON, STOCKHOLM

U.D.C. 621.395.44
654.19

This article, after mentioning the present need for carrier program channels and the currently applicable CCITT recommendations, describes the construction, performance and application of the latest L M Ericsson program channel equipment designed to satisfy these requirements.

The Need for Carrier Channels

Long-distance channels for the transmission of broadcast programs between studio and radio sender are at present mostly provided by direct transmission of the audio-frequency band, often over special screened pairs or quads, in cables carrying other traffic. It is relatively easy to make provision for such pairs when laying new cables, and the techniques of obtaining the necessary transmission quality are well established. Latterly, however, the increasing use of radio links to carry multiplex carrier telephony for transmission of telephone channels has led to difficulties in the provision of adequate numbers of audio program channels, especially as it is usually desired to reserve for order-wire facilities at least part of the frequency band used by such channels. At the same time the number of channels needed is rising at an increasing pace, due amongst other things to the advent of television, where for instance accompanying sound commentary may sometimes be needed in several languages simultaneously. For the transmission engineer it is natural to look for a solution to carrier techniques, which as in the case of commercial telephony provide the most economical way of deriving extra circuits.

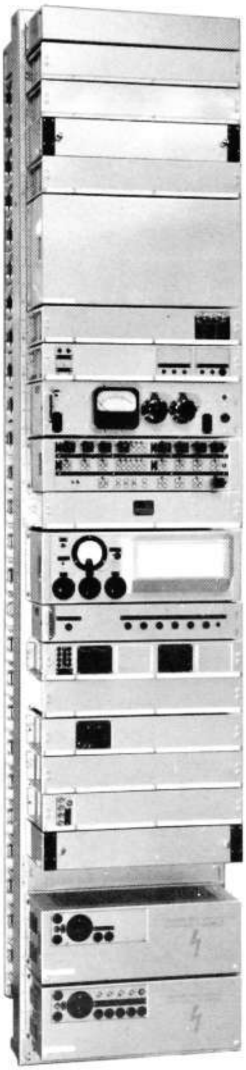


Fig. 1 X 241

A ZAB 1 bay

A fully-equipped bay can accommodate four sending and four receiving terminals

Transmission Performance Objectives

Naturally it will be expected that the performance of a carrier-derived channel will be substantially the same as that of the audio program channel for which it substitutes. For international working the CCITT has established recommendations which have found wide acceptance, and tests have shown that CCITT "normal circuit" quality is indistinguishable from the original for the great majority of listeners. Nevertheless there remains at least one frequent misconception which it may be worth disposing of. This concerns the frequency range needed for good quality reproduction. The CCITT recommends a frequency response extending up to 10 kc/s, whereas it is widely believed that for so-called "high fidelity" reproduction a response up to some 15 kc/s is desirable. For audio-frequency lines and radio senders it is a comparatively simple matter to provide this, whereas extending the frequency range in carrier systems implies that other traffic facilities must be foregone. It is therefore important to resolve this diversity of views. The explanation is that transient distortion can become objectionable if delay (phase) distortion is excessive below 10 kc/s. The easiest way to ensure that this is small is to design for an extended frequency range. But *provided the CCITT delay distortion limits are also maintained*, a 10 kc/s upper limit is subjectively very satisfactory. As a result of conclusive evidence in this respect, the CCITT has recently abandoned its recommendation for a channel with extended frequency response. It may also be remarked that a wider transmitted band, besides displacing more telephone channels, also accepts a wider noise band during transmission, and for the rare critical listener who can appreciate the extended response, the higher noise may actually result in a subjective worsening.

This brings us to the subject of the noise objective for carrier program channels. It is to be expected that the cable or radio links over which transmission will be made are designed primarily to accommodate the maximum number of telephone circuits. This in turn means that they exploit fully the line noise limit recommended by CCITT of 3 pW/km measured at a point of zero relative level with telephone psophometric weighting. As techniques are available for improving the noise level in some channels at the expense of others (e.g. by suitable pre-emphasis of the transmitted frequency band), it may be supposed that all telephone channels are on substantially the same footing in this respect–in other words, we can regard the spectrum of noise as flat ("white noise").

Now the nominal maximum circuit for program transmission according to current CCITT recommendations is 1000 km (although this is at present under review), and the allowable psophometric line noise power in each telephone channel to be substituted amounts to 3000 pW or – 55.2 dbm0p.[1]

This psophometric noise level is that which would be produced by white noise with a level of – 51.6 dbm0 in a 4 kc/s band. The noise in a 12 kc/s band is three times as much, or – 46.8 dbm0. The effect of measurement with program psophometric weighting is to raise this figure by 5.2 db, i.e. it is at a level of – 41.6 dbm0p*. The acceptable limit according to CCITT recommendations is a psophometric voltage of 6.2 mV at a point of relative level + 6 db, that is – 48.0 dbm0p*. Thus even if the noise contribution of the terminal equipment is completely neglected, an improvement of 48.0–41.6 = 6.4 db has to be looked for. Of this, 3 db is available to us due to the fact that CCITT permit the relative level for a program channel to be set that much higher than for a telephone channel. It is possible to obtain the remainder by the use of a suitable pre-emphasis of the program band. This is because the most disturbing frequencies, i.e. those with the greatest effect on the psophometer, are in fact those which occur in speech and music with relatively low amplitude. However, there is at present no generally accepted form of pre-emphasis curve, so that a little forethought needs to be taken with its use. This is especially so since it is recommended that frequency response be measured with input at each test frequency at zero absolute level, which may result in inconveniently high transmission levels for the emphasized frequencies, even though these would not occur in normal operation.

As the whole matter of noise in program channels is being reviewed at present by CCITT, the above conclusions must be regarded as tentative, and a certain flexibility in design regarding this point was considered desirable.

Other Desirable Features

As this equipment is intended for general application in conjunction with any carrier system fulfilling CCITT recommendations, it was necessary to foresee interconnexion at some recognized point common to all such systems. What these do have in common is use of a basic group, most modern systems in fact using basic group B, 60–108 kc/s. Two possible frequency allocations

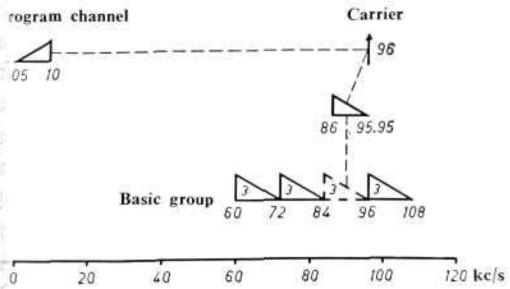


Fig. 2 X 2411

Modulation plan

[1] The term x dbm is used to mean an absolute power level of x db relative to 1 milliwatt.
The term —x dbm0 is used to mean a power level of x db below 1 milliwatt at a point of zero relative level, i.e. x db below normal channel test level at any point in the transmission system.
The term x dbm0p is used to mean an interfering power level in a telephone channel measured with the CCI telephone psophometer, and giving the same reading as the calibrating tone with a level of x dbm0.
The term x dbm0p* has a corresponding meaning for measurements in a program channel using the CCI program psophometer.

1*—902345

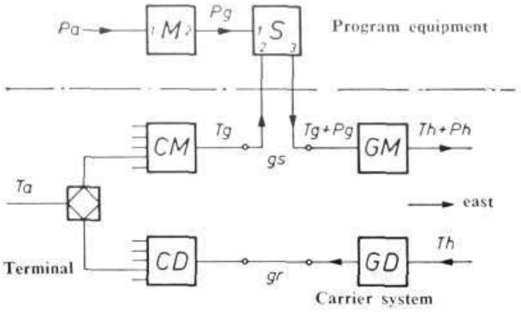


Fig. 3 X 2410

Connexion for inserting program in an outgoing group

Symbols for figs. 3, 4, 5 and 7

TRAFFIC

T	telephone channels	g	at group frequencies
P	program channel	h	at high frequencies
W	westward	s	send
E	eastward	r	receive
a	at audio frequencies		

PROGRAM EQUIPMENT

- M modulation equipment
- S h.f. sending equipment
- R h.f. receiving equipment
- D demodulation equipment
- B branching equipment

(These blocks and the numbering of their external connexions corresponds with those of figs. 10 and 11.)

- CM channel modulators
- CD channel demodulators
- GM group modulators
- GD group demodulators

within this group are recommended by CCITT, of which Position I using the band 84–96 kc/s is preferred. In contrast to the alternative Position II (64–76 kc/s), this allocation is also compatible with the use of 3 kc/s carrier spacing as used by some Administrations, and has furthermore the convenience of corresponding to a single sub-group of 3 telephone channels in those systems which employ this technique (see fig. 2). This was therefore to be the frequency allocation. Levels were to be adjustable over those recorded by CCITT as in use in different systems.

The equipment ought to ensure freedom from interruptions during operation. This implies the duplication of tubes or amplifiers with appropriate supervision and alarms, and other checking facilities.

The permissible frequency error in carrier systems according to CCITT recommendations is 2 c/s. While this is imperceptible for speech, it implies that in a music transmission a certain note and its octave, for instance, may be 2 c/s "out of tune" with each other, and this is not insignificant. However, frequency errors generally arise as a result of slow long-term drift, so that if corrected prior to a transmission satisfactory results are obtained. It is thus desirable to provide for adjustment of the demodulating oscillator frequency, and for checking this adjustment during the line-up period preceding a transmission.

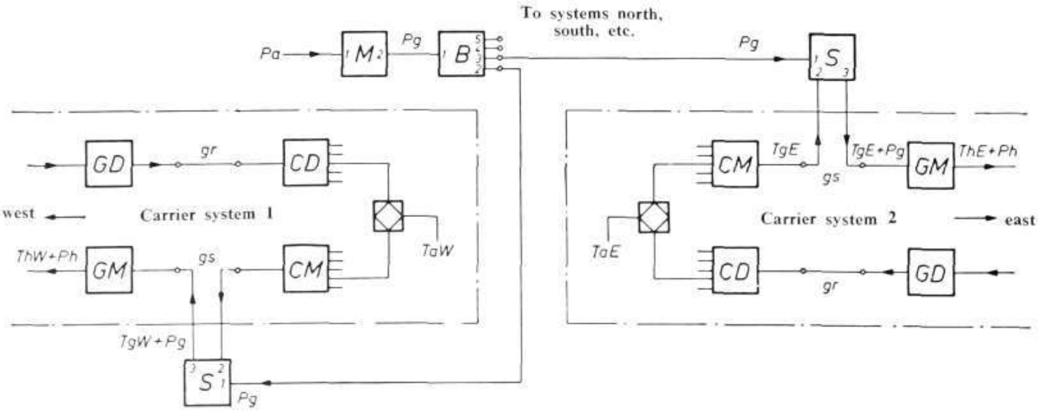
The design should also provide easy servicing and flexibility of adaptation to traffic requirements at minimum cost. This of course is largely catered for by the standardized plug-in unit equipment practice. However, it is of interest to consider some of the traffic facilities which have been provided for in the design. Besides the simple sending and receiving terminals, the most important facilities are those of *time sharing*, *through-connexion at group frequencies*, and *branching*.

The first of these is concerned with the fact that the principal need for program transmission does not usually coincide with the busy hour for telephone traffic, and that better utilization of the carrier system may be obtained by allowing telephony in the program band when program transmission is not actually in progress. This requires appropriate safeguards from interruption of either type of traffic.

The need for through-connexion occurs when the program has to be transferred from one carrier system to another. Of course this could be done on an audio-frequency basis, by providing a full receiving terminal at the incoming system and a full sending terminal for the outgoing system.

Fig. 4 X 7755

One program sent to two or more carrier systems



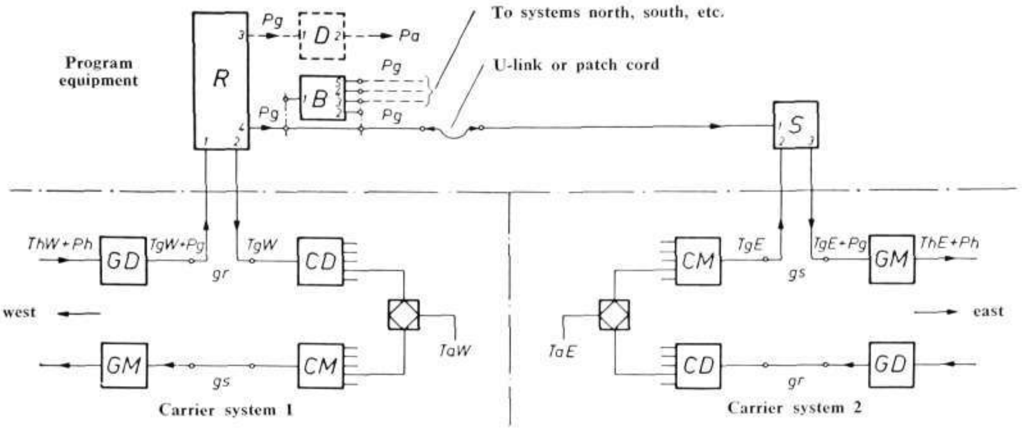


Fig. 5 X 7756

Through-connexion of program at group frequencies with optional audio drop

Fig. 6 X 2413

v.u. meter, U-link panel and current distribution panel

This would in fact give a technically acceptable result, since the equipment is designed to maintain CCITT tolerances even for *three tandem links*. However, it is more economical to transfer the onwardgoing program without demodulation out of the 84–96 kc/s range, which at the same time means that less distortion is introduced. If the program is also needed at audio-frequency in the transfer station for local distribution, a demodulator can be connected to a branch output.

The cost of the modulator and filter unit is a relatively large part of a sending terminal. Therefore if an incoming program at audio frequency has to be transmitted over a number of different carrier systems, it pays to avoid duplication of this part. For this reason a branching unit has been designed which provides several outputs at the same level as its input in the 84–96 kc/s range. This can also be used for branching at a transfer station (where through-connexion occurs) with corresponding economy.

Some of the possible arrangements resulting from these facilities are shown in figs. 3, 4, 5 and 7. Changes in the normal set-up can be rapidly established with U-link or patch-cord connexions.

Another feature considered desirable was to have a compact layout in the case of a small installation. The bay layout has therefore been made such that one complete sending terminal and one entirely independent receiving terminal together with all common equipment occupy one side of the bay only. A fully-equipped bay can accommodate up to four sending and four receiving terminals. A small installation may need to be placed at a point remote from normal audio-frequency program distribution equipment. For these cases it is possible, instead of the full complement of channelling equipment, to equip the bay with audio-frequency line amplifiers and equalizers. In certain cases also where group translation equipment is not available (e.g. in smaller carrier systems), it is possible to mount equipment providing a further frequency translation on the bay.

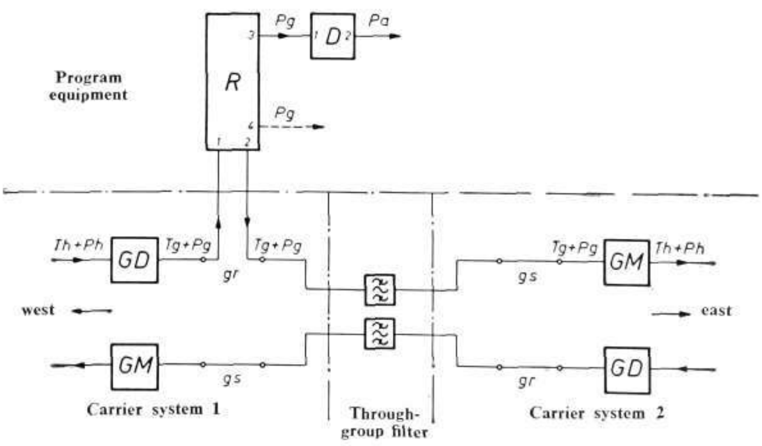


Fig. 7 X 8140

Dropping off program at audio frequencies from a through-connected group

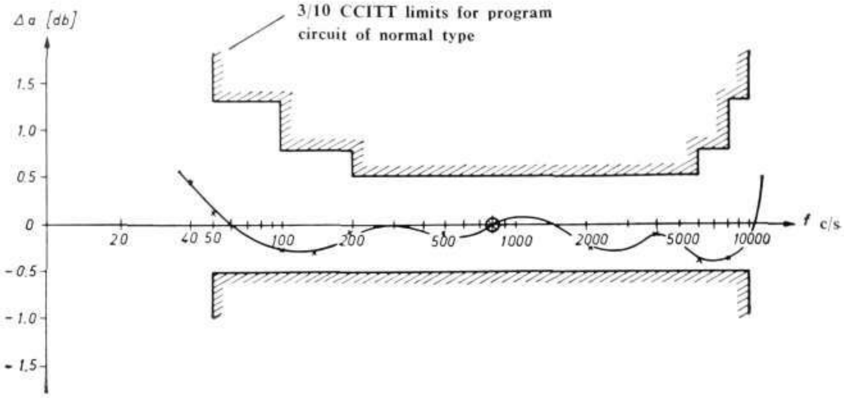


Fig. 8 X 8141

Typical frequency response curve for a sending and receiving terminal "back-to-back"

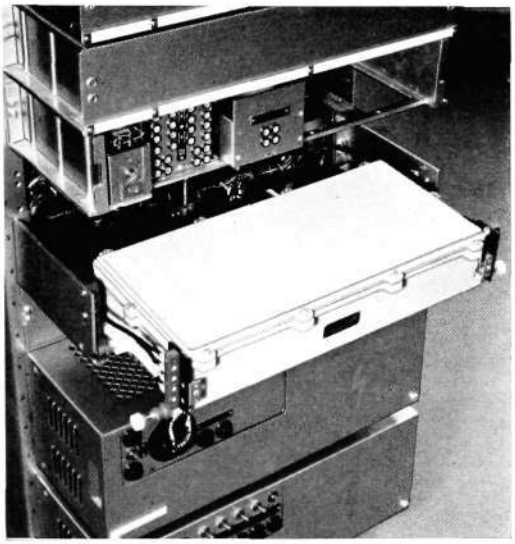


Fig. 9 X 2412

Channel filter, partly withdrawn from the bay

Design

The essential problem of this equipment is that of modulation so as to obtain a single-sideband signal in the recommended frequency allocation of 84–96 kc/s. With a lower limit for transmitted frequencies of 50 c/s, the filter requirements by normal techniques become rather exacting. Consequently various alternatives were also considered. The possibility of using vestigial sideband technique does not appear to be fully compatible with other recognized techniques, especially the use of out-of-band signalling in the 96–100 kc/s telephone channel. Slightly simpler filter requirements would result from the use of two stages of modulation, but not sufficiently to outweigh the extra cost. The phase-splitting method of single-sideband modulation offers many advantages and was studied in some detail. However, it proved possible to arrive at a single filter design for sending and receiving terminals and for through-connexion without demodulation. This fact, together with the avoidance of maintenance adjustments, resulted in a final decision in favour of conventional technique (see fig. 2). The performance of the filter may be judged from fig. 8.

Block diagrams of the final design of sending and receiving terminals are given in figs. 10 and 11; further details of their functioning are given in the next section.

Circuit Description

The sending and receiving terminals are in principle entirely independent items of equipment, in contrast to the usual design for telephony, where a complete circuit must always consist of a go and return channel. Program transmission is normally a one-way service, and it will generally not be possible to make use of the corresponding frequency band in the return direction of the carrier system. This is because the CCITT have specified a crosstalk

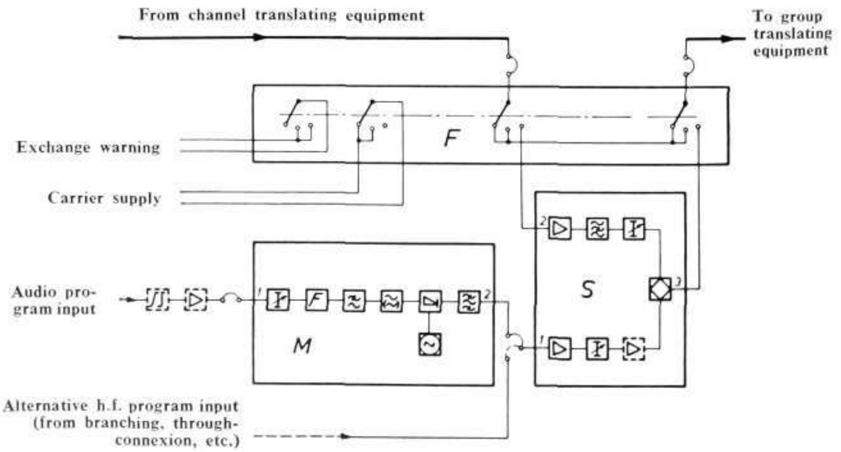


Fig. 10 X 8142

Sending terminal block schematic

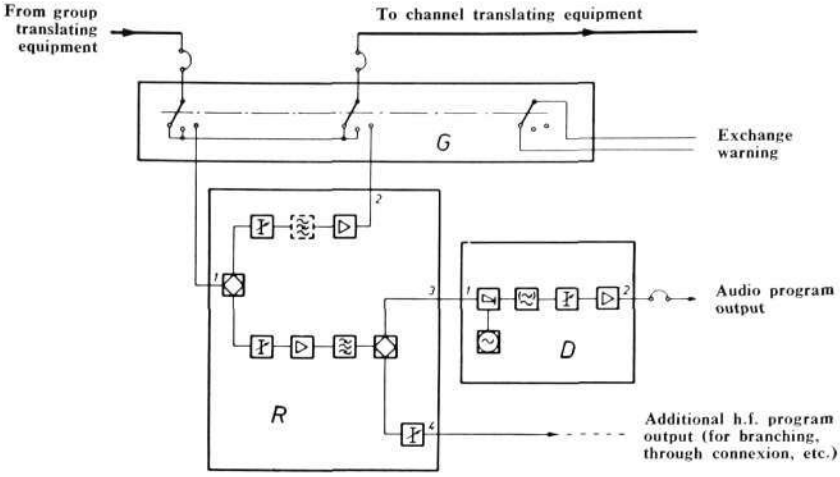


Fig. 11 X 8143

Receiving terminal block schematic

limit between go and return directions in a carrier system of not more than 35 db (4 nepers) and this is quite inadequate for the required quality of program transmission performance if use is made of the return path for another service. For modern systems, however, when the channel translating equipment is excluded, it may be possible to obtain a sufficiently high crosstalk figure to permit different programs to be sent in opposite directions if needed.

The audio input to the modulation equipment block *(M)* of the sending terminal is arranged to correspond either to that of an international link or an international line as recommended by CCITT (either 0 or + 6 dbr). However, where the equipment is installed in a small station where no other program repeaters or switching equipment are provided, a line equalizer and audio amplifier may optionally be provided ahead of the modulation equipment block (see fig. 10). In the transmission path the regular modulation equipment includes in succession an attenuator for level adjustment, a limiter, a low-pass filter, and a pre-emphasis network. This latter can be replaced by a pad with flat frequency response, if preferred, by altering some strap connexions. The modulator itself is of the conventional balanced type, and a common 96 kc/s oscillator feeds up to four sending terminals which can be mounted on the same bay. This oscillator, as indeed all other active units, has duplicated tubes whose cathode current is continuously monitored. The lower sideband of 96 kc/s is selected by the channel filter.

The h.f. sending equipment block *(S)* provides for the introduction of the modulated program into the group path. It comprises principally amplifiers and attenuators to allow the relative levels to be adjusted over the range of those occurring in the basic group frequency range. The remaining telephone channels and the program channel are brought together to form the completed basic group via a hybrid. In addition this equipment comprises a stop filter for the 84–96 kc/s band. This is needed because the channel filters of the *remaining* telephone channels will naturally only be designed to ensure compliance with the normal telephony crosstalk recommendations for the extracted telephone channels in this band, so that additional filtering is needed to ensure the higher performance recommended for crosstalk to a program channel.

The remaining equipment block *(F)* in the sending terminal is the optional switching for time-sharing. The first position of the switch provides for direct through-connexion of the group frequencies, whereby all twelve telephone channels may be used. The second position is a preparatory position in which the three telephone channels to be substituted are still connected through, but the exchange is notified to remove them from traffic. On receiving confirmation that this has been done, the switch may be placed in the third

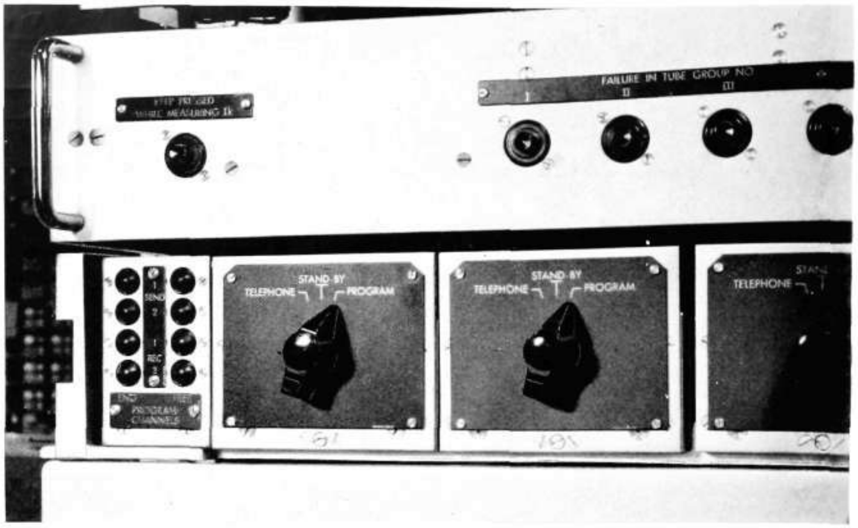


Fig. 12 X 8144

Telephony/program time-sharing changeover switches with associated signal lamps to the left. Above, tube failure alarm unit.

position. The three telephone channels are cut out of service and the program equipment inserted.

The receiving terminal (fig. 11) similarly consists of three blocks of equipment. The block for time-sharing switching *(G)* has an analogous function to that in the sending terminal. The h.f. receiving equipment block *(R)* has the converse function of the h.f. sending block, namely, to extract the modulated program from the telephone channels associated with it in the group. This is done by the "leak" method, that is, while the modulated program in one path is filtered out from the telephony ready for demodulation or h.f. through connexion to another group, it is not stopped in the path of the original group but continues to pass on with those telephone channels. Where demodulation of the telephone channels is going to be effected, we have to consider that their channel filters will normally only be designed to afford protection from an adjacent channel with a lowest transmitted frequency of 300 c/s whereas in the program channel the lowest frequency is 50 c/s. This is of especial importance if out-band signalling is used. To cater for this, a narrow band-stop filter may be included in the group path. After the filter for the program band, the program path is branched to give simultaneous outputs, at levels suitable for through-connexion and for demodulation respectively.

The demodulation equipment block *(D)* contains the demodulator proper and an oscillator individual to the channel, a de-emphasis network which is the inverse of the pre-emphasis network in the sender, an attenuator and audio amplifier. By providing a small range of frequency adjustment on the oscillator, it is possible to correct for possible frequency errors in the carrier transmission path, and a simple but effective means is provided for checking carrier synchronism prior to program transmission. This consists in sending a tone, usually 800 c/s, considerably distorted at the sender so as to be rich in harmonics, and measuring the output at the receiver with a built-in peak voltmeter. If there has been a frequency shift, the overtones will no longer be in true harmonic relation to the fundamental at the output, but will slowly shift in phase, resulting in a varying peak voltage observable as a beat on the instrument. Use is also made of the 96 kc/s oscillation for monitoring the tubes in the audio amplifier.

A telephone instrument may also be included in the equipment to provide for conversation, for example between the two terminals via the speaker circuit of the carrier system, or over any other trunks which may be provided.

To ensure the greatest possible reliability of service, all operating voltages are monitored by relays giving alarm if any voltage fails. All fuses are of a type giving alarm on failure. Any failure causing interruption of service gives an urgent alarm. Other failures, e.g. one tube of a pair with duplicated function, crystal oven temperature outside limits, etc. give a non-urgent alarm.

Electrical Characteristics

Frequency Range

The effectively transmitted band of frequencies is 40–10000 c/s. Transmission takes place in basic group B (60–108 kc/s) in the CCITT preferred position 84–96 kc/s (CCIF Green Book, vol. III bis, page 237). The 96 kc/s carrier is suppressed.

Levels and Impedances

The acceptable range of audio program input levels to a sending terminal is from − 13 dbr to + 10 dbr. With the extra amplifier mentioned earlier, levels down to − 40 dbr can be accepted. The nominal audio output level from a receiving terminal is either 0 or + 6 dbr. The nominal impedances for the audio input and output are 600 ohms, balanced. The group output level from a sending terminal can be adjusted between − 26 dbr and − 52 dbr. The same limits apply to the relative input and output levels of the telephone channels which make up the outgoing group. The corresponding range of group levels for a receiving terminal is from − 2 dbr to − 30 dbr. (The telephony levels are unchanged when the program equipment is inserted.) The nominal value of impedance at group frequencies can be either 150 or 135 ohms balanced, or 75 ohms unbalanced. The return current coefficient against the selected nominal value does not exceed 10 % within the effectively transmitted band (return loss 20 db).

Frequency Distortion

Fig. 8 shows a typical response curve for a sending and a receiving terminal looped back-to-back on the carrier side. The limits shown are $^{3}/_{10}$ of those recommended by CCITT for a program circuit of normal type. These limits are kept with a good margin, thus leaving plenty to spare for possible additional distortion arising in the carrier system group link.

Delay Distortion

The table below gives the guaranteed delay distortion for *ZAB 1* terminals back-to-back together with the CCITT recommendations for comparison. It will be seen that the delay distortion for the *ZAB 1* terminals is less than $^{1}/_{3}$ of the CCITT limits. Further distortion from the carrier group link need not be expected, since the program channel is far removed from the edges of the group frequency band.

Delay distortion	*ZAB 1*, sending and receiving terminal connected back-to-back	CCITT, entire circuit
$t_{10000} - t_{min}$	$\leq$ 2 milliseconds	$<$ 8 milliseconds
$t_{100} - t_{min}$	$\leq$ 6.5 "	$<$ 20 "
$t_{50} - t_{min}$	$\leq$ 12 "	$<$ 80 "

Non-Linear Distortion

The harmonic distortion coefficient for *ZAB 1* terminals looped back-to-back at line-up level does not exceed 2 %, corresponding to a total harmonic ratio of 34 db. With "maximum voltage" applied (9 db above line-up level) the figures are 3 % or 30 db. These values are maintained for supply voltage variations of ± 10 %. The value recommended by CCITT for the latter case is 20 db (Green Book, vol. III bis, page 236). As stated by CCITT in a note, further distortion from the carrier system is practically negligible: this is because the carrier equipment being common to several channels must be highly linear in order not to produce unwanted intermodulation products.

Frequency Stability

The frequency stability, i.e. the relative frequency variation between sender and receiver carrier oscillators, is better than 0.1 c/s per day. This is of the same order as can be expected of modern carrier systems.

Transmission Quality, Through-Connexion Facilities

From what has been said above, it will be seen that *ZAB 1* equipment provides program transmission meeting CCITT recommendations for circuits of normal type (CCIF Green Book, vol. III bis, pages 232–238).

These recommendations are also met for three *ZAB 1* links (corresponding to the hypothetical reference circuit) tandem-connected on an audio-frequency basis. Using through-connexion at group frequencies, at least four tandem-connected links are possible. The transmission performance achieved is such that even critical listeners could not detect any lowering in artistic quality in a program after transmission over a *ZAB 1* link.

Mechanical Construction

In a normal *ZAB 1* bay (see fig. 1), four sending and four receiving terminals can be accommodated. When not more than two sending and two receiving terminals are needed, amplifiers and equalizers for the incoming audio program can be included if desired, thereby in many cases dispensing with a separate audio repeater and equalizer bay. Mains supply units, current distribution, supervisory and alarm equipment, carrier oscillator for sender modulators, crystal oven and thermostat etc. serve all channels in the bay in common and hence are designated common equipment. Since the various equipment blocks are composed of plug-in units, the bay can readily be built out as required to suit particular traffic requirements. Also if these traffic requirements are varying, they can be met by appropriately shifting plug-in units. All group amplifiers are identical and can be interchanged at will: this is also true of the channel filters for sender or receiver, the carrier oscillators, hybrids, and audio amplifiers. Only three different long-life tube types are used in the bay, and for these types equivalents are to be found among internationally available normal radio types. These features simplify and economize in maintenance and first cost and supply of spares.

The mechanical construction of *ZAB 1* follows the general principles for L M Ericsson's carrier telephone equipment. Electrical components (resistors, capacitors, inductors) are mounted as sub-assemblies in pressure-tested sealed boxes. This ensures unimpaired performance even under extreme climatic conditions. The sub-assemblies are wired together in mounting frames to form plug-in units which connect to the bay wiring via sockets giving reliable contact. Several such units are carried on a shelf mounted on the bay frame. Larger units of common equipment (such as mains supply units, current distribution panel, U-link panel, crystal oven) are mounted directly on the bay frame and are permanently wired in circuit. To facilitate maintenance and fault-finding, in cases where full accessibility is not possible from the front, such panels are mounted so as to swing out on hinges.

The *ZAB 1* bay has the following standardized dimensions when equipped on both faces: height 2590 mm, width 514 mm, depth 456 mm. The front carries the common equipment and one sending and one receiving terminal; the rear carries 3 sending and 3 receiving terminals.

The U-link panel, time-sharing changeover switches and current distribution panel are placed at a convenient height on the front of the bay. The U-link panel contains all the important level measuring points. All operations needed for traffic switching are effected on this panel and by the changeover switches. The current distribution panel carries fuses and the common instrument which can be switched to measure all important voltages and currents. A volume meter, either of the peak indicating or v.u. type, can be mounted on the bay at eye level. The units are protected by removable light metal dust covers.

Performance Data

Effectively transmitted frequency band	40—10000 c/s
Frequency allocation in CCITT's basic group B	86.00—95.96 kc/s
Carrier (suppressed)	96 kc/s
Range of adjustment for carrier frequency	± 10 c/s
Stability of carrier frequency during a period of 24 hours with simultaneous mains voltage variation of ± 10 % and ambient temperature variation from + 10° C to + 40° C	< ± 0.1 c/s
Carrier leak to line	< − 26 dbm0
Variation of level in program terminals	
for ± 10 % change in mains voltage	− 0.1 to + 0.3 db
for change of ambient temperature from + 10° C to + 40° C	< ± 0.5 db
Frequency response, sending + receiving terminal	< 3/10 of CCIF limits for normal type program circuit
Frequency distortion for telephone channels	< ± 0.1 db
Program levels at audio frequencies	
Sender input, normally	+ 10 to − 13 dbr
„ „ , with extra amplifier	— 40 dbr min
Receiver output	0 or + 6 dbr
Levels at group frequencies	
Sender	— 26 to — 52 dbr
Receiver	— 2 to — 30 dbr
Impedances, input and output, audio side	600 ohms
„ „ „ „ , group side	150 ohms balanced
or	135 „ „
or	75 „ unbalanced
Return loss against nominal impedance	> 20 db
Delay distortion $t_{50} - t_{min}$	< 12 ms
$t_{100} - t_{min}$	< 6.5 ms
$t_{10000} - t_{min}$	< 2 ms
Total harmonic ratio, for send and receive terminals looped back-to-back, with "maximum voltage" (+ 9 dbm0) applied	> 30 db
Noise voltage at receiver output (relative level + 6 dbr) measured with program psophometer for back-to-back terminals	≤ 1.6 mV
Weighted noise power referred to zero relative level for back-to-back terminals	< 1000 pW
Unweighted noise voltage at receiver output (relative level + 6 dbr) in the frequency range, 30–20000 c/s for back-to-back terminals	< 4 mV
Noise contribution in the telephone channels of the group from one send and one receive terminal when "maximum voltage" is applied, measured with telephone psophometer	< 15 pW

2*—902345

Crosstalk in a *ZAB 1* bay

between any two program channels	> 87 db
,, ,, ,, telephone channels	> 87 db
,, ,, telephone channel and a program channel terminal	> 85 db
,, the sending terminal and receiving terminal with same number	> 85 db

The *ZAB 1* system maintains the above performance under the following climatic conditions:

Ambient temperature	+ 10° C to + 40° C
Relative humidity in the temperature range + 10° C to + 20° C	10 %—85 %
Relative humidity at 40° C	10 %—75 %
Tube types used (commercial equivalent types in brackets)	*18AK5 or 403B (6AK5)* *18AQ5 or 6AQ5L (6AQ5)* *18C51 or 2C51L (2C51)*

Mains supply

Voltage	110/127/150/220/240 V
Frequency	45—65 c/s

Power consumption

on starting	600 VA max
running	450 VA max

Radio Link 1RL10 for 60(120) Telephone Circuits

C BRAMBANI, A/S ELEKTRISK BUREAU*, OSLO

U.D.C. 621.396.65

The radio link described has been developed by A/S Elektrisk Bureau in Oslo at the instigation of Telefonaktiebolaget L M Ericsson. This system operates in the band 225–470 Mc/s using frequency modulation. It is designed for 60 (or with certain modifications 120) telephone circuits with CCI frequency allocation, and will operate in conjunction with L M Ericsson multiplex equipment.

In recent years, radio links have taken an ever stronger position in long-haul telecommunication networks. In certain respects the radio system has unquestionable advantages. By means of radio, reliable communication can be realized where terrain and climate present prohibitive difficulties for construction and maintenance of a cable route. In many other cases, a radio link may be favourable with respect to initial cost and installation time. Due to the long spacing between repeater stations, and the recent development of highly reliable tubes for very high frequencies, the maintenance cost is also kept low.

To-day, radio links are manufactured for a wide variety of traffic handling capacities. Systems of 24, 60, 120, 240 and 600 circuits are customary. For still higher capacity, a number of radio links, each carrying 600 telephone circuits, can be operated in parallel.

To meet the demand for communication equipment of medium traffic handling capacity, the radio link type *1RL10* was developed by A/S Elektrisk Bureau, Oslo, at the instigation of Telefonaktiebolaget L M Ericsson. It was originally designed for transmission of 60 telephone circuits in the baseband 12–252 kc/s (or 60–300 kc/s). With slight modifications the same equipment can be used for 120 telephone circuits (60–552 kc/s). Besides handling ordinary telephone traffic, the link may also be used for transmission of high quality broadcast channels. Thus it may find application in a television link as an auxiliary system, transmitting sound channels, intercommunication, remote control signals etc. Due to its stability, the link also provides an excellent facility for telephone channels permitting v.f. telegraphy.

A number of links are installed or are under installation in Norway, as seen on the map in fig. 1. Another link is being installed between Rio de Janeiro and Nova-Friburgo in Brazil. The Oslo–Kristiansand radio link, which comprises 7 hops with a total length of 298 km, was put into regular service in November, 1956. A considerable amount of operational experience has been gained since that time. In the following description this link is frequently referred to.

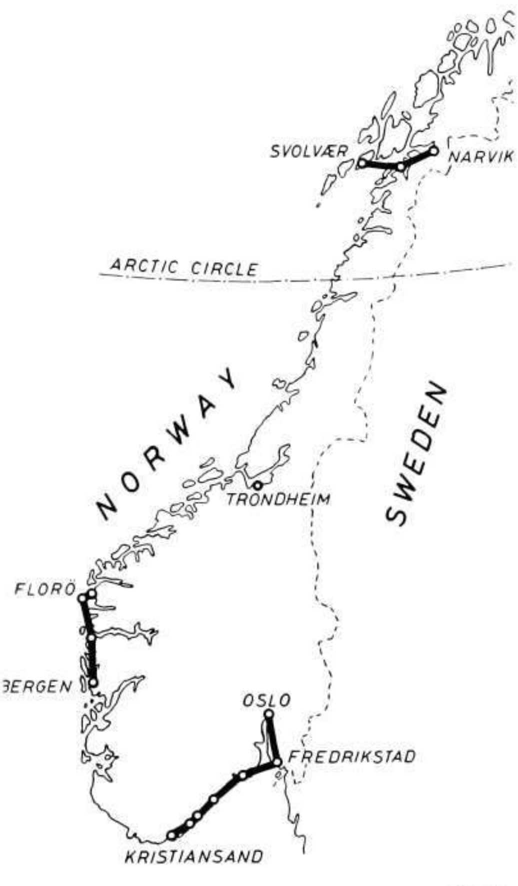


Fig. 1
Map of the radio links installed in Norway

System Specifications

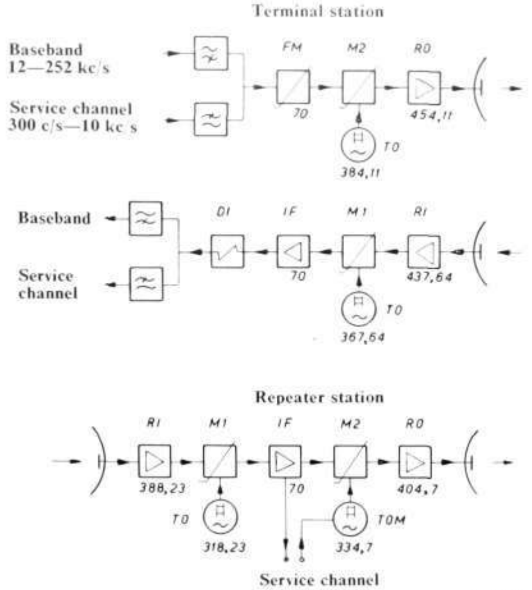
The radio link comprises:

A terminal station at each end of the link. The sender converts information in the baseband into a frequency-modulated radio signal. The receiver performs a reverse operation for the other direction of transmission.

Repeater stations. These receive the frequency-modulated signal, amplify it and retransmit it at a frequency different from the frequency of the received signal. This operation does not include demodulation to the baseband.

The hop. This is the propagation space between two successive stations. The hop should provide a line-of-sight path between the antenna sites of the two stations. The length of a hop is dependent on the properties of the intermediate terrain and does not normally exceed 50 to 100 km.

* Member of the Ericsson group.



X 2381
X 2382

Fig. 2

Schematic block diagrams of the two types of stations

RI	**Input amplifier**
M1	**Input mixer**
IF	**Intermediate frequency amplifier**
FM	**FM exciter**
DI	**Discriminator**
M2	**Output mixer**
RO	**Output amplifier**
TO	**Converter oscillator**
TOM	**Modulated converter oscillator**

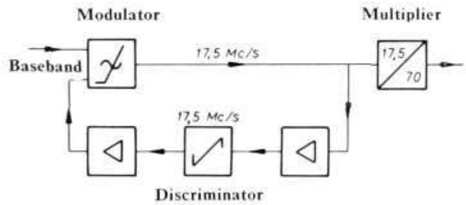


Fig. 3 X 2383

Block schematic diagram of FM exciter

Fig. 4 X 2384

Mixer and 10 watt output amplifier (RO)

Fig. 5 X 2385

Input amplifier and mixer (RI)

The principal data of the system are:

Baseband frequency range	300–10000 c/s and 12–252 kc/s
Input and output impedance 300–10000 c/s	600 ohms balanced
Input and output impedance 12–252 kc/s[1]	150 ohms balanced
Input level 300–10000 c/s	− 27 dbr
Output level ,, ...	+ 9 dbr
Input level 12–252 kc/s[1]	− 52 dbr
Output level ,, ...	+ 1.75 dbr
Level stability	± 0.5 db
(The power levels refer to a channel test tone level for a deviation of 200 kc/s r.m.s.)[2]	
Modulation type	frequency modulation
Transmitter frequency tunable in the range[3]	225–470 Mc/s
Transmitter power output	5–10 watts
Antenna type	$\lambda/2$-dipole with parabolic reflector
Antenna gain at 400 Mc/s	20 db over $\lambda/2$ dipole
Receiver noise factor at 400 Mc/s	12 db max.
Intermediate frequency	70 Mc/s
Number of tubes in a terminal station .... (Two-way communication)	60
Number of tubes in a repeater station .... (Two-way communication)	58
Power consumption of terminal station	400 watts
,, ,, ,, repeater ,, ...	450 watts
Dimensions of radio terminal:	1 bay 20 1/4″ × 18″ × 86″ (514 × 460 × 2190 mm)
,, ,, ,, repeater:	same as for terminal

[1] Level and impedance ratings are in accordance with CCIR recommendations. Line amplifiers for the baseband 60—300 kc/s (75 ohm unbalanced) are optional, alternatively for 72 channels with a baseband of 12—300 kc/s.
[2] By adjusting built-in attenuators the frequency deviation can be set to other values.
[3] Certain frequency combinations may give rise to interference. The frequency scheme should therefore be worked out in cooperation with the manufacturer.

System Description

Schematic block diagrams of the two types of station are shown in fig. 2.

In the terminal sender, modulation of the radio frequency carrier by the baseband and service channel is performed by the frequency-modulated exciter *FM*, the carrier frequency being 70 Mc/s. The exciter output, which has a level of 1 watt, is fed to a power mixer *M2* together with the output from a crystal controlled converter oscillator *TO*. The desired conversion product is selected and amplified in the sender output stage *RO* before it is fed to the antenna.

Fig. 4

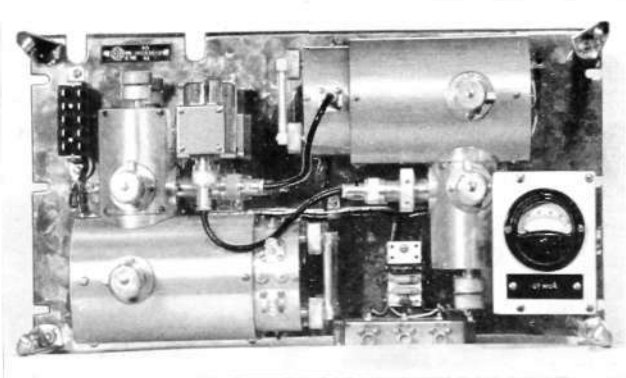
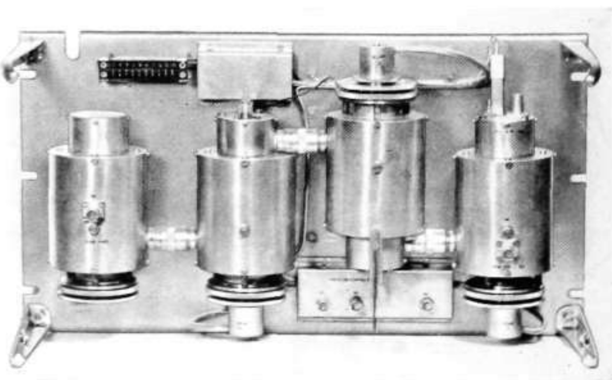


Fig. 5



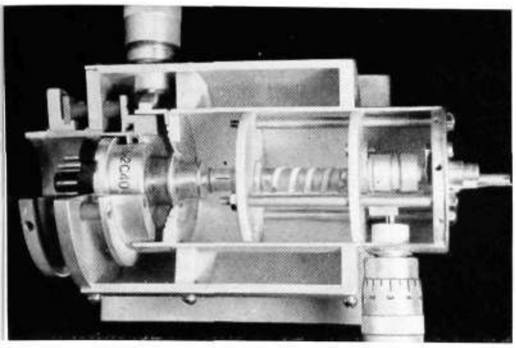


Fig. 6 X 2386

Amplifier stage of input amplifier (RI). Cut-away view.

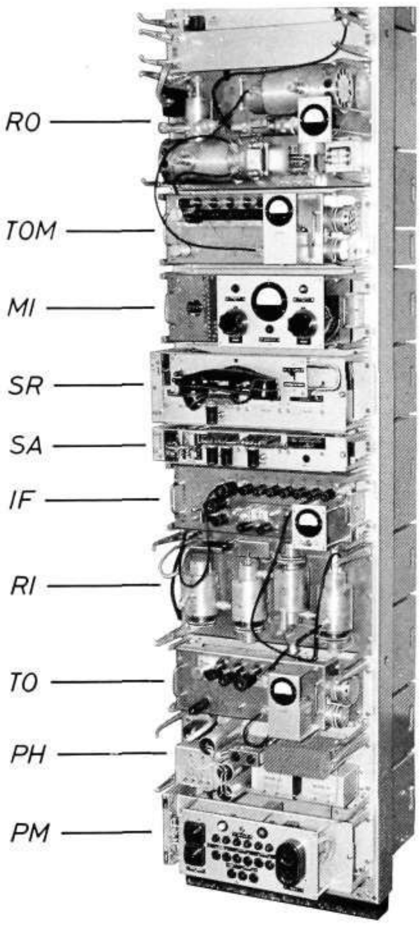


Fig. 7 X 2387

Repeater bay of Oslo—Kristiansand link. Panel covers removed.

RO	**Sender output mixer and 10 W amplifier**
TOM	**Modulated converter oscillator**
MI	**Measuring panel**
SR	**Service channel receiver**
SA	**Service channel amplifier**
IF	**Intermediate frequency amplifier**
RI	**Receiver input amplifier and mixer**
TO	**Converter oscillator**
PH	**400 V power supply for RO**
PM	**Mains distribution panel**

In the terminal receiver, the signal from the antenna is first amplified in an input amplifier *RI* and thereafter converted in a mixer to the intermediate frequency of 70 Mc/s. The converter oscillator *TO* is the exact duplicate of that used in the sender. After the mixer follows an intermediate frequency amplifier *IF* which feeds 1 watt at 70 Mc/s to the discriminator *DI*.

In a repeater station, the receiver section comprises an input amplifier, mixer and *IF* amplifier as in the terminal receiver, but the *IF* amplifier output is fed directly to the output mixer. Both the output mixer and sender output stage are exactly the same as the corresponding parts of the terminal station. The converter oscillator *TOM*, however, differs somewhat from its terminal counterpart, the repeater version permitting modulation. This is necessary for transmission of the service channel signals from a repeater station.

For service channel reception in a repeater, the *IF* amplifier includes a discriminator.

Frequencies indicated on the block diagrams are the actual frequencies used in the Oslo–Kristiansand link.

The repeater stations are, as appears from the above, of the "non-demodulating repeater" type, with separate crystal controlled oscillators for the receiver and sender mixers. The 70 Mc/s intermediate frequency appears in both receiver and sender, with power levels allowing direct interconnexion. This also facilitates the establishment of a loop connexion on a 70 Mc/s basis, in terminals as well as repeaters, thus providing a convenient procedure for system performance measurements.

In the following sections, a brief description of the units *FM*, *RO*, *RI*, *IF* and *DI* is given.

Frequency-Modulated Exciter FM

This unit employs direct frequency modulation of a self-excited oscillator by means of a reactance tube. The oscillator operates at 17.5 Mc/s, necessitating a subsequent frequency quadrupling. The advantage of direct frequency modulation is that the required linearity can be achieved using a relatively modest number of tubes and components. On the other hand, frequency stability is not adequate; therefore an automatic frequency correction is required. This is done in the conventional way by checking the frequency in a discriminator, as shown by the block diagram of fig. 3. The discriminator yields a corrective signal which is amplified and impressed on the reactance tube together with the modulation signal.

The linearity of this oscillator has proved to be very satisfactory. The oscillator is also easy to align and has shown satisfactory long-term stability of frequency as well as of linearity.

Output Mixer and Amplifier RO

Fig. 4 shows the unit *RO* which comprises two stages, both employing the "disk-seal" triode *2C39A*.

The first stage acts as a mixer (designated *M2* in fig. 2), its input being fed at 1 watt from both *FM* exciter and converter oscillator. Power output from the mixer is also about 1 watt. The signal is amplified in the second stage, which delivers 10 watts to the antenna.

The circuits in both stages consist of resonant coaxial lines. They are tunable throughout the entire frequency range 225–470 Mc/s.

The frequency response of the combination *FM-RO* has 4 Mc/s bandwidth at – 0.1 db, and is symmetrical about the centre frequency.

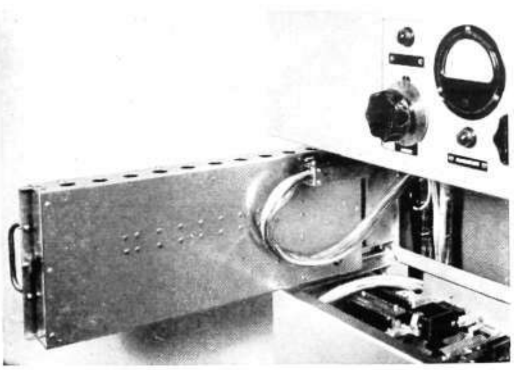


Fig. 8 X 2388

Detail of terminal bay

Panel swung out to show supply leads and multi-way plug

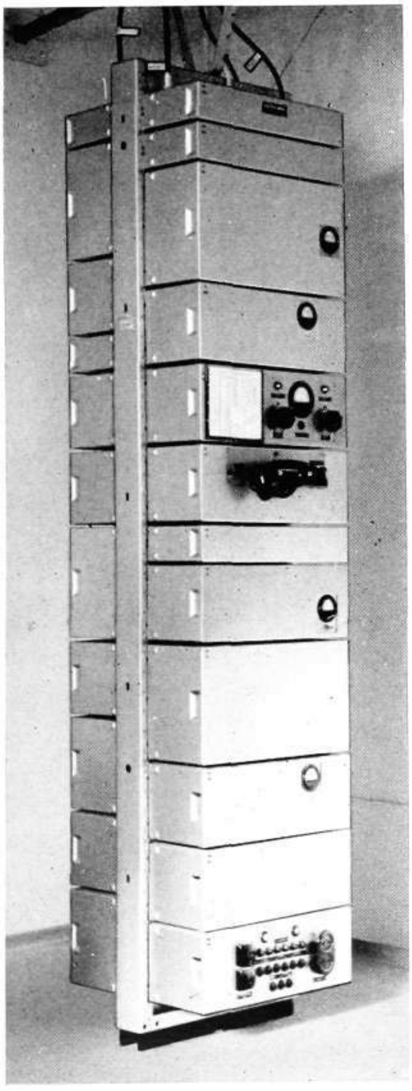


Fig. 9 X 2389

Repeater bay with covered panels

Input Amplifier RI

Fig. 5 shows the unit. The circuits of this amplifier also consist of resonant coaxial lines employing the disk-seal triode *2C40*. Referring to fig. 5, to the left is seen first a passive band-pass filter section. Then follow two equal amplifier stages, and finally the input mixer (designated *M1* in fig. 2), also employing tube *2C40*. Fig. 6 is a cut-away view of an amplifier stage.

The combined input amplifier-mixer has a gain of 20 db and a noise figure better than 12 db. All stages are tunable throughout the entire frequency range.

Intermediate Frequency Amplifier IF

The amplifier is of conventional design with stagger-tuned pairs. The tube *403 B* (= *6AK5*) is used throughout, except in the last stage which employs a *6761* tube to handle the high power level (1 watt). A conventional automatic gain control keeps the output level constant within 1 db at 20 db fading.

The maximum gain is about 100 db, the 3 db bandwidth is 7.5 Mc/s. The *IF* amplifiers in the repeaters have a built-in discriminator for service channel detection, as mentioned above.

Discriminator DI and Limiter

The discriminator is of the so-called "Round-Travis" type [bibl. 1], employing two resonant circuits tuned to 65 and 75 Mc/s respectively. Preceding the discriminator is a two-stage limiter using germanium diodes. The reduction of amplitude modulation obtained in the limiter amounts to 55 db for modulation frequencies from 300 c/s to about 2 Mc/s.

Mechanical Construction

The location of the individual units appears in fig. 7, which shows a repeater bay. The panels are mounted on both sides of the rack. Radio units for one transmission direction are assembled on the same side; the power supply units are common for both directions. All panels except the heaviest, are hinged and can be swung out (fig. 8) for inspection and servicing during operation. After disconnecting the supply voltages (multi-way plug), the unit is easily removed from the hinges for replacement by a spare unit.

All units are protected by panel covers (fig. 9). The covers have no top or bottom, thus providing a vertical air duct for natural cooling of the equipment.

Electrical Components

The total operational reliability of the radio link is determined by the reliability of individual components. All components are therefore selected with the utmost care, they are all tropicalized and conservatively rated. Except for the disk-seal triodes *2C39A* and *2C40*, "long life" tubes with a guaranteed minimum life of at least 10000 hours are used throughout. The failure statistics discussed in the chapter "Operational Experience" confirm that due to conservative rating, very satisfactory life-time figures are achieved also for the disk-seal tubes. The following tube types are used in the system:

403B and *404A* (radio frequency pentodes), *2C51* (double triode), *6761* (pentode), *2C40* and *2C39A* or *2C39B* (disk-seal triodes).

Antenna System

Of the many possible antenna types for this frequency range, a dipole in a parabolic reflector seems to be that which, besides satisfying the requirements of transmission performance, is also favourable with regard to economy and reliability.

It is desirable to employ the largest possible reflector. With larger reflectors, the received signal strength increases and the radio path distortion decreases (see discussion in the section "Signal-to-Noise Ratio") thus the signal-to-noise ratio is improved. However, practical considerations regarding weight, cost and available space set an upper limit to the size.

For Oslo–Kristiansand, reflectors with a square aperture of 3 by 3 metres are used (fig. 10). More recently, a circular reflector of 3.5 m. diameter has been adopted for use on subsequent installations. The latter type is made of seawater-resistant aluminium and weighs only 60 kg. The gain of this aerial system is 20 db relative to a dipole at 400 Mc/s.

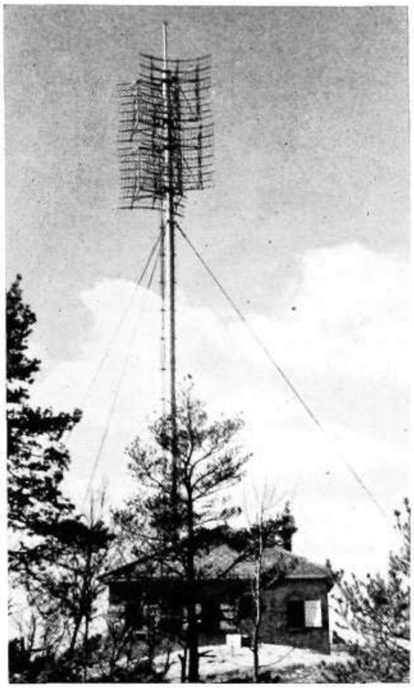


Fig. 10 X 2390

Repeater station with square-aperture parabolic antennas

Fig. 11 shows the dipole mounted in the aluminium reflector. The dipole has one parasitic element (auxiliary reflector).

It is very important to have a good impedance match between dipole and feeder. The dipoles are therefore adjusted individually to give a standing wave ratio better than 1.1 over a 4 Mc/s wide band centered on the working frequency.

Antenna Feeders

Long feeder cables between antenna and radio equipment are frequently unavoidable. These should preferably be of a low-loss type. A so-called Styroflex cable has proved to be very suitable. The Styroflex cable is a special coaxial cable, in which the inner conductor is mechanically supported by a polystyrene tape helix. The outer conductor is a $^3/_4$" aluminium tube, which makes the cable somewhat rigid and difficult to handle. The characteristic impedance (nominally 50 ohms) is stated to be constant within 2.5 %.

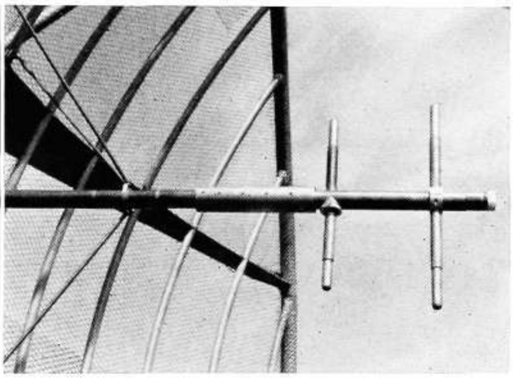


Fig. 11 X 2391

Dipole with parasitic element in aluminium reflector

On short feeder runs, up to some 10–20 metres, a simpler type of cable may be used, such as the solid dielectric type *RG17U*. The attenuation figures at 400 Mc/s for these two cable types are:

$^3/_4$" Styroflex:	3.3 db per 100 metres
RG17U	: 6.7 ,, ,, ,, ,,

In fig. 12 cut-away views of the two cable types are shown.

Common Antenna Operation

When large antennas are used, it may be desirable to work several radio-frequency channels on a single antenna. This is done on the Oslo–Fredrikstad link, which runs parallel with the two first hops of the link Oslo–Kristiansand. Dipole and feeder are common, and the two channels are separated by branching filters. Two senders work together on one antenna, and two receivers on the other, the frequency difference in one pair being 8 Mc/s.

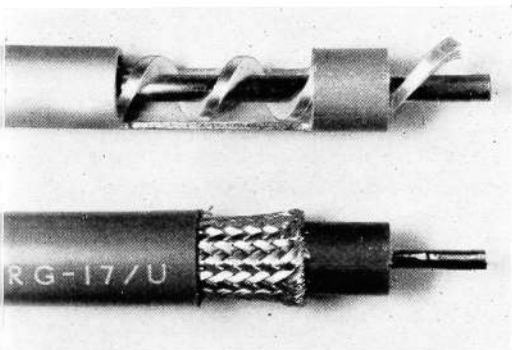


Fig. 12 X 2392

Cut-away view of feeder types

Upper: Styroflex, lower: RG 17 U

Auxiliary Equipment

Service Channel

For intercommunication between the radio stations, a speech channel band of 300–3000 c/s is utilised. The stations are rung using a common v.f. signal of 2700 c/s. In the radio terminals the service channel modulates the *FM* exciter in the usual way (see block diagram fig. 2). In repeaters, the crystal stage of the sender converter oscillator is phase modulated.

Measuring Panel

Each radio bay is equipped with a central measuring panel where all tube currents and other vital currents and voltages can be read. This device has proved to be very useful. In many cases, regular logging of the readings enables the operator to detect, for instance, tube faults in the latent stage. Thus the faulty component can be replaced before the transmission is appreciably impaired.

Fault Indication

The fault indication device enables information about faults to be transmitted from repeaters to terminal stations. If the latter are also unattended, the information can be transmitted further over a conventional line. A general fault warning is sent automatically. By operating a remote interrogating device at the terminal station, the faulty station can be identified and more specific information as to the kind of fault can be obtained. In its simplest form this device can indicate a total of 8 different faults from each station. If desired, the information capacity can easily be increased.

Stand-by Channel

At present, it is almost impossible to satisfy the requirements of the telecommunication authorities regarding the reliability of national and international telephone networks, as far as the radio equipment itself is concerned, without duplicating the radio equipment. The required freedom from service interruptions can be accomplished by installing stand-by equipment to take over traffic when the regular equipment fails. The stand-by channel is put into action by an automatic switching device which operates if the sender output falls below a pre-set level, or if the level of pilot tone is too low.

Path Attenuation, Choice of Station Sites

Assuming that sender and receiver are located in free space, the calculation of signal power arriving at the receiver antenna is very simple. For practical use the following formula is suitable:

$$E_r = 0.13 \cdot \sqrt{P_t R} \cdot \frac{\lambda}{d} G_t G_r \qquad (1)$$

E_r = resulting voltage in a matched receiver antenna (volts)

P_t = power fed to sender antenna (watts)

R = load resistance of receiver antenna (50 ohms)

λ = wavelength in metres

d = distance between sender and receiver antenna (metres)

G_t = gain of sender antenna relative to half-wave dipole (voltage ratio)

G_r = gain of receiver antenna relative to half-wave dipole (voltage ratio)

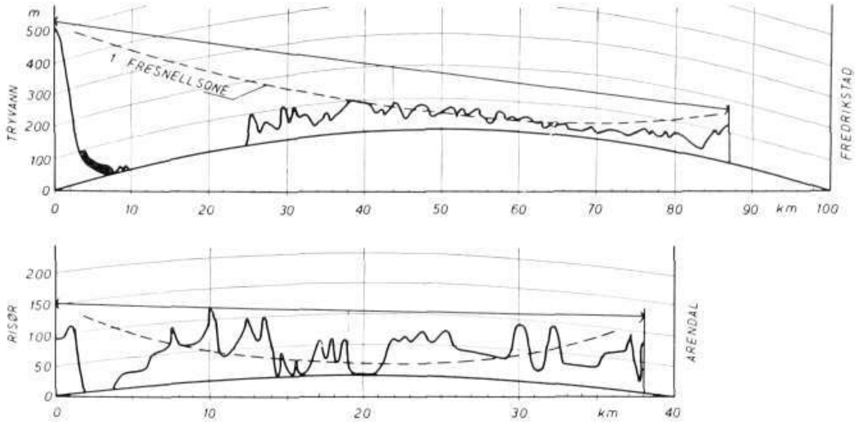
In actual cases the path attenuation is influenced by the presence of the earth. With a small ground clearance for the line-of-sight from sender to receiver, the terrain has a screening action, and the received power is less than the free space value. With larger clearance, parts of the power emitted may also reach the receiver by reflexion from the ground. Depending on phase conditions, this contribution to the received power may be positive or negative with respect to the direct signal. The calculation of received power over an actual path is therefore somewhat uncertain, but reasonable accuracy may be attained if the following points are observed:

1. It seems generally accepted that an unobstructed first Fresnel zone is sufficient to give "free space" conditions, [bibl. 2 and 3]. (First Fresnel zone is the locus (ellipsoid) of reflexion points giving a path difference of half a wavelength between direct and reflected beam).

Fig. 13 X 8128

Path profiles on the Oslo-Kristiansand route

Normal earth radius



2. With a tangent path over smooth ground, an additional loss of the order of 20 db can be expected [bibl. 4].
3. With a tangent path over a sharp obstacle, the additional loss amounts to about 6 db. [bibl. 5].

Plotting path profiles is one of the first things to do in planning a link route. Subsequent check of line-of-sight between the stations should always be made by optical means. It is our experience that once a free line-of-sight is ascertained, measurement of path attenuation is unnecessary. It should be noted, however, that this rule does not apply to hops where severe reflexions can be expected, as for instance over water.

Fig. 13 shows path profiles of two of the hops on the Oslo–Kristiansand route. The earth curvature appears very exaggerated, because distance and height are drawn to different scales. The longer of the two hops has almost complete clearance for the first Fresnel zone, while the shorter has a tangent path over a sharp obstacle. The measured additional losses are 1 and 6 db respectively, which are in good agreement with the expected figures.

It appears from the measurements presented in the next section that if a part of the energy radiated from a sender reaches a receiver via a reflexion path, cross-talk noise results due to interference between the direct and the reflected wave. This special type of distortion can be reduced to some extent by suitable choice of station sites.

The same type of interference can also result if a part of the sender power overreaches its hop and reaches a second receiver tuned to the same frequency. To avoid this effect, a zigzag course of the link route is preferable,

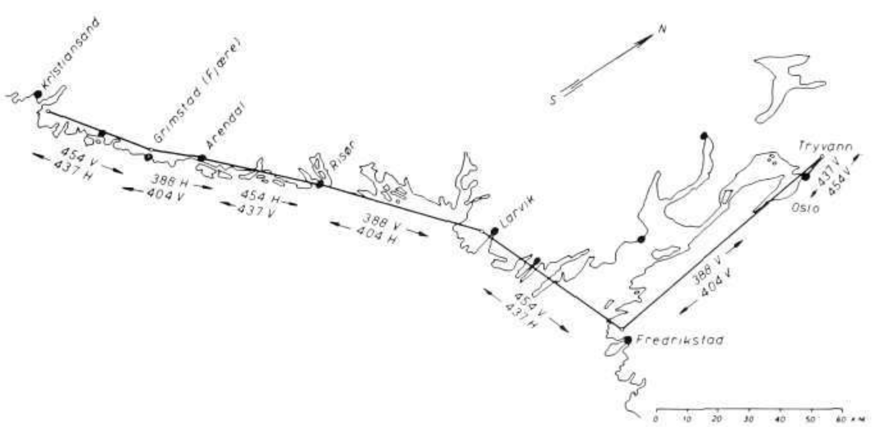
Fig. 14 X 8129

Frequency scheme for the Oslo-Kristiansand link

Frequencies: 388.23 Mc/s, 404.7 Mc/s, 437.64 Mc/s, 454.11 Mc/s

H Horizontal polarization

V Vertical polarization



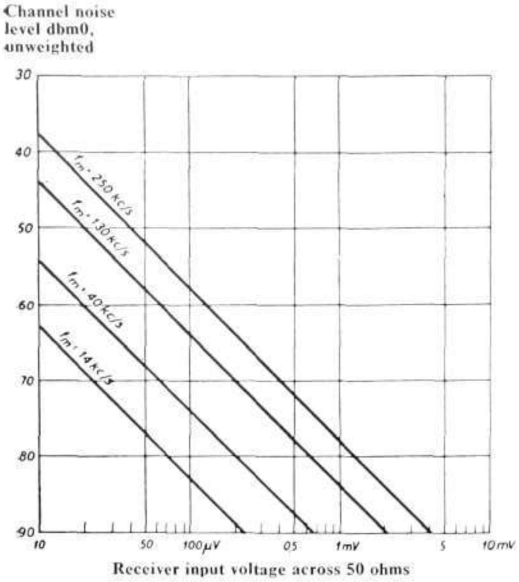


Fig. 15 X 2393

Thermal noise

Channel test tone deviation = 200 kc/s r.m.s
Noise figure F = 12 db
f_m = centre frequency of telephone channel

because of the directivity of the aerials. If it is impossible to avoid placing several stations in a straight line without screening terrain formations, this interference can be minimized by a suitable choice of frequencies, or by alternating the polarization of the aerials.

Fig. 14 shows as an example the frequency scheme for the Oslo–Kristiansand link. In order to economize with frequency space, the same frequencies are used on alternate hops.

Originally, only vertical polarization was employed. This resulted in "jump-over" interference at some stations. The polarization was therefore alternated, as appears from the figure.

Signal-to-Noise Ratio

In the following, the noise problems on radio links are briefly reviewed, and the performance obtained on the Oslo–Kristiansand link is presented in comparison with the CCIR recommendations on transmission performance [bibl. 6]. It should be noted that, according to established practice, the signal-to-noise ratio (abbreviated s.n.r.) is expressed in terms of a noise power level denominated dbm0. This actually means the ratio in decibels of a reference signal level, the so-called channel test tone, to the noise level in a single telephone channel of 3100 c/s bandwidth. As is known, the test tone is defined as having an absolute level of 1 mW at a point of zero relative level. CCIR has recommended certain values of the frequency deviation of the transmitted signal which result when the test tone is impressed on the baseband terminals of an FM radio link. For 60 circuit systems, 50, 100 and 200 kc/s deviation (r.m.s.) are recommended values.

A radio link introduces two principal sources of noise in a telephone channel:

1) Circuit noise and tube noise originating from the input stages of radio receivers; in the following such noise is designated *thermal noise*.

2) *Crosstalk* (intermodulation from other channels caused by non-linear distortion in the transmission elements.) Crosstalk is mainly unintelligible. The requirements for freedom from distortion are, as is known from conventional carrier frequency techniques, extremely strict, and at present it seems that they can only be satisfied by radio systems using frequency modulation.

The thermal noise level caused by one receiver alone is easy to calculate. It is characteristic for frequency-modulated systems that the noise level depends on the frequency location of the channel in the baseband. The channel at the high end of the baseband has the poorest s.n.r. In fig. 15, the s.n.r. for several individual channels is plotted against receiver input voltage.

All non-linear elements in the system contribute to the crosstalk. The largest contributions come from modulator and demodulator, from all radio frequency circuits (because of the inherent delay variations), from aerial feeders and from the hop between transmitter and receiver. Calculation of crosstalk noise is very complicated and a detailed discussion is beyond the scope of this paper. Usually, the crosstalk noise will also be worst in the highest channels.

Noise voltages from thermal noise and crosstalk are uncorrelated and add on a power basis. If the degree of modulation (frequency deviation) on a radio link is increased, the relative thermal noise level decreases. On the other hand, the crosstalk noise increases, and consequently an optimum deviation can be found, which gives the best s.n.r. in any certain system. This optimum deviation is not necessarily the same for channels at the high and low ends of the baseband.

Measurement of Signal-to-Noise Ratio

Conventional methods of measuring the transmission performance of carrier frequency systems appear to be unsuitable for testing radio links.

More recently a new test procedure, the so-called "white noise" method, has come in use [bibl. 7]. According to this method, the multiplex signal is substituted by a signal of random noise (white noise) of the same bandwidth. The test noise loads the system in a realistic manner, and the results can easily be interpreted. This method has proved to be so effective for testing multi-channel systems that CCIR and CCITT have proposed specifications for the test noise loading for various system sizes.

A noise test equipment has been developed at the laboratory of Elektrisk Bureau. All measurements on the Oslo–Kristiansand radio link have been made with this equipment. The test equipment permits quick checking of the signal-to-noise ratio (s.n.r.) of a number of individual channels within the baseband. For the sake of simplicity, however, only the results for the lowest and highest channel are presented here. By plotting curves of s.n.r. against applied test noise power, the optimum degree of modulation can easily be found.

Transmission Quality Requirements

The CCIR recommendations apply to a reference link of 2500 km length. According to CCIR Recommendation No. 200, a maximum noise of 5000 pW (psophometric) is allowed in a busy hour in the absence of fading. The figure refers to a point in the system of zero relative level. No recommendation is given about how this noise is to be distributed. In bibl. [8] and [9] a suitable distribution is proposed. Based on this proposal, we may assume the permissible noise power for the route Oslo–Kristiansand (298 km):

Line noise:	$5000 \frac{298}{2500} =$	600 pW
2 terminals:		500 pW
	Total	1100 pW

This corresponds to a noise level of − 60 dbm0 (s.n.r. of 60 db).

For *one hop* comprising two terminals separated by a distance of 50 km the requirement is fixed at − 65 dbm0.

Measured performance Oslo–Kristiansand

As mentioned above, the s.n.r. for the Oslo–Kristiansand link has been measured using the white noise method. Thus the noise level in a telephone channel has been plotted as a function of the degree of modulation, the latter expressed in terms of frequency deviation of the channel test tone. A test-noise loading of + 2.8 dbm0 has been used. This rating is based on the CCIR recommendation for the noise loading of N channels:

$$P_n = -15 + 10 \log_{10} N \text{ dbm0} \tag{2}$$

However, this rating applies when $N \geqslant 240$ channels. For smaller channel numbers, a higher relative loading is proposed:

$$P_n = -1 + 4 \log_{10} N \text{ dbm0} \tag{3}$$

when $12 \leqslant N < 240$ [bibl. 10]. This proposition is not yet ratified as a recommendation. According to formula 3, the noise loading for 60 channels should be + 6.1 dbm0. If this rating is used, the results presented below should be corrected.

Three different types of measurement have been made:

1. Sending and receiving equipment of a terminal station looped at intermediate frequency – that is, with no radio frequency equipment included. The unit *FM* in fig. 2 is connected to the discriminator *DI* with a limiter included.

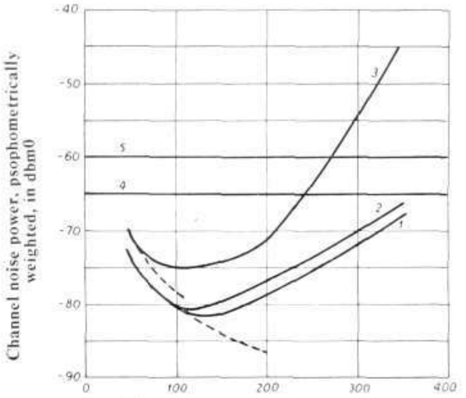


Fig. 16 X 2394

S.n.r. measurements with noise loading. **Lowest channel, 14 kc/s.**

1 Loop at intermediate frequency
2 Loop at radio frequency
3 Oslo—Kristiansand
4 Limit applicable to 2
5 Limit applicable to 3

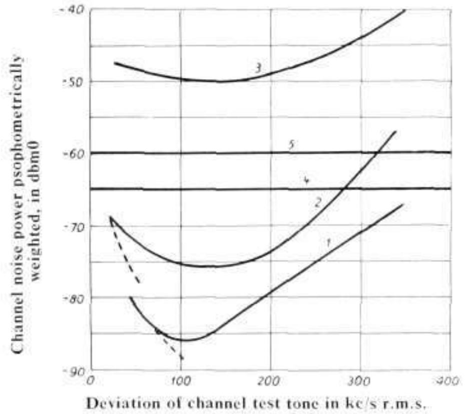


Fig. 17 X 2395

S. n. r. measurements with noise loading. Highest channel, 250 kc/s.
Curves explained under fig. 16.

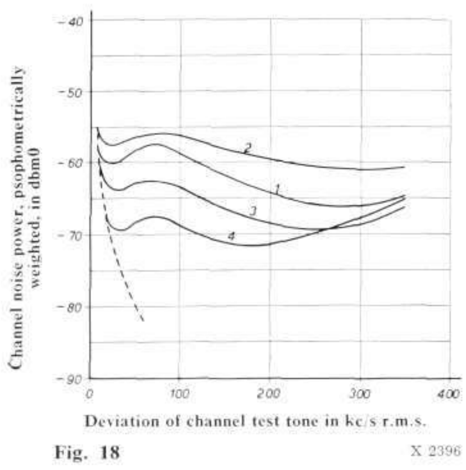


Fig. 18 X 2396

Measurements at 250 kc/s over a 5 km optical path

1 Normal dipoles in parabolic reflectors
2 One reflector substituted by a "corner reflector"
3 As 1, with improved radiation pattern of dipoles
4 As 3, with reflectors netting-clad

2. Sending and receiving equipment looped at radio frequency via an 80 db attenuator. Radio frequency equipment is included but not antennas and feeders.

3. The entire radio link Oslo–Kristiansand.

In figs. 16 and 17, the solid lines indicate total s.n.r., while the dotted lines indicate s.n.r. due to thermal noise alone.

Fig. 16 shows the results obtained in the 14 kc/s channel. The curves exhibit a pronounced maximum of s.n.r. As expected, curve 1 (for terminal equipment looped at intermediate frequency) shows the best results. The deterioration when the entire route is included (curve 3) is small except with a very high degree of modulation. With normal modulation, all figures are substantially better than the requirements.

Fig. 17 shows the corresponding results obtained for the highest channel (250 kc/s). Curve 1 exhibits approximately the same figures as for the lowest channel, but there is an appreciable deterioration for terminal equipment looped at radio frequency (curve 2). This is mainly caused by the delay distortion of the radio frequency circuits. For the entire route the deterioration is very pronounced, and far greater than was expected. The radio equipment alone complies with the requirements, but in the actual link this channel falls short by about 10 db.

This result has been subject to extensive research. An approach to the problem was made with a local terminal loop including feeders and antennas separated by about 2 metres. The results were comparable to case 1 above, proving that antennas and feeders performed well.

It soon became evident that the distortion was originating from the hop itself, and suspicion was focussed on possible unwanted signal paths between sender and receiver, caused by terrain reflexions (multi-path propagation). Measurements on a 5 km. experimental link are summarized in fig. 18. Curve No. 1 shows s.n.r. resulting when the normal antennas were used. The curve follows an unexpected pattern, the s.n.r. deteriorating rapidly at a very low degree of modulation. The best s.n.r. is obtained at a very large deviation. The conventional view that s.n.r. is best when the contributions from thermal noise and crosstalk are equal, does not apply to this case. To explain this pattern, it must be assumed that the transmission path *exhibits distortion factors of high order*. This phenomenon, however, cannot be thoroughly dealt with here.

Fig. 18 further shows that the crosstalk can be substantially improved if antennas with less side lobe radiation are used. It seems quite feasible to satisfy the CCITT recommendations. The investigation, not yet concluded, also seems to suggest that the path length is of minor significance for the crosstalk noise, provided the path is within line-of-sight.

Distortion due to a reflected signal can also arise in a fundamentally different way, namely by "amplitude to phase conversion" in the receiver proper. Investigations have shown, however, that this contribution is negligible.

Operational Experience

The Oslo–Kristiansand radio link has now been in operation for more than 17 months, and the experience gathered so far is a good basis for judgement of the operational problems to be encountered and the reliability which can be achieved.

It should be noted that *no stand-by equipment* is installed on this link. Usually, the occurrence of a fault, for instance a tube failure, involves total traffic stoppage. The duration of the stoppage cannot be shorter than the time spent by the serviceman travelling to the station. With the exception of Oslo and Tryvann, which are staffed 24 hours a day because of other services, the stations are unattended. It is fairly easy to reach these stations, but takes nevertheless between half an hour and an hour, even in summer. In winter conditions it takes even longer.

Table 1. Summary of faults from 1.12. 1956 to 1.5. 1958
without stand-by

Cause of fault	Total number in use	Faults causing break-down	Faults not causing break-down	Total of faults	Break-down hours	Break-down in % of time
Tubes 2C39A	56	7	11	18	38.5	0.31
Tubes 2C40	42	1	19	20	1.2	0.01
Other tubes	482	4	6	10	16.1	0.13
Other components		17	26	43	65.6	0.53
Lightning		1	0	1	5.0	0.04
Mains power failure		15	0	15	47.0	0.38
Unknown cause		13	3	16	7.5	0.06
Sum		58	65	123	180.9	1.46

The summary of service failures presented in table 1 should be judged with these conditions in view. The breakdown time is dominated by failures of the tube *2C39A*. The average lifetime of this tube has nevertheless proved to be satisfactory, being well above 10000 hours, probably in the neighbourhood of 20000. It appears from the summary that the mains power has failed several times. This is due to some deficiencies of the stand-by power plants which have later been overcome, and also because stand-by power is not yet installed at one of the repeaters.

The breakdown time has a decreasing tendency. Table 2 shows the percent breakdown time for each month from December, 1956 to April, 1958.

Breakdown or transmission impairment caused by climatic conditions has never been observed. It is remarkable that the performance of antennas and feeders has never been appreciably impaired, even under heavy snow and ice loading.

Table 2. Monthly failure statistics from Dec. 1956 to April 1958.
Radio link without stand-by.

Month		Breakdown in percent of time	Month		Breakdown in percent of time
Dec.	1956	3.25	Sept.	1957	0
Jan.	1957	1.3	Oct.	,,	0
Feb.	,,	1.18	Nov.	,,	0.16
March	,,	0.37	Dec.	,,	0
April	,,	1.9	Jan.	1958	0.1
May	,,	2.35	Feb.	,,	0.7
June	,,	2.3	March	,,	0.4
July	,,	4.1	April	,,	0.04
Aug.	,,	1.85			

Fading

On the Oslo–Kristiansand link, a continuous recording of fading has been made on the hop Tryvann–Fredrikstad. This hop is about 87 km long and thus the longest on the route. An exhaustive study of the recorded data is in progress. Preliminary investigation for the first six months of recording has shown that fading deeper than 10 db has occurred for 0.85 % of the time, deeper than 20 db for 0.06 %, and deeper than 30 db for 0.0003 % of the time. The latter figure corresponds to 7 minutes in half a year.

Recording of fading on the other hops has not been made, but there is no indication that fading occurs to any serious extent. Traffic breakdown or impairment due to fading has so far not occurred.

Service

The service work on the Oslo–Kristiansand link is performed at each station by the district telegraph technicians, who attended a 3-days instruction programme at the laboratories of Elektrisk Bureau. The service includes weekly routine inspections with logging of all instrument readings, and emergency visits ordered by the terminal operator in case of a fault at a station.

As mentioned above, this link is operating without any stand-by equipment. There are no complete replacement units stored at the stations. It should also be noted that the fault indication device mentioned earlier is not installed on the Oslo–Kristiansand link. Instead, a remote control equipment enables the terminal operator in Oslo to localize the faulty station, without giving specific information as to the kind of fault. The service work is therefore based on the assumption that all faults can be localized and repaired on the station. For this purpose a small stock of spare components is kept on all stations. In most cases, a fault can be localized in a few minutes by means of the measuring panel.

Repairing this kind of equipment on the spot may seem difficult. However, in practice it has worked out well. The majority of the failures are due to defective tubes. Several units are critical and need laboratory facilities for proper adjustment. In the case of a fault in one of these units, a temporary repair is made on the spot, and a replacement unit is sent as soon as possible. This procedure has never resulted in a temporary impairment of transmission performance.

Bibliography

1. Travis, C: *Automatic Frequency Control.* Proc. Inst. Radio Engrs *23*(1935): 10, pp. 1125—1141.
2. Friis, H T: *Microwave Repeater Research.* Bell Syst. Tech. J *27*(1948): 2, pp. 183—246.
3. Ortusi, J: *La propagation des ondes métriques et centimétriques (longueurs d'onde comprises entre 6 m et 3 cm). Détermination de l'equivalent de transmission.* Ann. Radioélectricité *9*(1954) 37, pp. 227—273.
4. Guenther, R: *Radio Relay Design Data 60—600 Mc/s.* Proc. Inst. Radio Engrs *39*(1951): 9, pp. 1027—1034.
5. Starr, A T & Walker, T H: *Microwave Radio Links.* Proc. Instn Elect. Engrs Pt III *99*(1952): pp. 241—256 & 289—293.
6. International Radio Consultative Committee (CCIR). *Documents of the VIIIth Plenary Assembly.* Warsaw 1956. Vol. 1 Geneva 1956.
7. White, R W & Whyte, J S: *Equipment for Measurement of Interchannel Crosstalk and Noise on Broad-Band Multichannel Telephone Systems.* Post Off. Elect. Engrs' J *48*(1955/56) 3, pp. 127—132.
   International Telegraph and Telephone Consultative Committee (CCITT). *Red Book Vol. I, 1st Plenary Assembly.* Geneva 1956, pp. 444—450.
8. Vasseur, J P: *Les faisceaux hertziens à courant porteurs devant les récommandations du C.C.I.F.* Ann. Radioélectricité *9* (1954): 35, pp. 47—82.
9. Knudtzon, N: *Anvendelse av C.C.I.F. rekommandasjoner på radiolinjer.* Elektrotek. T *68*(1955): 7, pp. 121—127.
10. International Telegraph and Telephone Consultative Committee (CCITT), International Radio Consultative Committee (CCIR). *Report of the Joint CCITT-CCIR Working Party on Circuit Noise.* Doc. 575, 1958. Geneva December 1958.

Vehicle-actuated Traffic Signals at Södertäljevägen—Sockenvägen, Stockholm

G BERGLÖF, THE STOCKHOLM STREETS IMPROVEMENT BOARD, STOCKHOLM

U.D.C. 625.746
656.057

L M Ericsson's vehicle-actuated traffic signal systems have been described in earlier numbers of Ericsson Review. In a vehicle-actuated system the green signal periods vary automatically from one cycle to the next according to the current volume of traffic passing through the intersection. The particular feature of L M Ericsson's system is the use of electric cable detectors which are installed under the road surface, being therefore unexposed to wear from passing vehicles. Consequently the life of the detectors – which are normally the most heavily taxed components in a road signal plant – is practically unlimited. The author of this article is the engineer responsible for the planning of all signal installations in Stockholm. The installation he describes is a new and rather complicated one in a suburb on the south of the city. The control apparatus in L M Ericsson's system has proved to possess the necessary flexibility for dealing with many new requirements in traffic control.

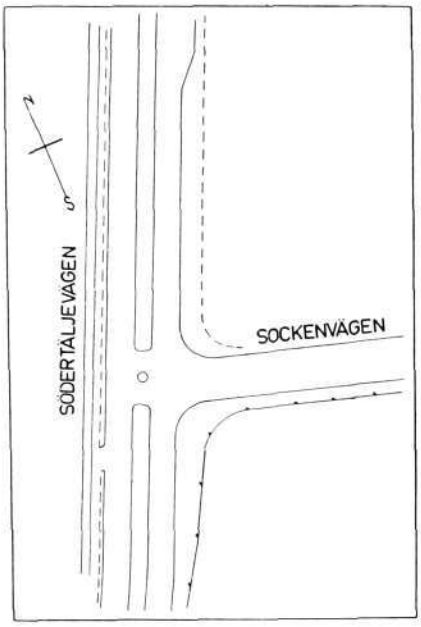


Fig. 1 X 2406
Södertäljevägen—Sockenvägen before the 1957 reconstruction

A traffic signal plant manufactured by L M Ericsson was installed at the end of June 1958 at the junction of Södertäljevägen and Sockenvägen about 1 mile south-west of the Liljeholmen bridge. Sockenvägen comes in from the east to meet Södertäljevägen in a T-junction. The traffic at the junction has progressively increased, and by 1956 had reached such proportions that some action to improve the situation had become imperative. This was confirmed by the high accident statistics at the junction.

Södertäljevägen forms part of Highway One and is the approach road to Stockholm from the south, but is at the same time an important link between the city and the south-western suburbs. Sockenvägen provides a link eastwards, particularly with certain suburbs, and serves to some extent as an outer circular road, stretching from Södertäljevägen to Skarpnäck on the boundary of the town of Nacka.

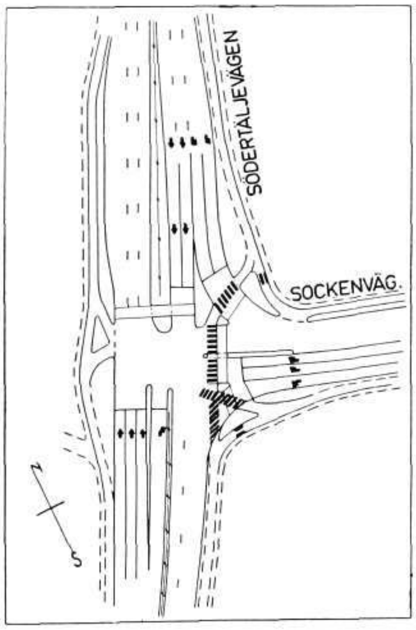


Fig. 2 X 2407
The junction after the reconstruction

The two roads meeting at this junction are accordingly very important arteries, the main streams of traffic being along Södertäljevägen in both directions and from Sockenvägen via Södertäljevägen townwards and vice versa. The traffic from Sockenvägen southwards is admittedly smaller, but is of no mean proportions nevertheless. The passage through the junction is complicated by the considerable bicycle and autocycle traffic on the side lanes on both roads, and by the large number of pedestrians proceeding especially to the several bus stops in the vicinity. There are also two schools and a fairly large resident population in the neighbourhood.

The appearance of the junction prior to the reconstruction is shown in fig. 1. The new plan, involving the installation of traffic signals, was based on a traffic count at the Södertäljevägen–Sockenvägen junction on June 3, 1955. The traffic quantities recorded in that count during morning and afternoon peak hours are shown in fig. 3, the first figure representing motor cars, lorries and buses, the second motor cycles and autocycles, and the third push cycles. The final arrangement is shown in fig. 2. The work was completed during 1957 and the signals were installed at the end of June 1958.

The traffic signals consist of a vehicle-actuated system comprising seven phases, which on first thought may appear unnecessarily many. The various phases are illustrated in fig. 4.

On closer consideration it is seen that the phases consist of three "main phases" *B*, *D* and *F*, for the Södertäljevägen traffic in both directions, for traffic entering Södertäljevägen from Sockenvägen, and for traffic turning right from Södertäljevägen into Sockenvägen. Each main phase has a sub-phase for bicycles and autocycles in the same directions, *A*, *C* and *E1*. The bicycle phases can be kept quite brief; they operate only in response to a bicycle request and come immediately before each main phase. With this phase sequence, traffic turning left from Södertäljevägen into Sockenvägen can proceed uninterruptedly through the successive phases *B*, *C* and *D*. In the same way the traffic turning left out of Sockenvägen can proceed in phases *D*, *E1* and *F*, and the Södertäljevägen traffic towards town in phases *F*, *A* and *B*. The seventh phase *E2* is intended solely for pedestrians crossing the western carriageway of Södertäljevägen; it operates in response to a pedestrian request only if there is not already a request for phase *E1*, i.e. bicycle and autocycle traffic swinging right into Sockenvägen. The provision of phase *E2* means that the traffic on the eastern carriageway of Södertäljevägen is not interrupted if a single pedestrian wishes to cross the western carriageway. All pedestrian crossings have push buttons, and pedestrians can everywhere cross simultaneously with the vehicle traffic in one or more of the phases.

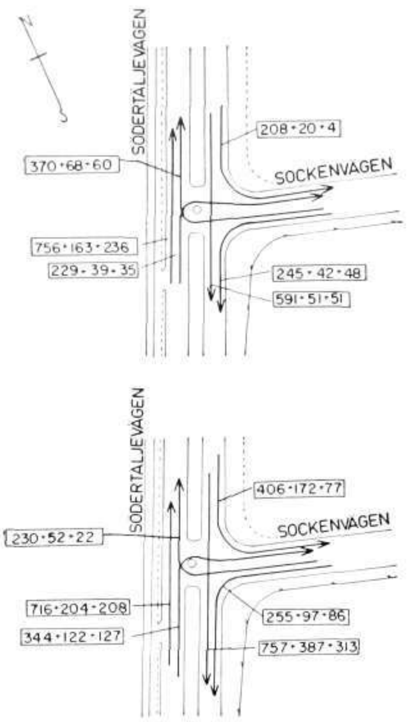
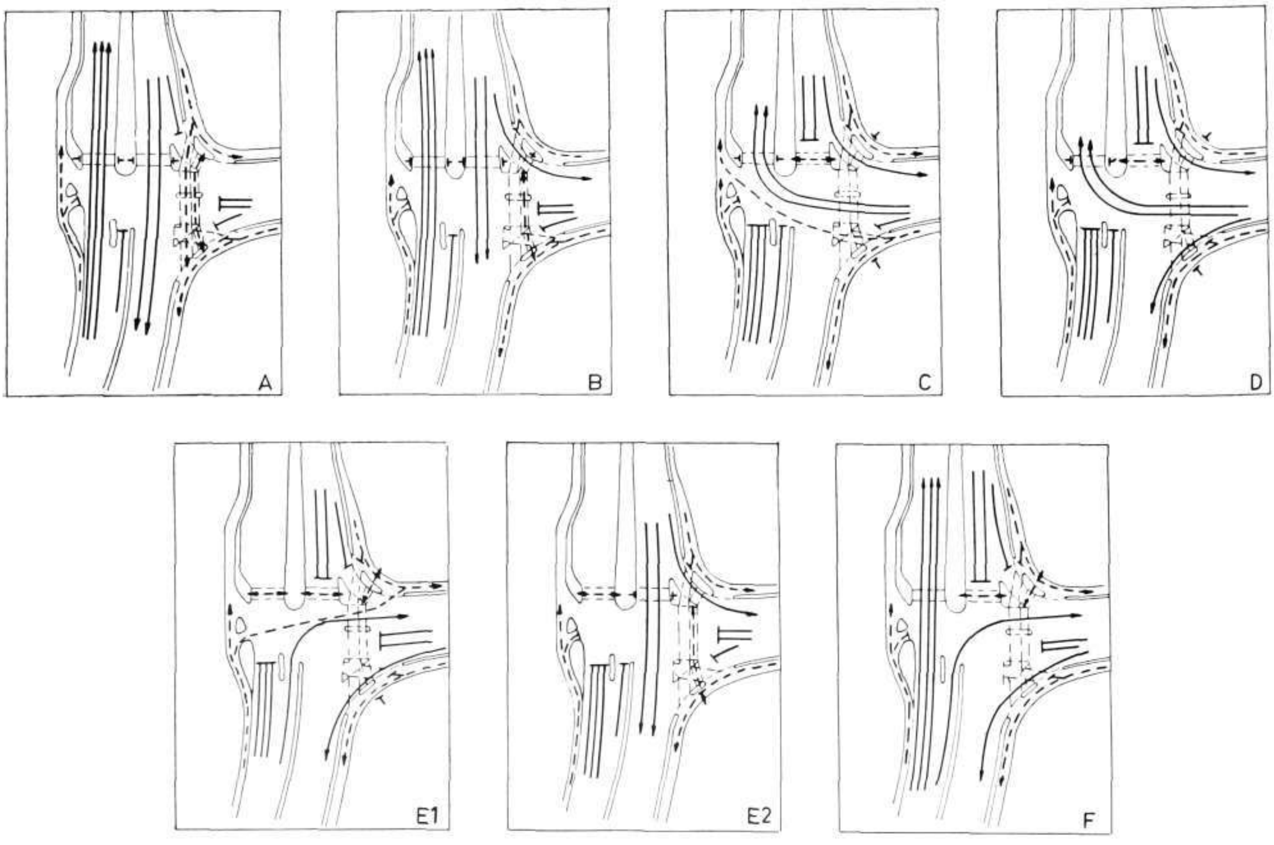


Fig. 3 X 2408

Traffic quantities counted on June 3, 1955, during peak hours in morning (above) and afternoon (below)

Fig. 4 X 7754

The seven signal phases in the 1958 plant: main phases *B, D, F*; sub-phases *A, C, E1*; and pedestrian phase *E2*



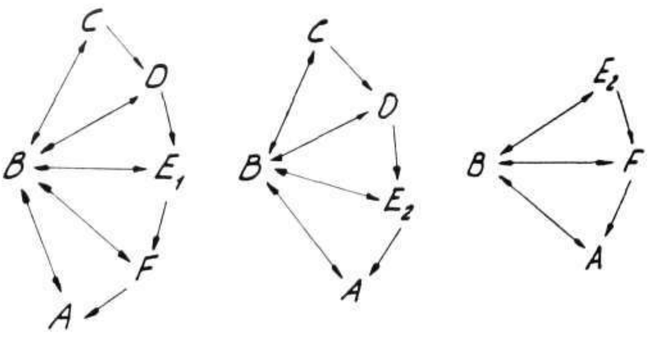


Fig. 5 X 8138

The phase sequence of signals may follow either of these three cycles; one or more phases, with the exception of phase *B*, may be skipped within any one cycle. In the absence of a request the cycle returns to phase *B*.

The phase sequence for traffic of all kinds and in all directions is *A–B–C–D–E1–F*, and any phase or phases are skipped for which no request exists. If there is no request for changing to green or for extension of the green period, the cycle returns to phase *B*; phase *B* cannot be skipped. A restriction exists to the extent that phases *C* or *D* cannot occur in the same cycle as the two phases *E2* and *F*. The reason for this is that, with the phase sequence *C–D–E2–F*, the forward-going traffic on the eastern carriageway of Södertäljevägen, after having waited through phases *C* and *D*, would start moving in phase *E2* and then be stopped again in phase *F* before being allowed to proceed again in phases *A* and *B*. Consequently, if a request from motor vehicles turning right out of Södertäljevägen is received after the change to phase *E2* has already started, the phase sequence will continue to *C*–(or *D*–)*E2–A* (or *–B*), whereas, if the request comes before the change to *E2* has started, the phase sequence will instead be *C*–(or *D*–)*E1–F* (or *–A* or *–B*). If phases *C* or *D* have not preceded phase *E2*, a change can be made to *F* or *A* or *B*. The possible combinations in any one cycle are illustrated in fig. 5, and, as stated, any one or more of the phases, except phase *B*, can be skipped in any cycle.

In order to make the fullest possible use of the capacity of the junction without unnecessary delays between one flow of traffic and another, phase *D* has been given a zero minimum period in phase sequences *C–D–E1* and *C–D–F*. The reason will be apparent if one considers that, at the end of phase *C*, there may still be traffic turning right out of Sockenvägen. The signals now change to phase *D*; but during the change to phase *D* the last right-turning vehicle from Sockenvägen may have passed the stop limit. In order that right turning traffic from Södertäljevägen shall not have to wait unnecessarily long, the change from phase *D* to whichever of phases *E1* or *F* has been requested must start as soon as the change from phase *C* to phase *D* has been completed. The left-turning traffic from Sockenvägen is not affected by the latter change but continues uninterrupted. On the same principle it has been arranged that the minimum *F* period shall be zero in the sequences *E1–F–A* or *E1–F–B*, and the minimum *B* period zero in the sequences *A–B–C* or *A–B–D*. The following rule may be formulated. If no light changes aspect more than once in three successive phases, the minimum green period for the middle phase shall be zero. Thus the change from the middle phase starts at the same instant as the change to that phase has been completed if the need for the middle phase no longer exists at that time.

The traffic-handling capacity of this junction since the installation of the signals has been very satisfactory. One complication, however, has been the long and steep hill leading up to the junction from the north; heavily loaded lorries have found it difficult to get moving and follow the vehicle in front without exceeding the predetermined interval. This has led to gaps in the columns, with the consequent risk of the signals switching to red. During the morning and afternoon rush hours the police have usually controlled the

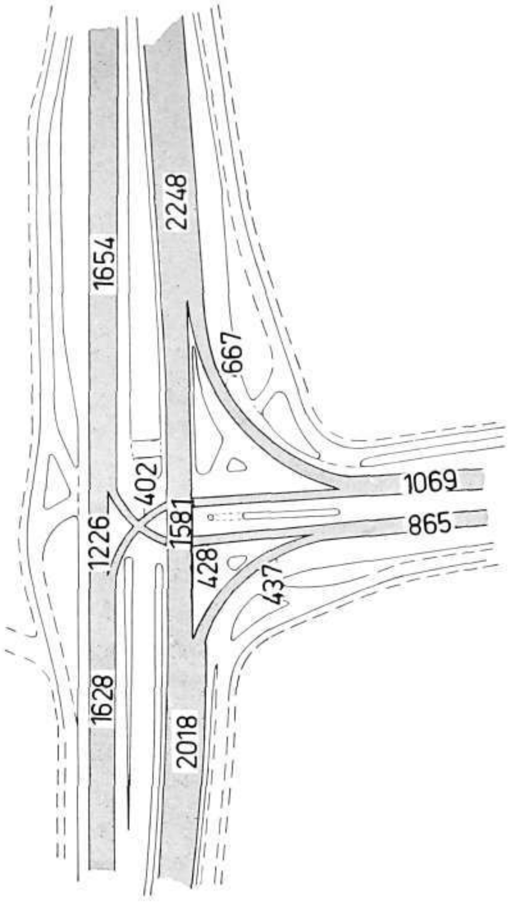


Fig. 6 X 2409

Traffic count during peak hour on November 15, 1958 (12.45 a.m.—1.45 p.m.)

signals by push-button operation, which has been very much simpler than the earlier method of traffic control by police on ordinary point duty. Four push buttons are provided for manual control of signals, one for each of phases *A*, *C* and *E1*, and one marked "No bicycles", which switches the signals from *A* to *B*, *C* to *D*, and *E1* to *F*. Phase *E2* cannot be operated by manual control.

After the signals had been in use for some months, a traffic count was made at the junction on November 15–17. The highest number of vehicles during one hour was counted on Saturday, November 15, between 12.45 a.m. and 1.45 p.m. The traffic quantities during this hour are shown in fig. 6, the volume per lane and hour being about 1200 motor vehicles, which, in view of the traffic being divided into three main phases, is a very high figure.

As stated in the introduction, the signalling plant with electric cable detectors was designed, manufactured and tested by L M Ericsson. Special relay sets were added to the standard equipment in order to meet all the requirements of this heavily trafficked junction with its combined motor vehicle, bicycle and pedestrian traffic. The plant has so far operated at the same high level of reliability as the previous systems supplied to the City of Stockholm by L M Ericsson.

L M Ericsson Exchanges Cut into Service 1958

Exchanges with 500-line selectors

Town	Exchange		Number of lines
Argentine			
Mendoza	Mendoza I	(extension)	1000
Brazil			
Americana		(extension)	500
Araçatuba		(extension)	500
Carangola		(extension)	160
Cuiabá			1000
Curvêlo			300
Divinópolis			500
Dracena			500
Franca			1500
Limeira		(extension)	1000
Maringá		(extension)	500
Mirassol			500
Oswaldo Cruz			500
Patos (Paraíba)			500
São José do Rio Preto		(extension)	500
Sete Lagoas			500
Tupã		(extension)	1000
Colombia			
Barranquilla	Estadio	(extension)	1000
»	Sur	(extension)	1000
Bogotá DE	Ciudad Universitaria		3000
»	San Fernando	(extension)	1000
Manizales		(extension)	2000
Medellín	Bosque	(extension)	1000
»	Centro	(extension)	500
Neiva		(extension)	500
Yarumal			500
Ecuador			
Guayaquil		(extension)	1000
Quito	Mariscal Sucre	(extension)	500
Ethiopia			
Addis Ababa	Centro	(extension)	500
Finland			
Oulu/Uleåborg		(extension)	500
Rauma/Raumo		(extension)	500
Tampere/Tammerfors		(extension)	2000
Turku/Åbo		(extension)	2000
Vasa/Vaasa		(extension)	500
Iceland			
Reykjavik	Grensås	(extension)	1500
Italy			
North Italy			
Padova		(extension)	2500
Schio		(extension)	300

Town	Exchange		Number of lines
Stra		(extension)	20
Treviso		(extension)	500
Venezia	Centro	(extension)	2400
Vicenza		(extension)	1500
South Italy			
Acireale		(extension)	1000
Avellino		(extension)	1000
Castellamare		(extension)	500
Castellamare del Golfo		(extension)	80
Catanzaro		(extension)	1100
Isola Liri			300
Lecce		(extension)	1000
Matera		(extension)	1000
Mazara del Vallo			1000
Messina		(extension)	4500
Molfetta		(extension)	1000
Napoli/Neapel	Bagnoli		1500
»	Centro	(extension)	3000
»	Fuorigrotta		2500
»	Museo	(extension)	500
»	Nolana	(extension)	1500
»	Portici		3000
»	Posillipo		2000
Palermo	Ferrovia	(extension)	2500
»	Polacchi	(extension)	3500
Potenza		(extension)	1000
Ragusa		(extension)	1000
Reggio Calabria		(extension)	1000
Salerno		(extension)	1300
Sora			400
Taranto		(extension)	1300
Trapani		(extension)	1000
Lebanon			
Beirut		(extension)	3000
Furn el Chebak			1500
Mexico			
México DF	Atzcapotzalco	(extension)	500
»	Madrid	(extension)	10000
»	Peravillo	(extension)	1000
»	Piedad		9000
»	Portales	(extension)	1000
»	Sabino	(extension)	500
»	Saro	(extension)	500
»	Valle	(extension)	1000
»	Victoria	(extension)	500
Puebla		(extension)	1000
Netherlands			
Rotterdam	Schiedam	(extension)	2000
»	West II	(extension)	3000
Norway			
Steinkjer			1500
Trondheim		(extension)	2500

Town	Exchange		Number of lines
New Zealand			
Kensington			500
Onerahi			500
Panama			
David		(extension)	200
Panama City	Panama IV		1000
Salvador			
San Salvador		(extension)	2000
Sweden			
Enköping		(extension)	500
Gävle		(extension)	500
Gothenburg	Biskopsgården		6000
»	Mölndal	(extension)	1000
Huskvarna		(extension)	1000
Jakobsberg		(extension)	500
Jönköping		(extension)	500
Karlskoga		(extension)	1500
Karlstad		(extension)	1500
Ludvika		(extension)	500
Norrtälje		(extension)	500
Stockholm	Kungsholmen	(extension)	1000
»	Farsta	(extension)	8000
»	Huddinge	(extension)	1000
»	Hässelby	(extension)	3000
»	Lidingö-Villastad	(extension)	1000
»	Lidingö-Brevik	(extension)	1000
»	Storängen	(extension)	1000
»	Sundbyberg	(extension)	1000
»	Viggbyholm	(extension)	1000
»	Årsta		10000
»	Örby	(extension)	3000
Trollhättan		(extension)	1000
Uppsala		(extension)	2500
Västerås		(extension)	1500
Turkey			
Antalya			1000
Çankiri			500
Uşak			500
Venezuela			
Barquisimeto		(extension)	1000
Cabimas			1500
Ciudad Bolivar		(extension)	1000
Coro		(extension)	900
Cumaná		(extension)	1650
La Concordia			1000
Lecheria			300
Maturin			1500
		Total	180710

Public exchanges with crossbar switches

Town	Exchange	Number of lines
Brazil		
Santo André	Santo André	4000
»	São Caetano	2000
»	São Bernardo	1200
»	Ribeirão Pires	200
»	Mauá	200
Burma		
Rangoon	North	2000
»	Insein	300
Denmark		
Aalborg	(extension)	2000
Copenhagen	Bella	1000
»	Damsø	1000
»	Herlev (extension)	1000
»	Hvidovre	5000
»	Rødovre (extension)	1000
»	Søborg	1000
Odense	(extension)	22000
Finland		
Helsinki/Helsingfors	Kaarela/Kårböle	1000
»	Malmi/Malm (extension)	1000
»	Meilahti/Mejlans (extension)	1000
»	Pakila/Baggböle (extension)	1000
»	Sörnäinen/Sörnäs (extension)	1000
Karjaa/Karis		1000
Indonesia		
Magelang		1000
Ireland		
Limerick	(extension)	400
Netherlands		
Rotterdam	Schiedam (extension)	2000
»	West II (extension)	3000
Pakistan		
Sukkur		1000
Sweden		
Skövde		6700
Yugo-Slavia		
Beograd	Krunski Venac	2000
»	Rakovica	600
Kraljevo		600
Niš	(extension)	1000
Sombor		1000
Zagreb	Pešćenica (extension)	1000
»	Trnje	2000
*U.S.A.**		
Leesburg, Florida		3000
North Madison, Indiana		600
Winter Garden, Florida		1500
Crestline, Ohio		1200
Galion, Ohio		1000
Woodland (Mansfield), Ohio		1000
Dalton, Georgia		4000
Live Oak, Florida		1000
Florida State University		1000
	Total	86500

* These exchanges, system NX-1, were delivered by North Electric Co., Galion, Ohio.

	Number	Number of lines**
Public rural exchanges with crossbar switches, system ARK, ART		
Denmark	—	100
Ethiopia	1	60
Finland	58	6500
Italy	2	1180
Netherlands	3	2300
Poland	—	1000
Sweden	2	3600
Total	66	14740
Rural exchanges with 100-line selectors, system XY		
Norway	13	2820

	Number	Number of lines**
Private automatic telephone exchanges PAX and PABX (delivered from Stockholm)		
Exchanges with 500-line selectors	39	13820
Exchanges with crossbar switches	17	4130
All-relay exchanges	489	4431
Exchanges with 100-line selectors, system AHD	160	14770
Exchanges with 30- and 25-line selectors, system OL	308	10023
Total	1013	47174

** The number of lines includes both new exchanges and extensions of existing exchanges.

Ericsson LM NEWS *from* *All Quarters of the World*

Record Increase in World Telephones
U. S. A. still holds the lead

The telephone networks of the world are expanding at an ever increasing rate. In 1957 the number of installed telephones rose by 7,800,000 –the largest annual increase in the history of telephony. U.S.A. still holds first place with 37 telephones per 100 inhabitants. For the whole world the figure is only five.

"The World's Telephones", issued annually by the American Telephone and Telegraph Company, records fifteen countries with a million and more telephones at January 1, 1958. The year previously there were fourteen. The fifteenth country is the Soviet Union, for which statistics are now available.

The annual rise in telephones in the years prior to the late war was about one million. In 1939 there were 41.1 million telephones in the world. Since the war the increase has been very much faster, and there are now 117.8 million. The order of countries having more than 1 million telephones has not changed much. U.S.A. retains the lead, with Sweden still second. Canada again occupies third place. The only change of order is that Italy has passed Argentina.

Among the million-telephone countries the greatest expansion since 1948 has been in Japan, where the number of telephones has risen by 225.2 per cent. Next come Italy with an increase of 208.1 per cent, Spain 162.8 per cent, Holland 138.0 per cent, Canada 115.9 per cent, Australia 100.2 per cent. Among the other countries listed the increase varies between 58.8 and 85.9 per cent.

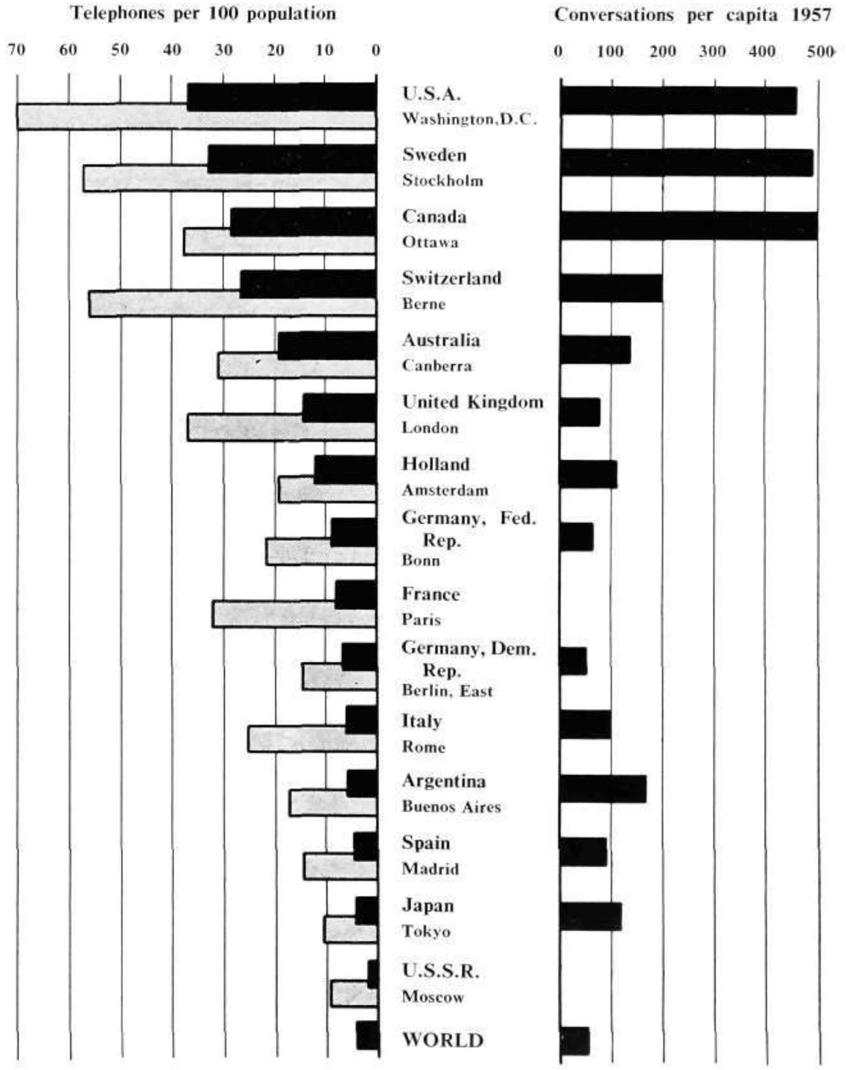
In these fifteen countries the telephone is still used most in Canada, but it looks as though Sweden might pass Canada in conversations per capita next year. U.S.A. is third in this respect, while statistics of per capita conversations in France and the Soviet Union are lacking. The figure for the whole world is approximate.

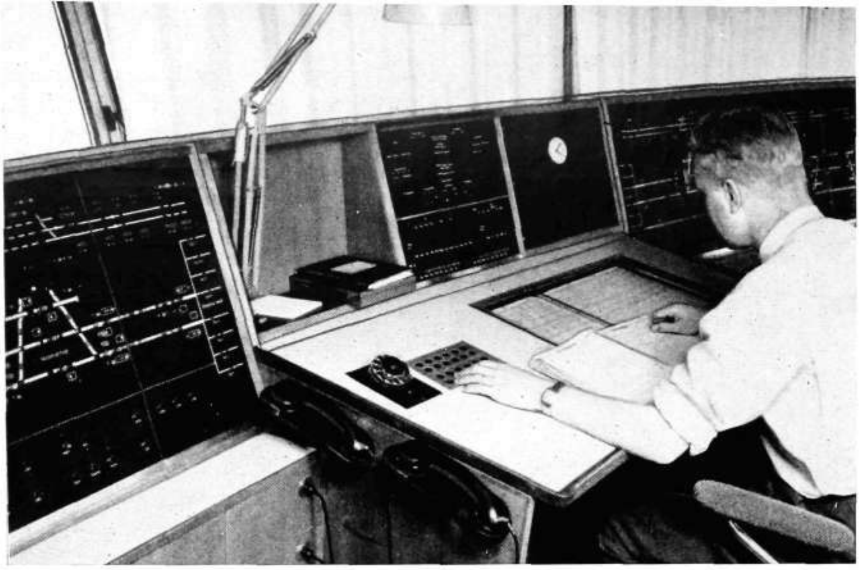
Among all countries in the world, however, the crown goes to Alaska, where every inhabitant has 581 conversations per annum. In Hawaii the figure is 522.2. The lowest figure is in French West Africa, one conversation per inhabitant per annum.

Washington, D.C., has a higher telephone density than any other city, 70 telephones per 100 inhabitants. San Francisco (60.1) had held the lead for many years, but has now been outdistanced by Washington, Atlantic City, N.J. (62.7) and Los Angeles (61.0). After the American cities come Basel, Switzerland, with 57.5, and Stockholm, Sweden, with 57.2.

Among the leading fifteen countries Switzerland has gone furthest in automatization, 99.7 per cent of Swiss telephones now being automatic. West Germany is second, followed by Holland, Italy and East Germany. U.S.A. is sixth with 89.4 per cent, Argentina seventh with 83 per cent, and Sweden eighth with 82 per cent.

Countries with above one million telephones





L M Ericsson visit to Far East

Early this year the president of L M Ericsson, Mr. Sven Ture Åberg, accompanied by Mr. Malte Patricks, made a journey to Thailand, Burma, Indonesia and Australia. The photograph below was taken in Bangkok and shows Mr. Åberg with Commander Tabpanawong Bunnag, Chief of Port Organization and (left) Mr. Sanong Thavisin, director of the Vichien Radio & Television Co. Ltd., the L M Ericsson representatives in Thailand.

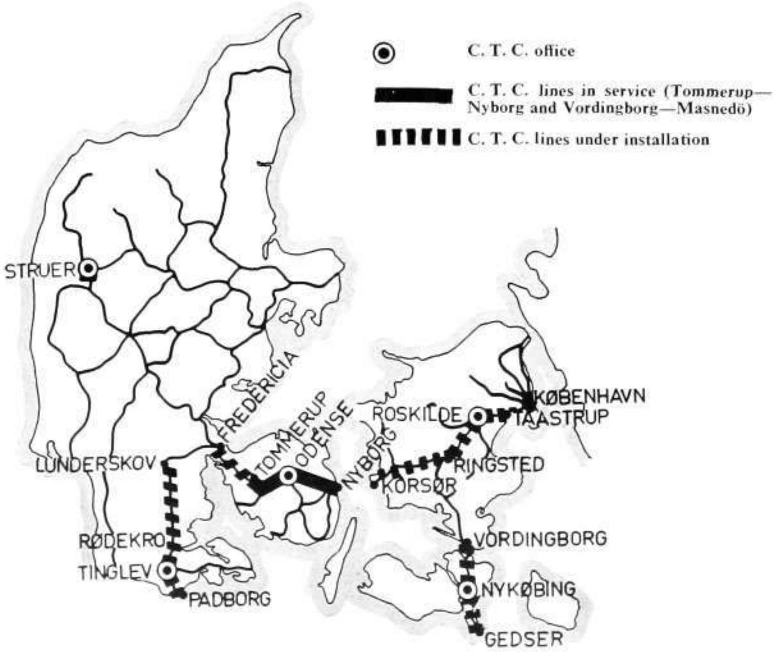
Danish State Railways install additional C. T. C. Plant

The Danish State Railways opened their first centralized-traffic-controlled section of line in 1956. This was a single-track line running from Vordingborg to Masnedö across the bridge linking the islands of Zealand and Falster. A second C.T.C. plant was brought into commission on the double-track line Nyborg–Odense–Tommerup in 1956 and 1957. The C.T.C. equipment for the latter installation is shown in the photograph above.

The interlocking equipment for these installations and the operators' desks for the C.T.C. offices were delivered mainly by L M Ericsson's Danish associates, Dansk Signal Industri A/S, while the remaining C.T.C. equipment came from L M Ericssons Signalaktiebolag in Stockholm.

The Danish Railways have a long-term plan for the installation of C.T.C. on several lines (see map). The aim is, first, to place the Nyköbing–Gedser section under centralized traffic control, later linking up with the Vordingborg–Masnedö system so as to form a continuous C.T.C. line between Gedser and Vordingborg with C.T.C. office at Nyköbing.

The double-track line Copenhagen–Korsör is to be converted to C.T.C., beginning with the Taastrup-Ringsted section with C.T.C. office at Roskilde.



The Nyborg–Tommerup line, with C.T.C. office at Odense, is to be extended to Fredericia.

The next project is the Lunderskov–Padborg line on Jutland, starting with the Tinglev–Rödekro section and a provisional C.T.C. office at Tinglev. Finally it is planned that C.T.C. shall be installed on the Struer–Hjerm line on Jutland with C.T.C. office at Struer.

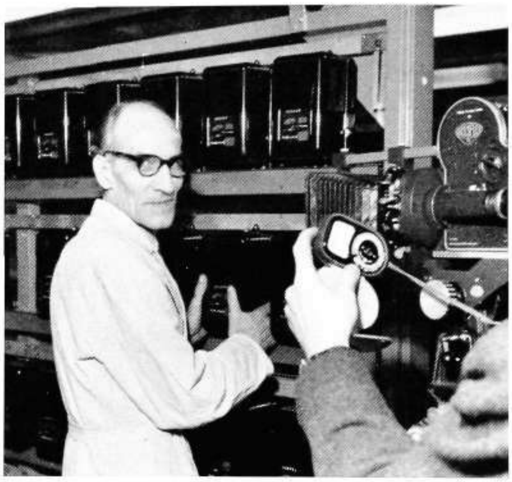
As before, the main part of the interlocking equipment will be delivered by Dansk Signal Industri and the C.T.C. equipment by L M Ericssons Signalaktiebolag.

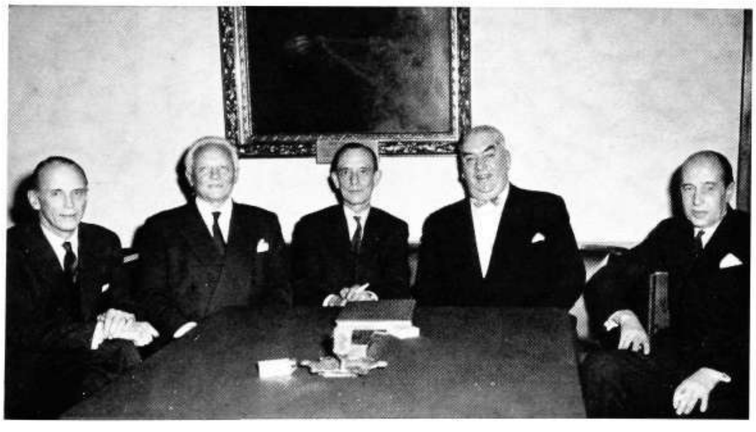
With the completion of this programme the Danish State Railways will be one of the biggest users of C.T.C. in Europe, considered in relation to total railway mileage.

The inauguration of the new 500-selector exchange at Årsta, Stockholm, did not in fact take place to the accompaniment of hula-hula dancing, as might be thought from the photograph. The garlands are not Hawaiian flowers, but plugs used for the cut-over of the new exchange. From left, Messrs. Malte Patricks and Eric Ledin, LME, and Mr. Olle Linder of the Swedish Telecommunications Administration.

A study group from the Norwegian Defence College visited Stockholm and Copenhagen in February. The Norwegian officers, led by Chief of the College Staff, Major General W Hansteen, are here examining a 500-line switch at Midsommarkransen.

(Right) Ivar Björklind who recently took part in the Swedish "Double or Quits" TV competition. Mr. Björklind is a transport worker at Ermi, Ulvsunda. His subject was "Swedish proletariat literature". A great favourite with the public, he unfortunately failed on the 2,500 kronor question. The photograph is taken from a TV film showing him at his daily work on Ermi's electricity meters. Ivar Björklind has already written one book and is to have a new novel published this autumn.





(Below) A unique photograph of ten telephone veterans from L M Ericsson's head factory, each of whom has worked more than 50 years with the company. All have received L M Ericsson's gold, silver and bronze medals, and all are shareholders in the worldwide enterprise which they have helped to create. (Standing, from left) Ludvig Ljungqvist (started 1897), Karl Larsson (83 years old and employed at LME for 63 years), Fabian Stagnell (started 1897), Albert Milton (started 1907) and Axel Lundgren (started 1898). (Sitting, from left) Thure Karlsson (52 years with company), Hilma Jansson (started 1908), Ruth Elg (started 1908), Lisa Carlsson (started 1907) and Axel Rydström (started 1905).

In conjunction with the installation of a new president at O/Y L M Ericsson A/B, Helsinki, representatives of Telefonaktiebolaget L M Ericsson paid a visit to the Finnish subsidiary and to the Finnish P.T.T. (From left, above) Mr. Sven Ture Åberg, Mr. S J Ahola, Director General of the Finnish P.T.T., Mr. Cornelius Berglund, LME, Mr. Sven Weber, previous president of O/Y L M Ericsson A/B, and the new president Mr. Ingmar Horelli.

L M Ericsson Exchanges in Ecuador to be Extended

A contract was recently signed by the government of Ecuador and L M Ericsson covering 5,000 lines of exchange equipment. This will be used for extension of the Ericsson exchanges at the capital city of Quito.

In conjunction with the signing of the agreement the President of Ecuador, Dr. Camilo Ponce Enriquez made an inspection of the Quito telephone exchanges, accompanied by a delegation of high government officials. The President is seen (left) with Dr. Sixto Durán Ballen from the Ministry of Public Works and Dr. José María Espinoza Correa, head of the Quito Telephone Company.

L M Ericsson delivers C. T. C. to Pakistan

L M Ericsson has been awarded the contract, in face of international competition, for relay interlocking plants for the two large railway stations at Karachi, capital of Pakistan, and for C.T.C. equipment on the roughly 20-kilometre double-track line between Karachi Cantonment Station and Landhi. The order is worth about 4 million kronor.

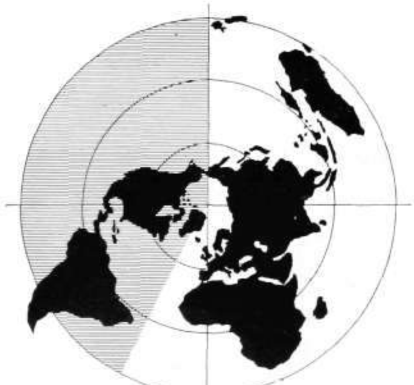
L M Ericsson is both to deliver and install the equipment. The work is to be completed in three stages, starting with the C.T.C. installation, followed by Karachi City Station and, finally, Karachi Cantonment Station. All installations are to be completed within two years.

Karachi City is a terminal station. Some 3 kilometres to the east lies Karachi Cantonment, and thence a double-track line runs east-northeast via Landhi. Karachi City and Karachi Cantonment are linked by three tracks, all of which will be equipped with relay interlockings. One track is to have signalling equipment for movement in both directions, the other two tracks being unidirectional. On the C.T.C. section both tracks will be equipped with signals for two-way movement and the C.T.C. office will be in the same building as the relay interlocking plant for Karachi Cantonment. The size of the plant will be realized from the fact that some 150 points are to be equipped with electrical point machines.

The Pakistan network covers some 12,000 kilometres of track. The signalling system, which has hitherto been mainly mechanical, is to be thoroughly modernized.

New 500-switch exchange delivered to Turkey

A new 500-switch exchange with 1,000 lines was recently opened at Antalaya in Turkey. The Antalaya exchange is one of thirty to be built by L M Ericsson in medium-sized Turkish towns. The Prime Minister, Mr. Adnan Menderes, officiated at the inauguration of the exchange. The photograph shows (from left) the head of the Telecommunications Department of the P.T.T., Turhan Zirh, the Prime Minister and the Swedish Ambassador, A. Croneborg.



Of all lines installed by L M Ericsson during 1958, 43% were of crossbar system and 57% of 500-line system.

New Reference List of L M Ericsson Public Automatic Exchanges

A new reference list of L M Ericsson public automatic exchanges throughout the world as at January 1, 1959, has just been issued.

Elsewhere in this issue is a list of all L M Ericsson exchanges cut-over during 1958. In addition to these figures the reference list contains data of the number of city, rural and transit exchanges hitherto delivered by L M Ericsson with location, system, capacity and year of opening. Exchanges on order are also listed.

U.D.C. 621.395.44
654.19

PYDDOKE, J & SCHILLING, H: *L M Ericsson Equipment for Carrier Channels of Program (Music) Quality, Type ZAB 1.* Ericsson Rev. *36*(1959): No. 1, pp. 2–12.

This article, after mentioning the present need for carrier program channels and the currently applicable CCITT recommendations, describes the construction, performance and application of the latest L M Ericsson program channel equipment designed to satisfy these requirements.

U.D.C. 621.396.65

BRAMBANI, C: *Radio Link 1RL10 for 60 (120) Telephone Circuits.* Ericsson Rev. *36*(1959): No. 1, pp. 13–24.

The radio link described has been developed by A/S Elektrisk Bureau in Oslo at the instigation of Telefonaktiebolaget L M Ericsson. This system operates in the band 225–470 Mc/s using frequency modulation. It is designed for 60 (or with certain modifications 120) telephone circuits with CCI frequency allocation, and will operate in conjunction with L M Ericsson multiplex equipment.

U.D.C. 625.746
656.057

BERGLÖF, G: *Vehicle-actuated Traffic Signals at Södertäljevägen –Sockenvägen, Stockholm.* Ericsson Rev. *36*(1959): No. 1, pp. 25–28.

L M Ericsson's vehicle-actuated traffic signal systems have been described in earlier numbers of Ericsson Review. The author of this article is the engineer responsible for the planning of all signal installations in Stockholm. The installation he describes is a new and rather complicated one in a suburb on the south of the city. The control apparatus in L M Ericsson's system has proved to possess the necessary flexibility for dealing with many new requirements in traffic control.

The Ericsson Group

Associated and co-operating enterprises

• EUROPE •

Denmark

L M Ericsson A/S *København F*, Finsens Vej 78, tel: Fa 6868, tgm: ericsson

Telefon Fabrik Automatic A/S *København K*, Amaliegade 7, tel: C 5188, tgm: automatic

Dansk Signal Industri A/S *København F*, Finsens Vej 78, tel: Fa 6767, tgm: signaler

Finland

O/Y L M Ericsson A/B *Helsinki*, Fabianinkatu 6, tel: A8282, tgm: ericssons

France

Société des Téléphones Ericsson *Colombes (Seine)*, Boulevard de la Finlande, tel: CHA 35-00, tgm: ericsson

Paris 17e, 147 Rue de Courcelles, tel: Carnot 95-30, tgm: eric

Germany

Ericsson Verkaufsgesellschaft m. b. H. *Düsseldorf 1*, Worringer Strasse 109, tel: 84 461, tgm: erictel

Great Britain

Swedish Ericsson Company Ltd. *London, W. C. 1*, 329 High Holborn, tel: Holborn 1092, tgm: teleric

Production Control (Ericsson) Ltd. *London, W. C. 1*, 329 High Holborn, tel: Holborn 1092, tgm: productrol holb

Italy

Setemer, Soc. per Az. *Milano*, Via dei Giardini 7, tel: 662241, tgm: setemer

SIELTE, Soc. per Az. — Società Impianti Elettrici e Telefonici Sistema Ericsson *Roma*, C. P. 4024 Appio, tel: 780221, tgm: sielte

F. A. T. M. E. Soc. per Az. — Fabbrica Apparecchi Telefonici e Materiale Elettrico »Brevetti Ericsson» *Roma*, C. P. 4025 Appio, tel: 780021, tgm: fatme

Netherlands

Ericsson Telefoon-Maatschappij, N.V. *Rijen (N. Br.)*, tel: 01692-555, tgm: erictel

den Haag—Scheveningen, 10, Palacestraat, tel: 55 55 00, tgm: erictel-haag

Norway

A/S Elektrisk Bureau *Oslo NV*, P.B. 5055, tel: Centralbord 46 18 20, tgm: elektriken

A/S Industrikontroll *Oslo*, Teatergaten 12, tel: Centralbord 335085, tgm: indtroll

A/S Norsk Kabelfabrik *Drammen*, P. B. 205, tel: 1285, tgm: kabel

A/S Norsk Signalindustri *Oslo*, P. B. Mj 2214, tel: Centralbord 56 53 54, tgm: signalindustri

Portugal

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

Spain

Cia Española Ericsson, S. A. *Madrid*, Conde de Xiquena 13, tel: 31 53 03, tgm: ericsson

Sweden

Telefonaktiebolaget L M Ericsson *Stockholm 32*, tel: 19 00 00, tgm: telefonbolaget

AB Alpha *Sundbyberg*, tel: 282600, tgm: aktiealpha-stockholm

AB Ermex *Solna*, tel: 82 01 00, tgm: elock-stockholm

AB Ermi *Bromma 11*, tel: 262600, tgm: ermibolag-stockholm

AB Rifa *Bromma 11*, tel: 26 26 10, tgm: elrifa-stockholm

AB Svenska Elektronrör *Stockholm 20*, tel: 44 03 05, tgm: electronics

L M Ericssons Driftkontrollaktiebolag *Solna*, tel: 27 27 25, tgm: powers-stockholm

L M Ericssons Signalaktiebolag *Stockholm 9*, tel: 68 07 00, tgm: signalbolaget

L M Ericssons Svenska Försäljningsaktiebolag *Stockholm 1*, Box 877, tel: 22 31 00, tgm: ellem

Mexikanska Telefonaktiebolaget Ericsson *Stockholm 32*, tel: 190000, tgm: mexikan

Sieverts Kabelverk AB *Sundbyberg*, tel 282860, tgm: sievertsfabrik-stockholm

Svenska Radioaktiebolaget *Stockholm*, Alströmergatan 14, tel: 22 31 40, tgm: svenskradio

Switzerland

Ericsson Telephone Sales Corp. AB, Stockholm, Zweigniederlassung Zürich *Zürich*, Postfach Zürich 32, tel: 325184, tgm: telericsson

• ASIA •

India

Ericsson Telephone Sales Corporation AB *New Delhi 1*, P.O.B., 669, reg. mail: 1/3 Asaf Ali Road (Delhi Estate Building), tel: 28512, tgm: inderic

Bombay, Manu Mansion, 16, Old Custom House, tgm: inderic

Calcutta, P. O. B. 2324, tel: 45-4494, tgm: inderic

Indonesia

Ericsson Telephone Sales Corporation AB *Bandung*, Djalan Dago 151, tel: 2135, tgm: javeric

Djakarta, Djalan Gunung Sahari 26, tel: Gambir 50, tgm: javeric

Lebanon

Telefonakt[illegible]son, Technical Office *Beyrouth*, Rue du Parlement, Immeuble Bisharat, tel: 33555, tgm: ellem

Turkey

Ericsson Türk Ltd. Şirketi *Ankara*, Âdil Han, Zafer Meydani, Yenişehir, tel: 23170, tgm: ellem

Istanbul, Istanbul Bürosu, Liman Han, Kat 5, No. 75, Bahçekapi, tel: 228102, tgm: ellemist

• AFRICA •

Union of South Africa

L M Ericsson Telephone Co. Pty. Ltd. *Johannesburg*, 70, Loveday Street, tel: 33-2742, tgm: ericofon

• AMERICA •

Argentine

Cía Sudamericana de Teléfonos L M Ericsson S. A. *Buenos Aires*, Belgrano 894, tel: 332071, tgm: ericsson

Corp. Sudamericana de Teléfonos y Telégrafos S. A. *Buenos Aires*, Belgrano 894, tel: 332071, tgm: cartefe

Cía Argentina de Teléfonos S. A. *Buenos Aires*, Perú 263, tel: 305011, tgm: cecea

Cía Entrerriana de Teléfonos S. A. *Buenos Aires*, Perú 263, tel: 305011, tgm: cecea

Cía Comercial de Administración S. A. *Buenos Aires*, Perú 263, tel: 305011, tgm: cecea

Industrias Eléctricas de Quilmes S. A. *Quilmes FCNGR*, 12 de Octubre 1090, tel: 203-2775, tgm: indelqui-buenosaires

Brazil

Ericsson do Brasil Comércio e Indústria S. A. *Rio de Janeiro*, C. P. 3601, tel: 43-0990, tgm: ericsson

São Paulo C. P. 5677, tel: 36-6951, tgm: ericsson

Canada

Ericsson Telephone Sales of Canada Ltd. *Montreal 8, Que.*, 130 Bates Road, tel: RE 1-6428, tgm: caneric

Toronto 18, Ont., 34 Advance Road, tel: BE 1-1306

[illegible]on *San Salvador, El Salvador C.A.*, Apartado Postal 188, tel: 4989, tgm: ericsson

Chile

Cía Ericsson de Chile S. A. *Santiago*, Casilla 10143, tel: 82555, tgm: ericsson-santiago-dechile

Colombia

Cia Ericsson Ltda. *Bogotá*, Apartado Aéreo 4052, tel: 11-100, tgm: ericsson

Ecuador

Telefonaktiebolaget L M Ericsson *Quito*, Casilla Postal 2138, tel: 33777, tgm: ericsson

Mexico

Cía Comercial Ericsson S. A. *México D. F.*, Apartado 9958, tel: 46-46-40, tgm: coeric-mexico

Industria de Telecomunicación S.A. de C.V. *México 6, D.F.*, Paseo de la Reforma 122, 6° piso, tel: 354814, tgm: industel

Peru

Cía Ericsson S. A. *Lima*, Apartado 2982, tel: 34941, tgm: ericsson

Soc. Telefónica del Perú, S. A. *Arequipa*, Casilla de Correo 112, tgm: telefonica

Uruguay

Cía Ericsson S. A. *Montevideo*, Casilla de Correo 575, tel: 84433, tgm: ericsson

USA

The Ericsson Corporation *New York 17, N. Y.*, 100 Park Avenue, tel: Murray Hill 5-4030, tgm: erictel

North Electric Co. *Galion, Ohio*, P. O. B. 417, tel: Howard 8-2420, tgm: northphone-galionohio

Venezuela

Cía Anónima Ericsson *Caracas*, Apartado 3548, tel: 543121, tgm: ericsson

Teléfonos Ericsson C. A. *Caracas*, Apartado 3548, tel: 543121, tgm: tevela

• AUSTRALIA & OCEANIA •

Australia

L M Ericsson Telephone Co. Pty. Ltd. *Melbourne C 1 (Victoria)*, Kelvin Hall, 55 Collins Place, tel: MF 56 46, tgm: ericmel

Agencies

• EUROPE •

Austria

Inglomark, Industrie-Beliefe-rungs-Gesellschaft Markowitsch & Co. *Wien XV*, Maria Hilferstrasse 133, tel: R 32-0-11, tgm: inglomark

Belgium

Electricité et Mécanique Suédoises *Bruxelles 5*, 56 Rue de Stassart, tel: 11 14 16, tgm: electrosuede

Greece

»ETEP», S. A. Commerciale & Technique *Athens*, 41, Stadiou Street, tel: 31211, tgm: aeterathinai

Ireland

Communication Systems Ltd. *Dublin*, 40, Upper Fitzwilliam Street, tel: 61576/7, tgm: crossbar

Iceland

Johan Rönning H/F *Reykjavik*, P. O. B. 45, tel: 14320, tgm: rönning

Yugo-Slavia

Merkantile Inozemna Zastupstva *Zagreb*, Pošt pretinac 23, tel: 25-222, tgm: merkantile

• ASIA •

Burma

Vulcan Trading Co. Ltd. *Rangoon*, P. O. B. 581, tel: S. 878, tgm: suecia

Ceylon

Vulcan Trading Co. (Private) Ltd. *Colombo 1*, 19, York Street, tel: 36-36, tgm: vultra

China

The Ekman Foreign Agencies Ltd. *Shanghai*, P. O. B. 855, tel: 16242-3, tgm: ekmans

Hong Kong

The Swedish Trading Co. Ltd. *Hongkong*, Prince's Building, Ice House Street, tel: 20171, tgm: swedetrade

Iran

Irano Swedish Company AB *Teheran*, Khiaban Sevom Esfand 201-203, tel: 36761, tgm: iranoswede

Iraq

Koopman & Co. T.H.M., N.V., c/o Messrs. Dwyer & Co. (Iraq) Ltd. *Baghdad*, P. O. B. 22, tel: 86860, tgm: havede

Japan

Gadelius & Co. Ltd. *Tokyo*, No. 3-19, Denma-cho, Akasaka, Minato-Ku, tel: 48-5361, tgm: goticus

Jordan

H. L. Larsson & Sons Ltd. Levant *Amman*, P. O. B. 647, tgm: larsonhus

Kuwait

Latiff Supplies Ltd. *Kuwait*, P.O.B. 67, tgm: latisup

Lebanon

Swedish Levant Trading Co. *Beyrouth*, P. O. B. 931, tel: 31624, tgm: skefko

Pakistan

Vulcan Trading Co. (Pakistan) Ltd. *Karachi City*, P. O. B. 4776, tel: 32506, tgm: vulcan

Philippines

Koppel (Philippines) Inc. *Manila P. R.*, P. O. B. 125, tel: 3-37-53, tgm: koppelrail

Saudi Arabia

Mohamed Fazil Abdulla Arab *Jeddah*, P. O. B. 39, tel: 2690, tgm: arab

Syria

Georgiades, Moussa & Cie *Damas*, Rue Ghassan, Harika, tel: 1-02-89, tgm: georgiades

Thailand

Vichien Radio & Television Co., Ltd. *Bangkok*, 299-301, Suriwongse Road, tel: 31 364, tgm: vision

Vietnam

Vo Tuyen Dien-Thoai Viet-Nam, Matériel Radio & Téléphonique du Viêtnam *Saïgon*, 17, Cong Truong Lam-Son, tel: 20805, tgm: telerad

• AFRICA •

Belgian Congo

Société Anonyme Internationale de Télégraphie sans Fil (SAIT) *Bruxelles (Belgique)*, 25, Boulevard du Régent, tel: 125070, tgm: wireless

British East Africa

Transcandia Ltd. *Nairobi, Kenya*, P. O. B. 5933, tel. 3312, tgm: transcanda

Egypt

The Pharaonic Engineering & Industrial Co. *Cairo*, 33, Orabi Street, tel: 4-36-84, tgm: radiation

Ethiopia

Swedish Ethiopian Company *Addis Ababa*, P. O. B. 264, tel: 1447, tgm: etiocomp

Ghana

The Standard Electric Company *Accra*, P.O.B. 17, tel: 2785, tgm: standard

Morocco

Elcor S. A. *Tangier*, Francisco Vitoria, 4, tel: 2220, tgm: elcor

Mozambique

J. Martins Marques *Lourenço Marques*, P. O. B. 456, tel: 5953, tgm: tinsmarques

Nigeria

Scan African Trading Co. *Yaba-Lagos 32*, P. O. B. 1, tgm: swedafrica

Rhodesia and Nyasaland

Reunert & Lenz, (Rhodesia) Ltd. *Salisbury (Southern Rhodesia)* P.O. B. 2071, tel: 27001, tgm: rockdrill

Sudan

TECOMA Technical Consulting and Machinery Co. Ltd.! *Khartoum*, P.O.B. 866, tel: 2224, ext. 35, tgm: sutecoma

• AMERICA •

Bolivia

Johansson & Cía, S. A. *La Paz*, Casilla 678, tel: 2700, tgm: johansson

Costa Rica

Tropical Commission Co. Ltd. *San José*, Apartado 661, tel: 3432, tgm: troco

Cuba

Mc Avoy y Cía *Habana*, Apartado 2379, tel: U-2527, tgm: macavoy

Curaçao N. W. I.

S. E. L. Maduro & Sons, Inc. *Curaçao*, P. O. B. 172, tel: 1200, tgm: madurosons-willemstad

Dominican Republic

Garcia & Gautier, C. por A. *Ciudad Trujillo*, Apartado 771, tel: 3645, tgm: gartier

Ecuador

Sociedad Radiotécnica Ecuatoriana *Quito*, Casilla de Correo 414, tel: 12140, tgm: rota

Guatemala

Nils Pira *Ciudad de Guatemala*, Apartado 36, tel: 3311, tgm: nilspira-g

Haïti

F. Georges Naudé *Port au Prince*, P. O. B. A 147, tel: 3075, tgm: nodeco

Honduras

Cía de Comisiones Inter-Americana, S. A. *Tegucigalpa D. C.*, P. O. B. 114, tel: 15-63, tgm: inter

Jamaica and Brit. Honduras

Morris E. Parkin *Kingston*, P.O.B. 354, tel: 4077, tgm: morrispark

Nicaragua

J. R. E. Tefel & Co. Ltd. *Managua*, Apartado 24, tel: 387-1169, tgm: tefelto

Panama

Productos Mundiales, S. A. *Panama, R. P.*, P. O. B. 4349, tel: 3-0476, 3-7763, tgm: mundi

Paraguay

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

El Salvador

Dada-Dada & Co. *San Salvador*, Apartado 274, tel: 4860, tgm: dada

Surinam

C. Kersten & Co. N. V. *Paramaribo*, P. O. B. 216, tel: 2541, tgm: kersten

USA

State Labs. Inc., *New York 12, N.Y.*, 649 Broadway, tel: Oregon 7-8400, tgm: statelabs. Only for electron tubes

• AUSTRALIA & OCEANIA •

New Zealand

ASEA Electric (N Z) Ltd. *Wellington C.1.*, Huddart Parker Building, Post Office Square, tel: 70-614,

ERICSSON Review

2
1959

ERICSSON REVIEW

Vol. XXXVI No. 2 1959

RESPONSIBLE PUBLISHER: HUGO LINDBERG

EDITOR: SIGVARD EKLUND, DHS

EDITOR'S OFFICE: STOCKHOLM 32

SUBSCRIPTIONS: ONE YEAR $ 1.50; ONE COPY $ 0.50

CONTENTS

On cover: Head office, laboratories and main plant of Telefonaktiebolaget L M Ericsson, Stockholm, with new group administration wing in foreground.

L M Ericsson's 960-Circuit System for Coaxial Cables

III Terminal Equipment (continued)

N TANGEN, TELEFONAKTIEBOLAGET L M ERICSSON, STOCKHOLM

In Ericsson Review No. 4, 1958, the parts of the terminal equipment which are directly concerned with the transmitted signal band were described.

In this second and final article on the arrangement of the coaxial terminal, the oscillator equipment is described. Its part in the system consists of the generation and distribution of the carrier frequencies and pilots for the system. The article concludes with a brief description of the power supply for the terminal equipment.

The Oscillator Equipment

The generation of all the necessary carrier frequencies and pilots and their amplification and distribution is carried out in the oscillator equipment. The designation oscillator equipment is really somewhat misleading, as oscillators in their normal sense nowadays only occur in a few cases. The reason for this is the stringent requirements placed on frequency stability, which makes it more advantageous to replace free-running oscillators by frequency-locked devices.

According to CCITT, a transmitted signal band should not be displaced by more than ± 2 c/s after all modulations involved in sending, receiving and possible through connexions. For a signal which is transmitted in the highest channel band (4024–4028 kc/s) this means that the respective transmitted frequencies must maintain a stability of about ± 1 c/s, as the terminals are normally not synchronized with each other.

The CCITT recommendation results in a minimum requirement of $\pm \frac{1 \text{ c/s}}{4028 \text{ kc/s}}$, or when rounded off 1 in 5 million (the stability is determined from the highest transmitted frequency of the system and not the highest carrier frequency). In addition to this, a certain safety margin is added, so that in a 4 Mc/s system a constancy of frequency of 10^{-7} or one period in 10 millions is normally required. It would thus be extremely expensive to generate all carrier frequencies for a coaxial system using separate oscillators –and in addition, the work of maintenance would be very extensive.

With larger oscillator equipment, the principle has therefore been developed of having only one oscillator – designated master oscillator – which provides the requisite stability and which via suitable frequency changing equipment synchronizes (or controls) all the other carrier frequencies.

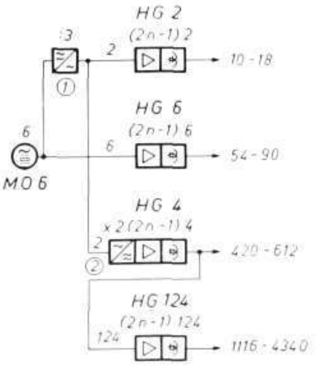


Fig. 1 X 2427

The principle of the generation of carrier frequencies

Mo 6 6 kc/s crystal-controlled master oscillator
1) Frequency divider 6-2 kc/s
(2) Frequency doubler 2 × 2 kc/s
HG2, HG4, HG6 and HG124—harmonic generators with basic frequencies 2, 4, 6 and 124 kc/s

L M Ericsson's Main Principle for Generation of Carrier Frequencies

L M Ericsson's 960-circuit system consists of four stages of modulation, namely channel modulation, sub-group modulation, group modulation and supergroup modulation. The number of carrier frequencies in the different stages are 3, 4, 5 and 15 respectively and all are odd whole multiples of certain fundamental frequencies. The basic principle aimed at has therefore been to generate these fundamental frequencies in a simple manner and then to multiply them up using suitable circuits.

The way this has been carried out is seen from the block schematic in fig. 1. For the sake of simplicity, only the frequency generating circuits have been included. The requisite filters and amplifiers are shown later in figs. 2 and 3.

As will be seen from the schematic, the generation is based on a crystal controlled master oscillator having a frequency of 6 kc/s *(MO6)*. Due to the low master frequency, the need for frequency division has practically disappeared. Only one frequency divider from 6 to 2 kc/s is included in the equipment.

The fundamental frequencies previously mentioned are 2, 6, 4 and 124 kc/s for the respective modulator stages. The multiplication of these frequencies occurs in so-called harmonic generators *(HG2, HG6, HG4* and *HG124)* which produce odd harmonics by means of non-linear magnetic characteristics.

The channel carriers 10, 14 and 18 kc/s are thus obtained from *HG2* as the 5th, 7th and 9th harmonics, the sub-group frequencies 54–90 kc/s as the 9th to 15th harmonics from *HG6* etc.

The carrier frequencies for the third modulator stage 420–612 kc/s have really 12 kc/s as the highest usable basic frequency but, for reasons which will be given later, 4 kc/s has been chosen instead.

Frequencies of 60 kc/s and 124 kc/s are also extracted from *HG4*. The first frequency is used as frequency comparison pilot, the latter as basic frequency in the generation of the supergroup carriers 1116–4340 kc/s.

Due to this arrangement, all carrier frequencies are automatically synchronized to the master oscillator. In this way the great advantage is gained of only having to supervise the constancy of frequency at a single point.

A more detailed description of the master oscillator and the frequency changing equipment follows in a later section.

The Electrical Construction of the Oscillator

The complete oscillator equipment for the 960-circuit system is shown in block schematic form in figs. 2 and 3.

Fig. 2 concerns the carrier frequencies for the first three stages of modulation (10–612 kc/s) with the associated pilot equipment and frequency checking. This part of the system consists of two bays, one for frequency generation and amplification and one for distribution and certain auxiliary equipment. The first is designated Low Frequency Carrier Supply Bay. The second bay is designated Carrier Distribution Bay.

Fig. 3 shows the carrier frequencies for the highest modulator stage and the pilots used there. In this case, all the equipment is mounted on one bay which is designated High Frequency Carrier Supply Bay.

The extent of each respective bay is denoted in the figures by broken lines.

As failure of one carrier frequency affects a large number of circuits, the equipment has been duplicated throughout. For each regular unit there is thus an identical stand-by unit, which is switched in automatically when the output level of the regular unit fails or falls below a certain minimum level.

A more detailed description of the change-over equipment follows in a later section.

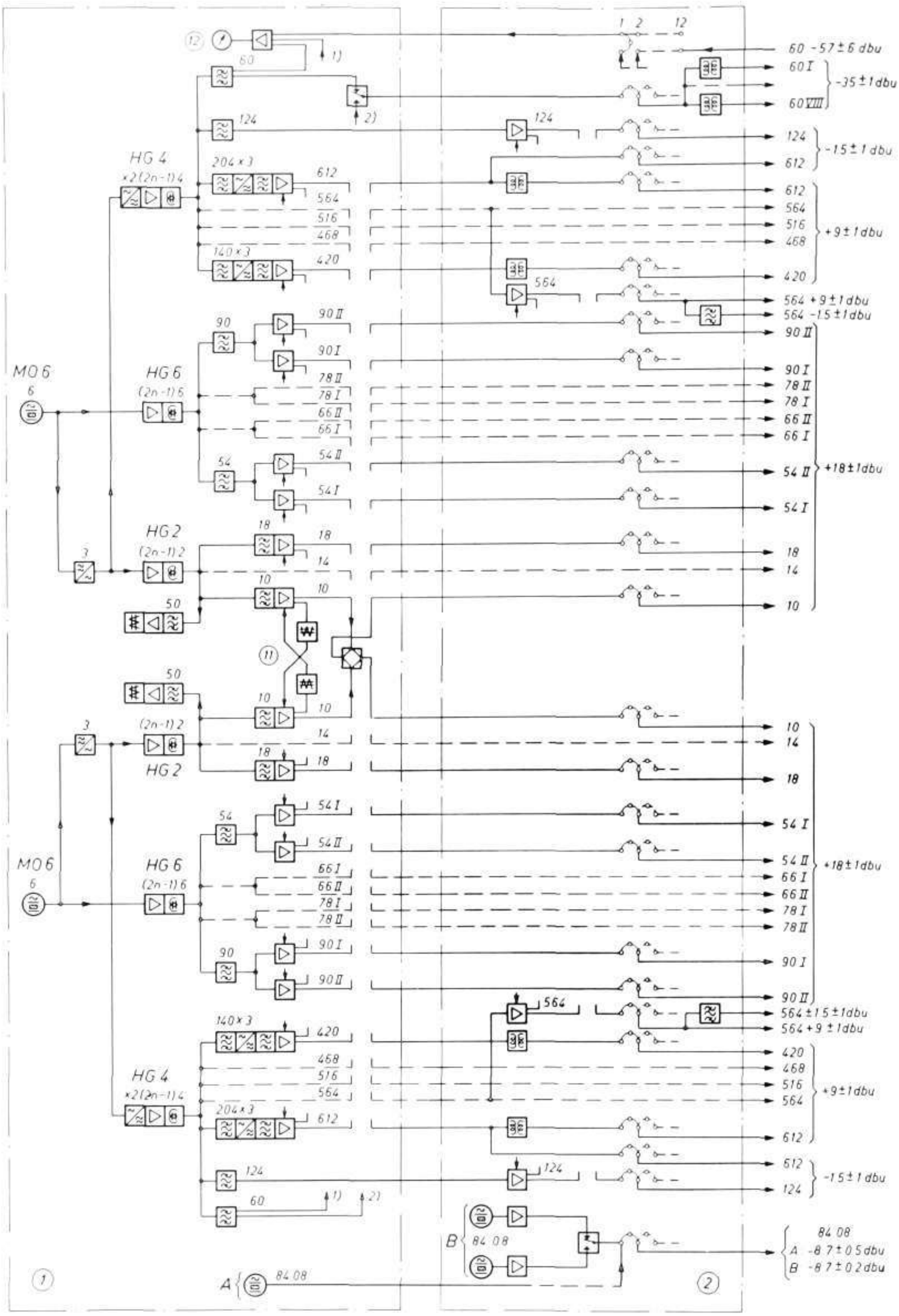


Fig. 2 X 8150

Block schematic of the Low Frequency Carrier Supply Bay and the Carrier Distribution Bay

(1) Low Frequency Carrier Supply Bay
(11) Electronic blocking and alarm
(12) Equipment for frequency comparison
(2) Carrier Distribution Bay

All frequencies are in kc/s

The harmonic generators previously mentioned are supplemented by carrier filters and amplifiers in figs. 2 and 3. Thus after the master oscillator and frequency divider come the harmonic generators *HG2* and *HG4*, of which the first is loaded by the group of filters 10–18 (10, 14 and 18 kc/s) and a small crystal filter for 50 kc/s. The output from the latter is used to control, via an amplifier stage, an alarm and change-over device which operates if the frequency divider falls out of synchronism. A corresponding arrangement after *HG4*, however, is not necessary. The regular filters have such a narrow pass band that the change which occurs with faulty frequency division automatically brings about a change-over to the stand-by equipment. In regard to *HG6*, this is of course directly controlled by the master oscillator.

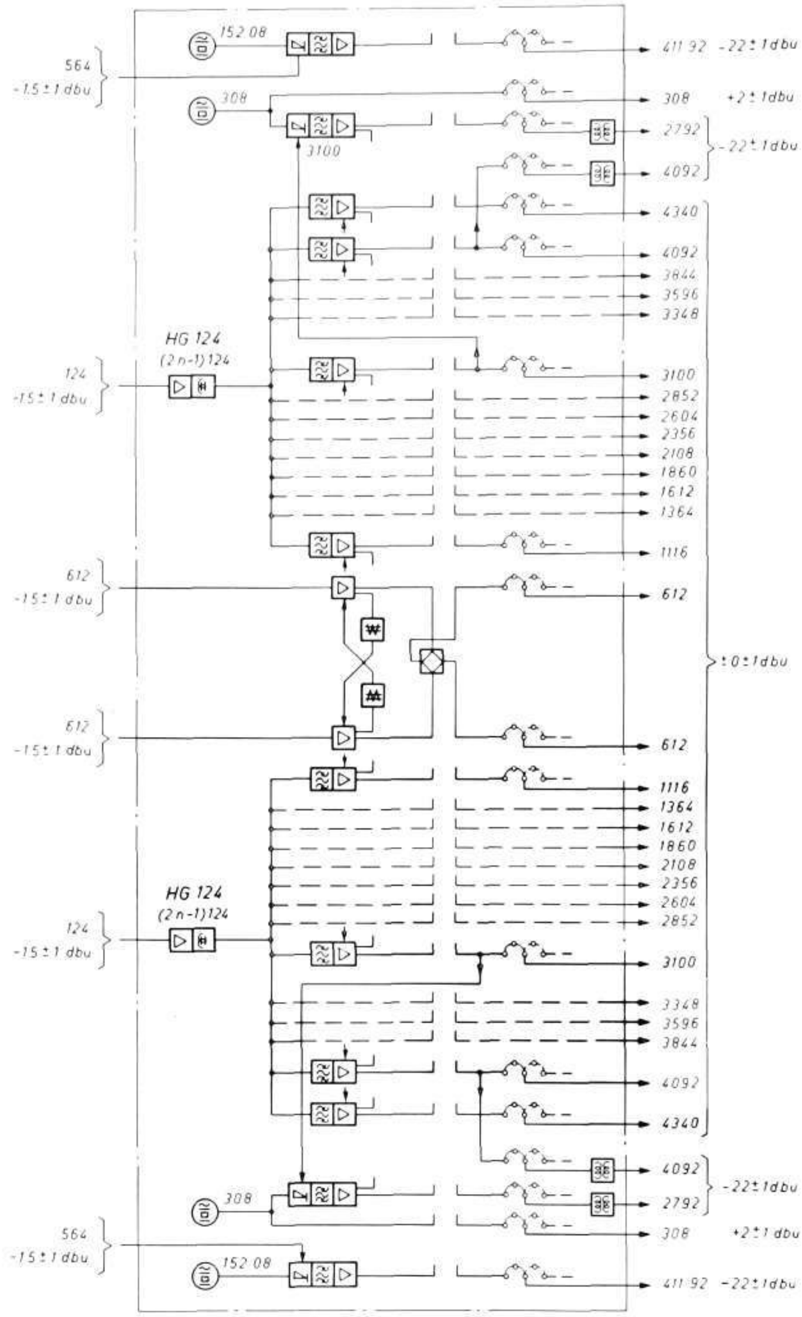


Fig. 3 X 8151

Block schematic of the High Frequency Carrier Supply Bay

The carrier frequency amplifiers in the regular and stand-by equipment are connected to a common hybrid across which the working amplifier develops its power. The stand-by amplifier, on the other hand, is blocked by a large negative bias voltage on a control grid. In the event of a fault on the regular equipment or with a certain drop in level, the stand-by is released and provides a blocking voltage in turn to the regular equipment. Mutual blocking is thus used, the principle of which is shown in fig. 2 for the carrier frequency 10 kc/s. The voltage drop across the respective alarm relays is used as the blocking voltage.

Any form of parallel operation of the regular and stand-by equipment is excluded. This is because there is no stable operating point for both regular and stand-by equipment to operate together simultaneously.

Fig. 4 X 2428

Low Frequency Carrier Supply Bay (right) with the associated Carrier Distribution Bay (left)

Where the dust covers have been removed, the following can be seen in the Carrier Supply Bay, lowest: master oscillator, regular and stand-by. Above these: harmonic generator HG6 and, top: carrier amplifier panel 612 kc/s containing filters, tripler and output stage. In the carrier distribution bay are seen the distribution amplifiers for 124 kc/s and 564 kc/s (the 564 kc/s amplifiers are lower)

The load on *HG4* is, however, arranged somewhat differently. This is because the required frequencies lie so high up in the spectrum (420–612 kc/s thus corresponds to the 35th to the 51st harmonics). Instead of working with 12 kc/s as the basic frequency *(HG12)* and extracting the group of carrier frequencies directly, it was more advantageous to carry out the frequency conversions in two stages. First of all $\frac{420}{3}$ kc/s, $\frac{468}{3}$ kc/s etc. are extracted from *HG4*, and these frequencies are then tripled in special harmonic amplifiers with power output stages. The advantage of this method is that a frequency range (140–204 kc/s) is obtained which is more favourable to the primary filters which are designed using crystals.

The 124 kc/s voltage drives a distribution amplifier in the subsequent carrier distribution bay, and the ordinary and stand-by paths for this frequency first come together in this bay.

The frequency comparison pilot 60 kc/s does not require extra amplification, and is sent direct from the filter to a relay circuit as shown at the top of the block schematic.

The relay circuit is normally controlled by the 124 kc/s distribution amplifier in the carrier distribution bay. The small crystal filter before this has sufficiently high selectivity to ensure that change-over to stand-by operation is made if the frequency of the master oscillator should undergo abnormally large changes.

At the top of the block schematic there is shown an equipment for frequency comparison. By using this it is possible to compare the regular and stand-by master oscillators in the same bay and also to compare each of these against an external 60 kc/s pilot.

The frequency comparator is based on the beat frequency principle, the instrument indicating the difference frequency between the incoming pilots.

As the frequency comparison is made at 60 kc/s, the time for one beat period must be greater than or equal to 167 seconds if the relative frequency error is to lie within the required $\pm 10^{-7}$. The carrier distribution bay, the block schematic of which is shown to the right in fig. 2, has distribution as its primary function, as its name implies.

Two cables for each frequency, except for the 60 kc/s and 84.08 kc/s pilots, come from the Low Frequency Carrier Supply Bay. All these cables are taken to a U-link panel enabling parallel measurements and interruption to be made. In addition, each U-link permits change over from the regular supply bay to stand-by equipment, if this is provided. The position of the U-link and the connexion of the stand-by conductors have been shown with dashed lines at the right of the schematic.

A complete stand-by equipment only exists, however, in large stations having many terminals.

At such stations it may sometimes be necessary to rearrange certain bays and if then there is a stand-by equipment, such work can be completely or partly carried out without causing an interruption in traffic. In addition, the arrangement means an increased operational reliability.

The cables go from the U-link field to the respective terminal strips, where connexion is made to the respective station cables. The carrier frequencies 10–90 kc/s are thus distributed via 16 cables per frequency with a fully built-out system (= 16 channel translating bays) and 420–612 via 2 cables per frequency (= 2 group translating bays).

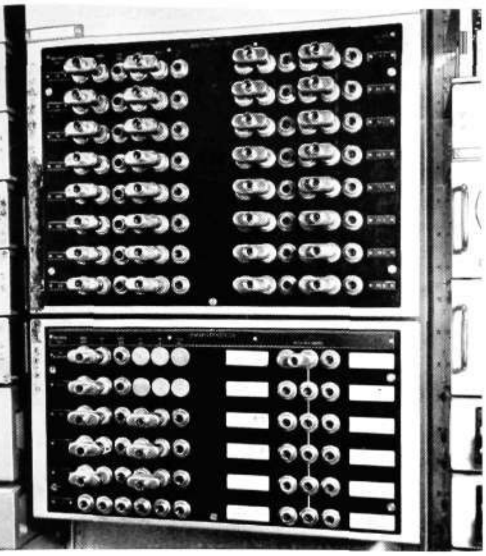


Fig. 5 X 2429

Carrier Distribution Bay U-link field for 10-612 kc/s

The bottom right hand field with the adjacest labels is the input for the external 60 kc/s pilots

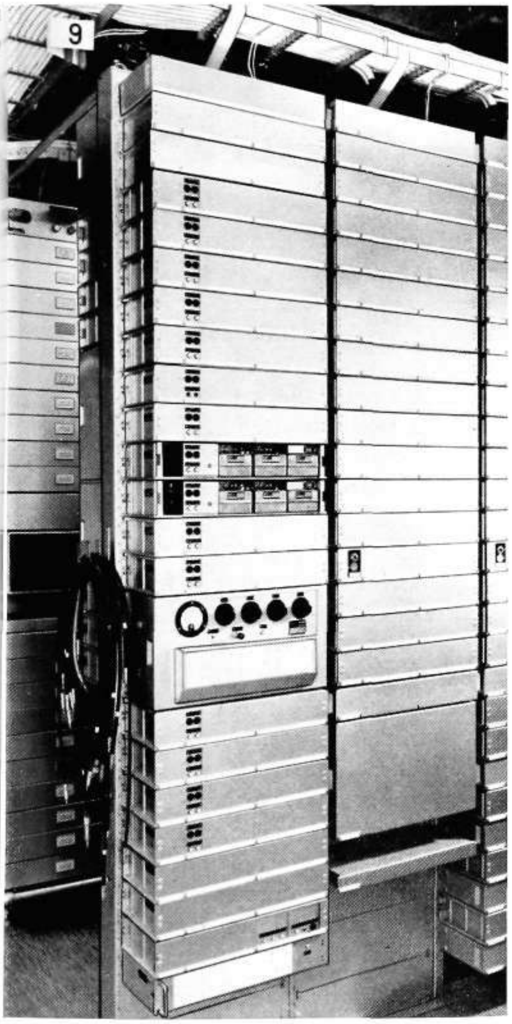


Fig. 6 X 2430

High Frequency Carrier Supply Bay

Where the dust covers have been removed are seen from left to right: change-over and supervisory unit, regular and stand-by carrier amplifiers and filters, and furthest to the right the distribution and measuring unit

Now, it is seldom or never that a terminal is built out initially to the full number of fodulating bays. It is most usual to start with a few supergroups and then build out progressively as the traffic requirements increase. To provide the respective carrier amplifiers under such conditions with as constant operating conditions as possible and simultaneously to ensure the necessary balance in the hybrids, a number of dummy loads have been connected into circuit. For the frequencies 10–90 kc/s, these are placed in the terminal strips of the low frequency carrier supply bay, and for the frequencies 420–612 kc/s, these dummy loads are placed in the carrier distribution bay.

The dummy loads are removed successively at certain stages of the building-out.

Besides the distribution of the carrier frequencies themselves, there is also a special distribution of pilot frequencies and auxiliary frequencies, which are 60, 84.08, 124, 564 and 612 kc/s.

As mentioned previously the 60 kc/s frequency is used as the frequency comparison pilot.

At the top of the block schematic of the carrier distribution bay is shown a U-link field with which it is possible to connect up to 12 different external pilots to the frequency comparator. Of these pilots, 8 can be taken from that number of incoming line groups and 4 from distribution bays within the station concerned.

In addition, it is seen that the station frequency comparison pilot can be distributed via U-links and transformers to 8 outgoing line groups.

The group reference pilot 84.08 kc/s can be provided in two different ways, which are denoted by the letters *A* and *B* in fig. 2. In case *A*, which has been the most usual, the pilot is only used for periodic checking of the groups. It is then not necessary to have duplication and long-term stabilization, and the pilot can be obtained in the simple manner shown from a single crystal-controlled oscillator. The requirement of frequency stability of group reference pilots is $\pm$ 1 c/s and the oscillator can therefore be designed in a relatively simple manner.

In case *B*, on the other hand, the pilot is sent out continuously either for measurement or regulation purposes. Duplication and stabilization have been introduced here and, owing to space requirements, the whole equipment has been placed in the carrier distribution bay.

The pilot is injected at a high impedance into the respective channel translating bay and the equipment is normally intended to supply a complete system or 16 channel translating bays.

The auxiliary frequency 124 kc/s is, as shown previously in fig. 1, the fundamental frequency used for the carrier frequencies of the highest stages of modulation, which are generated and distributed in the high frequency carrier supply bay. Each bay of this type supplies *one* system and thus has the same capacity as the other carrier supply bays. As supergroup through connexion has now introduced a need for up to 8 pairs of supergroup translating bays corresponding to 8 high frequency carrier generating bays, the carrier distribution bay has been provided with a duplicated distribution amplifier for 124 kc/s so as to be able to provide the necessary driving power.

The supergroup reference pilot 411.92 kc/s is generated and received in two different bays. The generation occurs in the high frequency carrier supply bay and this will be seen in fig. 3. On the other hand the reception takes place in the respective receiving supergroup translating bays. As in both cases it is a question of modulation (1 modulation [duplicated] per system in the sending direction and 1 modulation per supergroup in the receiving direction), an auxiliary amplifier is also required here to provide the power needed.

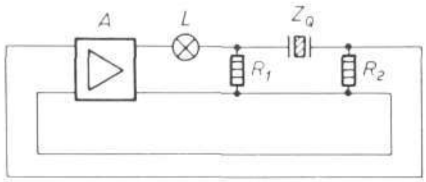


Fig. 7 X 2431

Simplified schematic to show the principle of the master oscillator

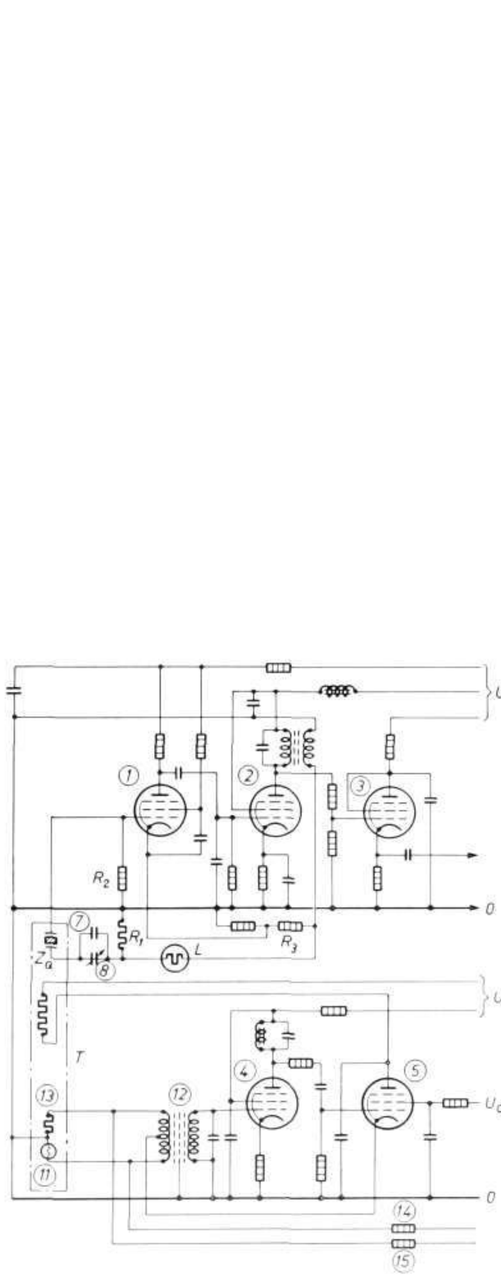


Fig. 8 X 2432

Circuit diagram of the master oscillator (top) and its temperature regulating equipment (bottom)

The frequency 612 kc/s is the common carrier frequency for the third and fourth modulator stages, but for reasons of reliability, no common amplifiers have been used. Only the drive power for the carrier amplifiers of the 4th stage is taken from the carrier distribution bay. These are mounted in the high frequency carrier supply bay as will be seen from fig. 3.

The high frequency carrier supply bay is thus provided with the frequencies 124, 564 and 612 kc/s. The use of the latter two frequencies has already been described, and the first is used as the basic frequency in the harmonic generator *HG124*, from which the carrier frequencies 1116–4340 kc/s are obtained.

In addition there is equipment for generation and distribution of the line pilots 308, 2792 and 4092 kc/s. As 4092 kc/s is also a carrier frequency, its use as a pilot only means the provision of some distribution transformers protected by resistors.

The generation of 308 kc/s occurs in a separate crystal controlled oscillator. The 2792 kc/s pilot is obtained as a combination of this frequency and the carrier frequency 3100 kc/s.

The 2792 and 4092 kc/s pilots are line pilots used in the 960-circuit system, while the 308 kc/s pilot is of less importance. The distribution of the first two pilots mentioned has therefore been designed to cater for feeding up to 4 High Frequency Bays.

Description of Some Important Units

6 kc/s Master Oscillator

The master oscillator comprises electrically two parts, the oscillator itself and the crystal oven with its electronically operated thermostat.

The Oscillator

The method by which the frequency determining characteristics of the crystal have been used in the circuit is seen in the simplified circuit diagram in fig. 7. Here, *A* is an amplifier with a large amount of negative feedback. The amplifier is thereby made highly linear and has very little phase shift. The gain is therefore independent of the amplitude of the input. A part of output voltage is now fed back to the input in such a phase that self oscillation occurs. The voltage fed back is first divided between the lamp *L* and the resistor R_1 and then by the impedance Z_Q of the crystal and the resistor R_2. Oscillation occurs at exactly the series resonant frequency of the crystal, as its impedance is then a minimum. The resistance of the lamp increases as the current flowing trough it increases. The amplitude of oscillation is therefore limited to such a value that the voltage which is fed back is just sufficient to maintain the output voltage. By separating the amplifying, the amplitude limiting and the frequency determining parts of the oscillator in this way a very high frequency stability is obtained.

In order to adjust the frequency of the oscillator, which is necessary when synchronizing to a frequency standard, a small trimmer capacitor is inserted *in series with the quartz crystal*. Self-oscillation then occurs at a somewhat higher frequency than that corresponding to the series resonance of the crystal. The more detailed electrical construction of the oscillator is seen in the circuit diagram in fig. 8. The oscillator itself consists of tubes *1* and *2*, while tube *3* is used in a cathode coupled buffer stage which provides protection from different load impedances. The negative feedback in the amplifier stage is provided between the output transformer of tube *2* and the cathode of tube *1*. The voltage fed back for obtaining self-oscillation is also taken from this transformer. The letters *L*, R_1, Z_Q and R_2 in figs. 7 and 8 denote corresponding components. In order not to have too large frequency changes when adjusting, the trimmer capacitor *8* is connected in parallel with a fixed capacitor *7*. Adjustment of the amplitude of oscillation may be made by altering the resistor R_2 and by a moderate variation of the amount of feedback using R_3.

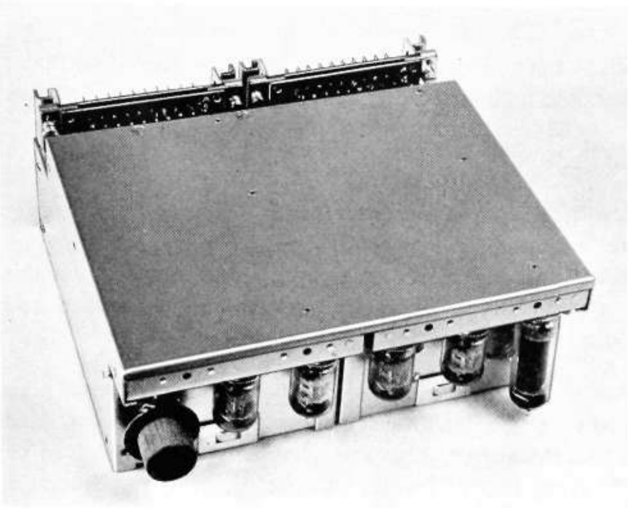
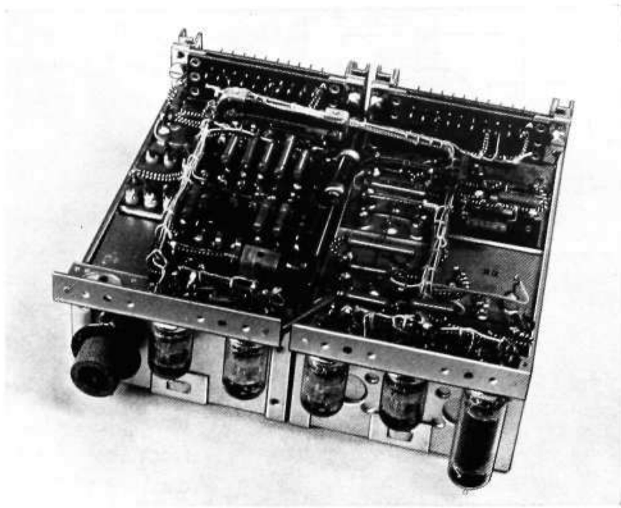
 

Fig. 9 X 8153

6 kc/s master oscillator with protective cover mounted on it

Fig. 10 X 8152

6 kc/s master oscillator with protective cover removed

The oven is mounted in the left section immediately behind the two tubes

Furthest to the left at the front is seen the knob for adjustment of frequency, and furthest to the right is seen the tube which regulates the current through the right is seen the tube which regulates the current through the heating winding

The crystal oven (denoted by *T* in fig. 8) consists of a copper cylinder in which the glass tube containing the crystal is inserted. Heating of the oven is carried out by a heater winding on the cylinder. The whole oven is placed under a pertinax mounting plate at the left hand side of the oscillator unit, which is best seen in fig. 10.

The oven temperature is regulated electrically and the temperature sensitive element consists of a thermistor (item *11* in fig. 8) which is secured by screws to the inner surface of the copper cylinder. The thermistor transduces the variations of temperature to changes of resistance, with about 3 % change in resistance per degree Centigrade.

The electronic regulation equipment itself, as far as alternating current is concerned, consists of a tuned amplifier, tubes *4* and *5* which are connected in opposition across a differential transformer, *12*. The d.c. anode current component of the final tube *5* flows through the heater winding of the oven. A balance resistor *13* and the thermistor *11* are included in the arms of the differential transformer. The direction of winding of the transformer is chosen so that the feedback is negative when the resistance of the thermistor is greater than the balance resistor. When the oven is cold the thermistor resistance is high, the feedback is negative and the amplifier is stable. Full anode current then flows through tube *5* and heats up the oven. When the oven has reached a certain temperature, the feedback becomes positive and self-oscillation occurs. Grid current thus begins to flow in tube *5* and a negative bias develops across the grid leak, which reduces the tube anode current. The smaller the resistance of the thermistor, the greater is the oscillation and therefore the less is the oven heating current. Finally, a state of equilibrium exists where exactly as much heat is supplied as that required to maintain the oven at a temperature where the resistance of the thermistor and the balance resistor are approximately equally large.

Themperature regulation of the type described above has a very quick reaction time and at the same time a large ability to stabilize. Thus there is only a variation of a few hundredths of a degree in the temperature of the oven with normal ambient conditions. In order to check the function of the oscillator, it is possible to connect a large resistor (*14* and *15*, respectively in fig. 8) either in parallel with the thermistor or its balance resistor and the change in the current through the oven heater winding is noted. The parallel connexion is made outside the unit by using an adjacent switch.

One supervisory relay is inserted in series with each anode lead to the tubes *4* and *5*. If the emission of either of these tubes fails so that the thermostatic regulation cannot function an urgent alarm is given.

The check on the frequency is carried out using the beat frequency meter described earlier.

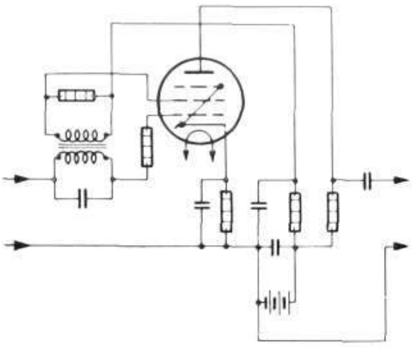


Fig. 11 X 2433

Circuit diagram of the frequency divider 6/2 kc/s

Frequency Divider 6—2 kc/s

The frequency divider consists in principle of an electron-coupled oscillator having a poorly defined self resonant frequency (low Q-value). Feedback is chosen so that strong odd-harmonic distortion is obtained giving an almost rectangular output voltage.

If such an oscillator is tuned to frequency f and a control frequency f_o is applied to its control grid, the frequency f_o lying near to the self-resonant frequency of the oscillator or any of its most prominent harmonics (in this case odd harmonics), a very stable synchronization between the applied and the output frequency occurs automatically.

The division of 6 kc/s to 2 kc/s is especially suitable for a frequency divider having the characteristics described above. This has also been demonstrated from the very good operational data. The control voltage may by halved or doubled without loss of synchronism. The direct voltages applied to the tubes can be varied by ± 30 % and the capacitor in the self-resonant circuit can vary by ± 5 % without loss of synchronism.

The advantage of this circuit is, however, its small dependence on aging and tube change which otherwise is a problem in such designs.

With L M Ericsson's frequency divider therefore, no subsequent adjustments are necessary. If the control voltage should disappear, the frequency change automatically causes an urgent alarm to be given and change-over to the stand-by side made via the 50 kc/s filter after *HG2* (see the block schematic in fig. 2).

A circuit diagram of the frequency divider is shown in fig. 11.

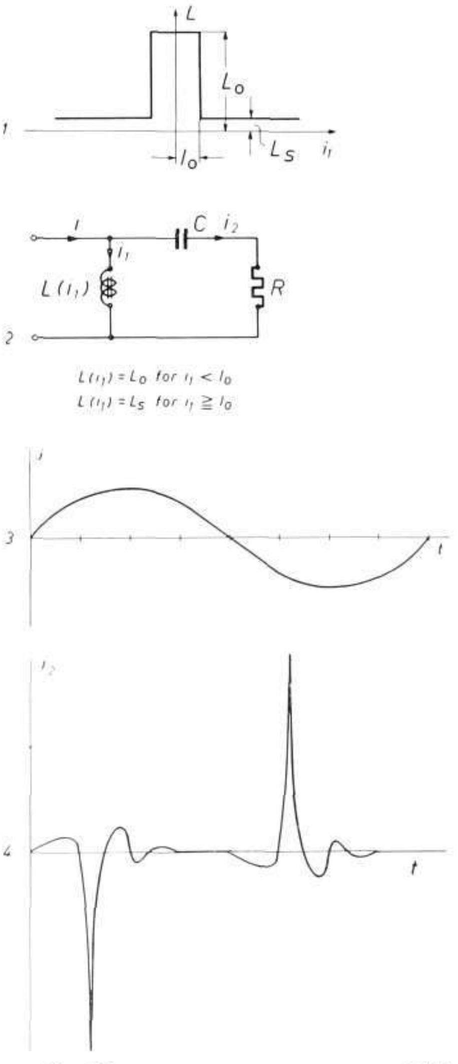


Fig. 12 X 2434

Schematic diagram of the method of operation of the harmonic generator

1. Simplified diagram $L = f(i)$
2. Circuit diagram
3. Drive current (from constant current generator)
4. Oscillating discharge characteristic

Method of Operation of The Harmonic Generator

The fundamentals of the method of operation of the harmonic generator are seen in fig. 12. The main component is an iron-cored inductor which is periodically saturated and thereby its inductance changes very rapidly. When the saturation limit of the inductor is exceeded, the *R-C* circuit is practically short-circuited, and in principle there is an oscillatory circuit consisting of the charged capacitor C, the load resistor R and the saturation inductance of the inductor L_S. Either aperiodic or oscillatory discharge behaviour is obtained, depending on the values of C, R and L_S

By regulating the discharge, the division of power within the given frequency spectrum is changed appreciably. The power of the fundamental which is fed in can thus be allocated, within certain limits, to just that group of harmonics which in this special case is of interest. Herein lies the great advantage of the harmonic generator over other non-linear frequency-locked devices. The losses are relatively small due to the discharge taking place while the inductor is saturated, as its permeability is low. In addition, the amplitude stability of the spectrum is very good.

Carrier Amplifier

Fig. 13 shows the circuit diagram of duplicated carrier amplifier with change-over equipment. The regular and stand-by equipment together with filters is hereby assembled on two identical panel units (the regular equipment is that shown uppermost in the figure), while the rest of the equipment is situated in different panels which are common to the whole bay (relay, alarm and transformer panels).

The amplifier itself is of selective type using overdriven valves and adjustable anode supply voltage. In this way independence of variations in the input voltage is obtained and it is only necessary to supply the d.c. power

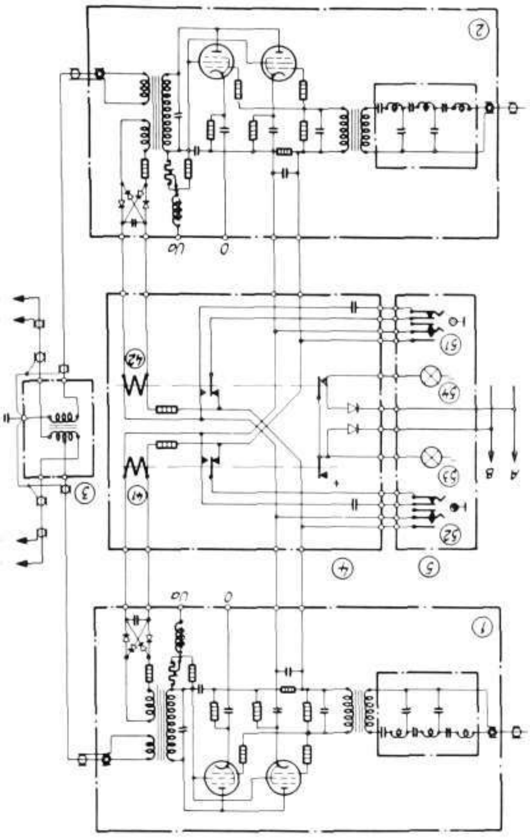


Fig. 13 X 2435

Circuit diagram of a duplicated carrier amplifier with alarm and change-over equipment

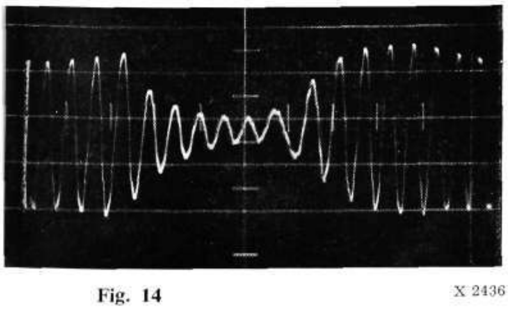


Fig. 14 X 2436

Change of amplitude in an approximately 3000 c/s signal frequency with push-button change-over of any of its carrier frequencies

which is required for a certain output power. Aging is compensated by successively raising the anode supply voltage, and hereby an appreciable increase in the operational life of the tube is obtained.

The amplifier uses two 18AQ5 or two 6AQ5L tubes and normally about 0.75 Watts in useful power is taken out. In addition, a bridge rectifier is fed from the amplifier to give a d.c. voltage for alarms and change-over equipment.

In the figure on the left, the connexion to the change-over equipment is chosen so that the upper amplifier panel operates as the regular unit. With normal operation the alarm relay *41* is thereby operated and the stand-by amplifier is blocked. In each of the blocking paths there is an R-C network having a long time constant. These networks are to protect the operating amplifier against various interferences and also to prevent undesired change-overs. In the event of a fault or with push-button change-over, however, these networks must be broken up as the interruption time would otherwise be too long. This has been arranged by disconnecting the capacitors by the respective alarm relay and by the manual change-over push-buttons.

The shunt capacitor in the regular/stand-by blocking path is short circuited with normal operation while the other capacitor is connected. If now a rapid disappearance of level occurs on the regular equipment, the stand-by equipment takes over the operation in the shortest possible time and relay *42* operates. Simultaneously, relay *41* releases, the lamp *53* lights and a non-urgent alarm (B alarm) is sent out. If the stand-by equipment should not be in working order, both lamps light and an urgent alarm (A alarm) is sent out.

With manual change-over, a similar procedure takes place. Change over to the stand-by equipment is carried out by pushing in button *51*. Two events now happen; the capacitor is disconnected from the blocking path from stand-by to regular equipment, and the blocking voltage on the control grid of the stand-by equipment is short circuited. The change-over can thereby take place without delay.

In addition, it should be emphasized that manual connexion of a blocked amplifier is always an operation which is free from risk. If the stand-by amplifier cannot take over operation, it cannot provide any blocking voltage and the amplifier which is in operation thereby continues operating undisturbed.

Fig. 14 shows a typical change-over operation recorded on an oscilloscope. The figure shows the interference in an approximately 3000 c/s signal voltage when manual change-over is made in any of the carriers involved.

All the 10–612 kc/s carrier amplifiers and the 124 and 564 kc/s auxiliary amplifiers are designed in accordance with the principles described above.

The carrier amplifiers 1116–4340 kc/s, on the other hand, have been designed somewhat differently depending on special conditions within this frequency range.

Thus these amplifiers are level stabilized using the AGC principle and the manual adjustment of the output level is based on the same method. The change-over and alarm equipment is, however, in principle the same as for other amplifiers.

There is also a certain difference from the mechanical point of view. Thus in the range 1116–4340 kc/s both filters and amplifiers are assembled in sealed boxes. In addition, as both the regular and associated stand-by units are contained in the same panel, the units have been made so as to be removable by using plug and socket contacts. The change-over equipment and the hybrid transformers are also not grouped in special panels, but placed together with the respective amplifiers.

Electrical Data

Summary of important data for the oscillator equipment of the 960-circuit system

A. Carrier Frequencies

1. *Frequency stability*

   After 6 months continuous operation of the master oscillator, the stability is on an average better than 10^{-7} per month.

2. *Level stability*

   Better than ± 1 db.

3. *Signal-to–interference ratio*

   For the carrier frequencies 10–4340 kc/s, the following applies:
   For impurities causing intelligible crosstalk: $\geqslant 80$ db.
   This value refers to a bay with constant loading and excludes station cables.

4. *Change-over data*

4.1 *Change-over on a fault*

   Limit for level for change-over to occur: approx. 4 db.
   Effective interruption time of carrier with automatic change-over from one unit to another: $\leqslant 2$ ms.

4.2 *Change-over by means of a push-button*

   Effective interruption time when connexion of stand-by equipment or re-connexion of the regular equipment occur: $\leqslant 2$ ms.

B. Pilots

1. *Frequency stability*

   84.08, 411.92, 308 and 2792 kc/s: ± 1 c/s.
   Stability of other pilots is the same as the master oscillator i.e. $\pm 10^{-7}$.

2. *Level stability*

   Stabilized group pilots 84.08 and 411.92 kc/s: ± 0.3 db. Pilots which are not specially stabilized: ± 0.5 db or 1 db as shown in figs. 2 and 3.

3. *Change-over data*

   Relay change-over time of the 60 kc/s and 84.08 kc/s pilots: approx. 100 ms.
   The change-over times of other relays shown in the schematics are equal to those of the corresponding carriers.

C. Number of Bays

The following bays are required for transmission of up to 960 telephone circuits through all stages of modulation.
1 Low Frequency Carrier Supply Bay.
1 Carrier Distribution Bay.
1 High Frequency Carrier Supply Bay.

Each Carrier Distribution Bay together with *one* Low Frequency Carrier Supply Bay can supply up to 8 Supergroup Translating Bays, sending and 8 bays, receiving with 60 kc/s and 564 kc/s (for frequency comparison and supergroup regulation), and up to 8 High Frequency Carrier Supply Bays with 124 kc/s and 564 kc/s.

Power Supplies

The terminal bays of the coaxial system obtain their requisite voltages from one, or for large stations, several Power Distribution Bays.

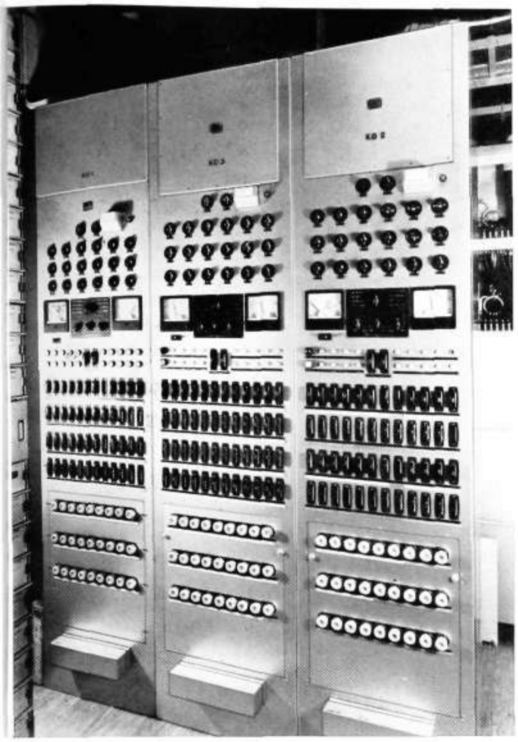


Fig. 15 X 2437

Power Distribution Bay

The voltages required are as given below.

Anode voltage U_a ± 130 V d.c.

Heater voltage U_f 18 or 6.3 V a.c. or d.c.

Relay voltage U_r – 24 V d.c.

Magnetic amplifier voltage U^t 18 V a.c.

The Power Distribution Bay contains transformers for heater and magnetic amplifier voltages. All distribution to the terminal bays is made from the bay, also the distribution of anode and relay voltages. The Power Distribution Bay is fed with voltages U_a and U_r either from the station batteries or possibly from a rectifier bay containing mains supply units for generation of these voltages.

A Power Distribution Bay can feed one complete terminal equipment for modulation of 960 circuits to and from the line group frequency band 60–4028 kc/s. Certain bays, such as the Voice Frequency Bay and the Carrier Supply Bay for generation of the lower carrier frequencies are also included in a number of small carrier systems, and in such cases these bays can be provided with mains supply units.

The tube types used in the coaxial system *ZAX 920/2* including the h.f. line equipment are:

18AK5 or 403B
18AQ5 or 6AQ5L
404A
18C51 or 2C51L

Table of the total power consumption per bay

Bay type	Anode voltage power W	Heater voltage power W	Relay voltage power W
Voice Frequency Bay with v.f. signalling receivers for 1-VF	90	230	20
2-VF	130	340	20
Group Translating Bay	130	150	10
Supergroup Translating Bay,			
for 16 Supergroups, sending	90	100	10
for 16 Supergroups, receiving*	130	105	45
Low Frequency Carrier Supply Bay	120	210	10
Carrier Distribution Bay	15	25	—
High Frequency Carrier Supply Bay	50	50	65

* Including equipment for supergroup regulation.

Long Range Polyphase Meters

S E LINDBERG, AKTIEBOLAGET ERMI, BROMMA

UDC 621.317.785.025.3

Ericsson Review No. 3, 1958, contained a description of ERMI's single-phase meter VEN 23 designed to operate under conditions of widely varying load. ERMI manufactures long range polyphase meters also and the present article deals with their design and general properties.

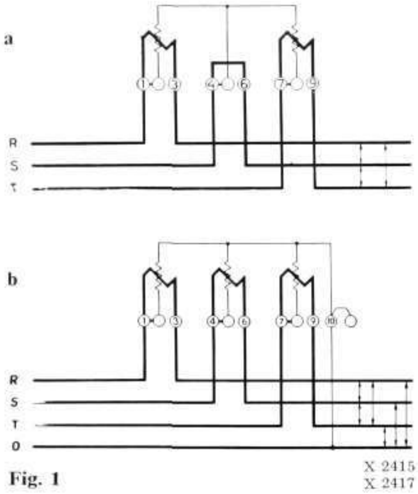


Fig. 1

Electricity meter for use on 3-phase 3-wire and 3-phase 4-wire supply

a with two driving elements
b with three driving elements

Fig. 2 X 8147

Polyphase meter VKN 14

The meter components, mounted on a sheet steel base, are easily accessible. The cover is made of impact-resistant transparent plastic.

Polyphase energy can be supplied through two types of system, one using simply the three phase conductors and the other having four conductors of which three are connected to a three-phase supply and the fourth to a neutral point in the source of supply.

Meters for 3-phase 3-wire systems will record energy consumption with sufficient accuracy using only two driving elements connected on the 2 wattmeter principle, even if the load or the voltage triangle is unbalanced. The circuit of this type of meter is shown in fig. 1 a. Whole-current meters are designated *VGN 14* and *VGN 14 B*, and transformer-operated meters *VGN 14 T*.

In a 4-wire system there must be three driving elements, one in each phase, if the meter is to register correctly (fig. 1 b). Whole-current meters for 4-wire systems are designated *VKN 14* and *VKN 14 B*, and transformer-operated meters *VKN 14 T*.

The *VGN 14 B* and *VKN 14 B* types have plastic bases, and the other types mild steel bases.

In many supply systems polyphase meters are more common than single-phase. They have to register larger quantities of energy than single-phase meters, and under more difficult load conditions. Therefore polyphase meters, too, must have a wide working range, that is, they must respond to very low

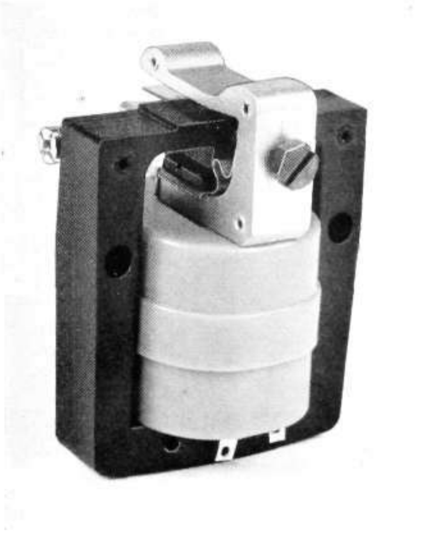


Fig. 3 X 2424

In the central core of the voltage system is an easily accessible hexagonal screw which serves as balance adjuster.

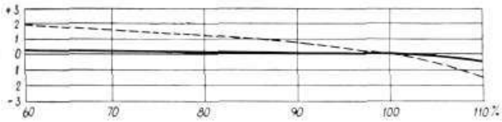


Fig. 4 X 2419

The voltage error of VKN 14 at 100 % balanced load and cos $\varphi = 1$ is less than $\pm$ 0.5 % even at voltage fluctuations of 60—110 % of the rated voltage.

—— cos $\varphi = 1$
- - - - cos $\varphi = 0.5$

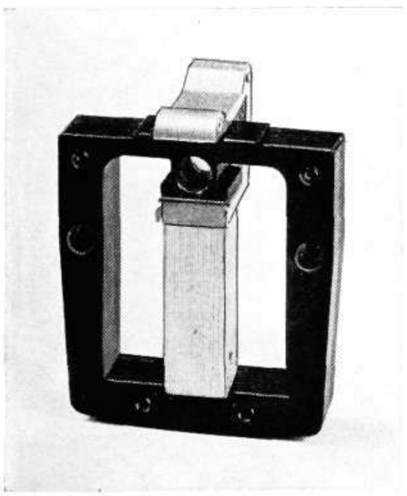


Fig. 5 X 2342

Iron cores of voltage system

The central core is surrounded by the "frame", on one side of which is an inward-pointing section which forms part of the sensitive magnetic shunt.

loads and their errors must be within the limits set by national standards from low up to high values of load current.

In view of the high costs of replacement and overhaul, meters should be capable of operating for several years without supervision. Accordingly their characteristics must be very stable even in an unfavourable environment such as large variations in temperature or humidity. Meters are often exposed to heavy over-voltages from lightning; these affect polyphase meters more than single-phase since the former are more often directly connected to long overhead lines. Polyphase meters must therefore be extremely carefully insulated.

One consequence of the general improvement in distribution systems is the greater liberty in respect to loads with high starting-current, which in turn involves the use of fairly heavy fuses. If the meter is not to be the weakest link in the chain, it must have a sufficiently high thermal rating.

The meters manufactured by ERMI will now be described on the basis of the general requirements related above.

General Construction

The general form of structure used in ERMI meters for many years has been retained in the new meters. It is considered to have very great advantages in that the various components are clearly visible for purposes of inspection; likewise replacements can easily be made in the event of repair or similar requirements.

The driving elements stand well clear of the base (fig. 2). They are perpendicular to the base and on a level with the rotor spindle, which makes inspection of the air gaps very easy since the light shines directly through them. The brake magnet is also well placed from this point of view.

The Driving Elements

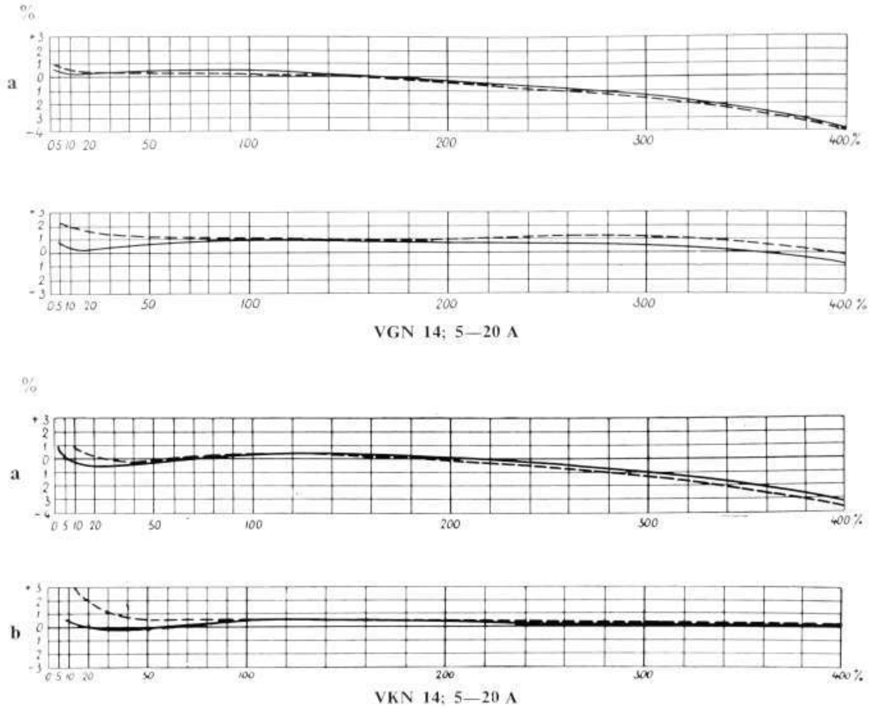
The same high-class driving elements are used in the polyphase as in the single-phase meters. They differ in one respect, however, in that they possess an additional adjusting device by means of which the torque of the rotor spindle is set to the same value for the two or three driving elements. This device, the *balance adjuster,* consists of a finely threaded iron screw which leads part of the driving flux in the voltage system past the rotor back to the central core (fig. 3).

The new design of the balance adjuster has made it possible to increase the *torque* by 20 % without increasing the internal losses in the voltage circuits. The greater torque improves the starting characteristics and reduces the error due to change in friction. The meters will therefore operate efficiently for a longer period between overhauls.

The *voltage system* of the polyphase meter (fig. 5), like that of the single-phase meter, has efficient magnetic shunts which, for example, permit the meter to operate without difficulty at half the rated voltage (fig. 4). The wire in the voltage coil has been made thicker than previously in order even better to stand up to lighting surges.

The *current systems,* too, have magnetic shunts, which assist in minimizing the error also at heavy loads (fig. 6). Meters *VGN 14 T* and *VKN 14 T* will never be loaded above 200 % of the rated current since the current transformers to which the meters are designed to be connected cannot be loaded to higher values.

As stated above, the *thermal ratings* should be of such magnitude as to allow fairly heavy fuses in the metered installations. The rectangular-section



X 8145
X 8146
X 8154

Fig. 6

Error curves

(above) 3-phase 3-wire meter VGN 14
(below) 3-phase 4-wire meter VKN 14
a balanced load
b single-phase load
—— cos φ = 1
- - - - cos φ = 0.5

wire in the current coils so effectively utilizes the winding area that, for example, a *VKN 14*-meter rated for 10 A can be used with a 35 A fuse without injury, since the thermal rating exceeds the test current which a 35 A fuse is designed to withstand during at least 1 hour.

The Swedish meter standards SEN 32 stipulate that the rise of temperature in the current coils shall not exceed 60° C when the meter is loaded to the thermal rating. The insulating material will withstand very high temperatures, so that there is a good margin to spare.

The Brake Magnet

The four-pole brake magnet reduces the vibrations in the rotor owing to the fact that the permanent flux of the magnet passes through the rotor at two closely adjacent points but in opposite directions (fig. 7).

The magnet is made of a very high-quality, hard magnetic material, an Alnico alloy with $(BH)_{max} = 2.5 \times 10^6$ gsoe, which gives it an extremely powerful braking action and a high resistance to short-circuit currents.

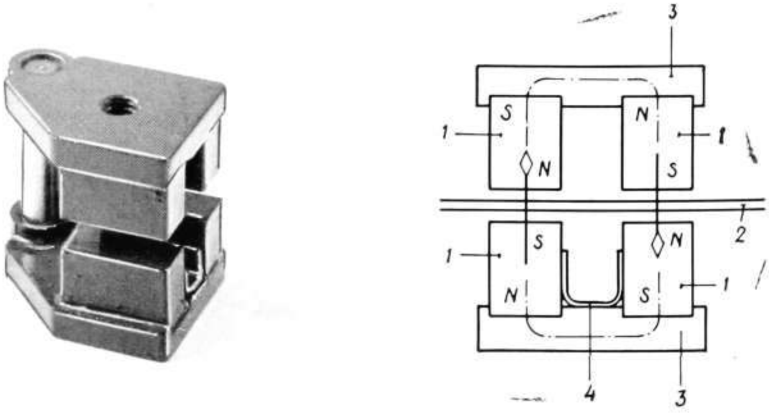


Fig. 7

X 2344
X 2335

The brake magnet has four magnetic prisms attached to pole pieces of sintered iron which are held together by a stainless steel cylindrical pin. The rotor is acted upon by two opposing fluxes.

1 Magnetic elements
2 Rotor
3 Yokes
4 U-shaped strip of nickel steel for temperature compensation

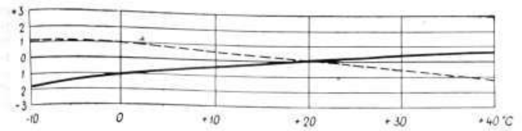


Fig. 8 X 2420

The temperature coefficient of VKN 14 is below 0.5 %/10° C within the range — 10° C to + 40° C.

—— cos φ = 1
- - - - cos φ = 0.5

The fine adjustment of the speed is made on the brake magnet by turning an eccentric with a box spanner or screwdriver. No loosening or tightening of a clamp is required either before or after setting the magnet, and the magnetic circuit remains unchanged throughout. As in the singlephase meter *VEN 23*, the brake magnet of the polyphase meter has a small U-shaped strip of nickel steel attached between two of the magnetic elements. This arrangement reduces the change in error due to variation of temperature to below 0.5 % 10° C (fig. 8).

To increase the volume of a radio set or the speed of a motor, a knob is turned clockwise. The same rule, that clockwise rotation causes an increase, has been adopted in all adjusting devices in ERMI meters which depend upon a rotary movement. Some of the screws have therefore had to be made with left-hand thread.

The Rotor

The polyphase meters have two rotors attached to a common spindle. They are made of 1.20 mm sheet aluminium of 99.8 % purity. The rotor system weighs only 52 g and is carried by a ball type bearing consisting of two sapphire cups with a highly polished steel ball of 1.6 mm diameter rolling between them (fig. 9). These vital parts, which are held together and protected by a sleeve, form an inner unit in the bearing; an outer threaded sleeve is attached by a locking nut to the frame. The inner unit rests on a spring of stainless steel and has the same dimensions as ERMI's pivot type bearings.

The balls in the lower bearings are made of a carbon steel alloy. The bearings are lubricated with a very light film of high class oil which also protects the ball.

The upper bearing is the same as in all ERMI meters, consisting of a highly polished steel pin revolving in a lubricated brass sleeve.

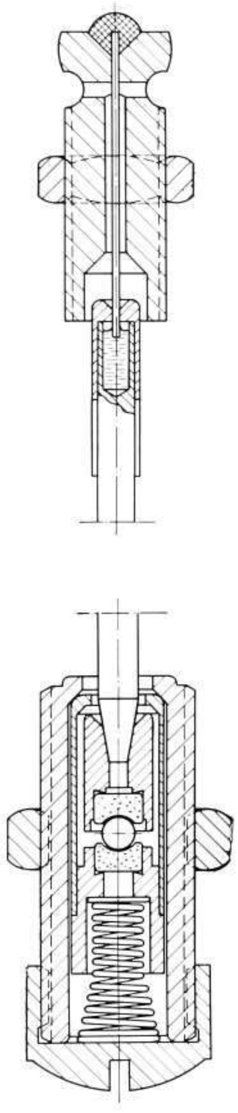


Fig. 9 X 2421

Upper and lower bearings

The lower bearing is a two-jewel type bearing with the jewel seatings and the inner sleeve of aluminium. The fit between the sleeve and the lower jewel seating is so good that the bearing can be easily dismantled without the ball falling out.

The Register

As stated in the previous article on the single-phase meter *VEN 23*, it is extremely important that the friction in the register should be both as low and as stable as possible. A considerable step in this direction was achieved by the use of light plastic drums and pinions and of pivoted stainless steel spindles (figs. 10 and 11). The register is entirely free from oil and is attached to the frame against rigid surfaces by a *single* screw which simplifies zeroing of the register in, for example, a long-time test.

The name plate covering the register carries all the meter data and either a diagram of connections or a diagram number. The former method is used on whole-current meters. The more comprehensive diagram showing the connection of the meter across instrument transformers is placed inside the lid, but the diagram number is marked on the register plate, which always has space also for a 13 × 40 mm property plate.

The Case

The requirements in respect to meter cases vary very considerably. Sometimes a metal case is required, at others a plastic case; some prefer grey and others black. ERMI offers several styles in order to satisfy all tastes and requirements.

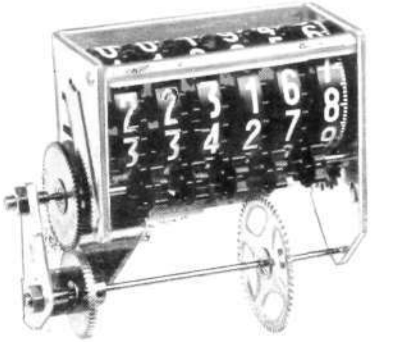


Fig. 10 X 2341

The six drums and five pinions of the register weigh only 4 g. The friction is only 0.4 mpcm.

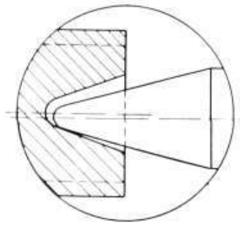


Fig. 11 X 2278

Journal of pivot bearing type register

Cone angle of spindle = 30°
Radius of spindle tip = 0.15 mm
Diameter of spindle = 1.2 mm
The pivot bearing reduces the radius of the spindle at the pivoting point from 0.6 to 0.15 mm.

The two main types have bases of mild steel and plastic respectively. Meters of the first type are designated *VGN 14*, *VGN 14 T*, *VKN 14*, *VKN 14 T*, according to whether they are whole-current or transformer-operated (*T*) and for use in a 3-wire system (*G*) or 4-wire system (*K*). Meters of the second type are called *VGN 14 B* and *VKN 14 B*; the latter meters are not designed for transformer-operation.

The comparatively large and heavy polyphase whole-current meters rated at 50 A are only made in the first type and have a mild steel cover.

The lighter whole-current meters with up to 20 A rating are made in both types and, in their standard form, have a transparent plastic cover. On request, however, meters with mild steel base can be provided with aluminium cover.

Meters for connection to instrument transformers always have an aluminium cover since they are often mounted on panels within recessed frames.

The use of a plastic cover on a meter with mild steel base affords better protection against electric shock than a metal cover, while at the same time the robust base provides adequate protection against mechanical damage.

A plastic base naturally increases the safety still further, but may render the meter more susceptible to damage in transit than a metal base. A plastic cover should have no surface finish and requires practically no maintenance; it need simply be wiped with a damp cloth at each meter overhaul, and no repainting is necessary.

ERMI decided on a robust thermosetting resin for the base (fig. 12) and an impact-resistant and heat-resistant transparent thermoplastic for the cover (fig. 13).

Fig. 12

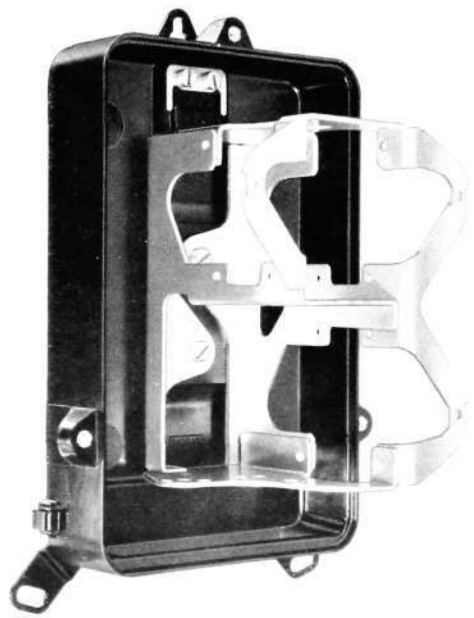


Fig. 13

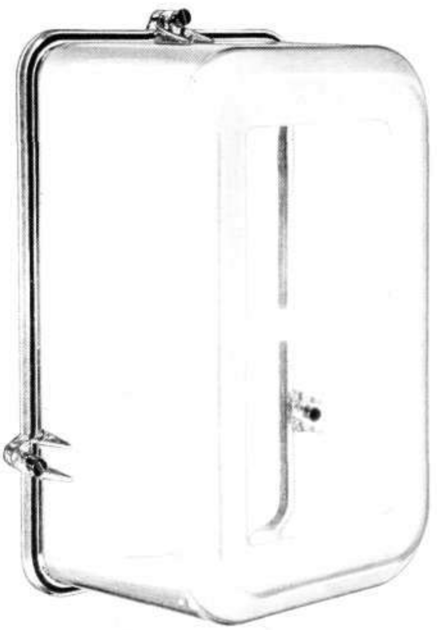


Fig. 12 X 2425

The meter is suspended on three mild steel lugs of equal thickness. The lugs are effectively insulated from the meter frame carrying the driving elements, the windings of which are also well insulated from the iron cores.

Fig. 13 X 2426

The impact-resistant thermoplastic cover will stand temperatures up to 95 °C.

The reasons for making the cover of transparent plastic are as follows. The usual glass inspection window is liable to break and, as on wristwatches, should be replaced by a strong plastic window. ERMI decided to go the full length and make the entire cover of plastic. A thermoplastic material was chosen in view of its greater elasticity than a thermosetting resin such as wood-filled phenolic. It also permits inspection of the meter mechanism without removing the cover.

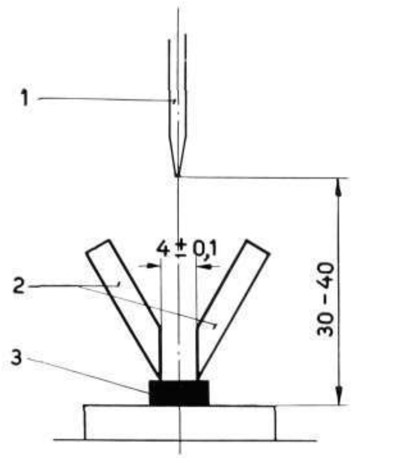


Fig. 14 X 2422

Apparatus for testing track resistance of insulation (Semko)

Two electrodes (2) are pressed against the material (3) at about 100 p during moistening of the material by drops of a solution of about 20 mm³ of ammonium chloride applied with a pipette (1). A new drop is applied as soon as the former has evaporated.

Terminal Block

Increasingly strict requirements are placed on the insulation of electrical apparatus, especially on materials which carry live parts. ERMI's polyphase whole-current meters of both metal- and plastic-base types have blocks of mineral-filled alkyd which possesses high resistance to tracking and distortion due to heat.

The *track resistance* is determined with an apparatus consisting of two electrodes 5 mm in width and 4 mm apart which are pressed against the specimen, the latter being at the same time moistened by drops of a 0.1 % solution of ammonium chloride (fig. 14). The alkyd withstands about 600 volts a.c. between the electrodes during the application of 50 drops of the solution. It is considered that material for terminal blocks should withstand a test voltage of 175 V applied in this way.

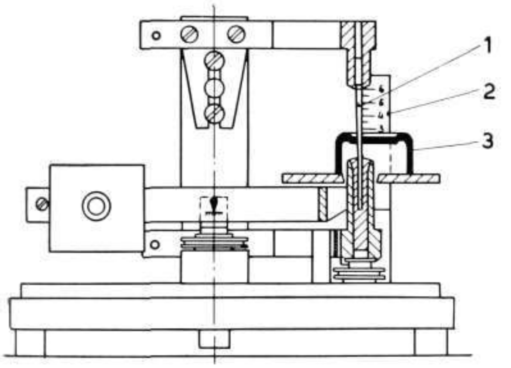


Fig. 15 X 2423

Hot mandrel apparatus for testing heat resistance of insulating material (Semko)

The material (3) is pressed against the tapered mandrel (1) which is heated by an electric current. The displacement is read on a scale (2).

The *heat resistance* is determined by pressure of a hot tapered mandrel with a force of 1.2 kp through a hole in the material shaped to make the mandrel (fig. 15). The displacement should not exceed 3 mm, nor should inflammable gases be formed. The alkyd in these terminal blocks passes the test when the mandrel is heated to about 450° C. The results of this test differ fairly considerably according to the thickness of the material, but the alkyd nevertheless stands up to a temperature well above the level of 300° C which is considered necessary in materials used for such purposes.

Fig. 16 X 8148

Terminal blocks

(Left) for 25 mm² and (right) for 50 mm² stranded conductor. The tapered holes facilitate insertion of the conductors and are sufficiently broad on the outside to take the conductor insulation as well.

Two types of terminal block are made, one for meters marked up to 20 A, either with metal or plastic base, and one for 50 A meters (fig. 16). Both blocks have free terminals which can be easily replaced in the event, for example, of a damaged thread. With the long range meters facilities have to be provided for connection to larger gauges of conductor. The former type of block will take a stranded conductor up to 25 mm², and the latter up to 50 mm².

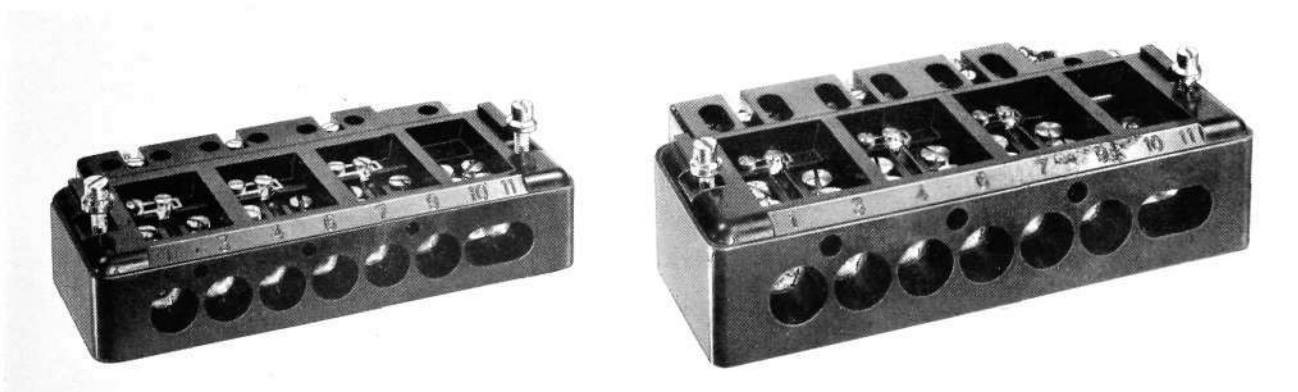


Fig. 17 X 8149

Both the short and the long terminal covers are of impact-resistant thermoplastic. They are secured to the block by captive and sealable screws.

After connection of the meter the terminals must be fitted with a cover which renders protection against electric shock and unwarranted interference. There are two types of terminal cover; one covers the block alone, while the other also protects the conductors between the block and the cut-out in the meter panel (fig. 17). The covers are secured by two captive screws threaded to the block and suitable for sealing. The material of the block is an impact-resistant plastic which, being also elastic, is resistant to stresses caused by unevenness in the meter panel.

Insulation

The good insulation of the meters has been achieved by effective enclosure and screening of live parts, by the large creepage and air gaps, and by the track-resistant material in the terminal blocks.

The thin wires of the voltage coils are well protected by polythene covers (fig. 18), and the current coils by adequately dimensioned plastic discs. The P.V.C.-insulated voltage leads have an additional layer of P.V.C. where they pass metal parts, and the down-leads from the current coils run at not less than 8 mm past metal parts in the frame or case. Through these measures all the whole-current meters comply with the specifications for SEMKO "Extra Insulation" Class II, marked with Ⓢ and ⧈ (see Ericsson Review No. 4, 1957).

The characteristic data of the meters are set out on the following page.

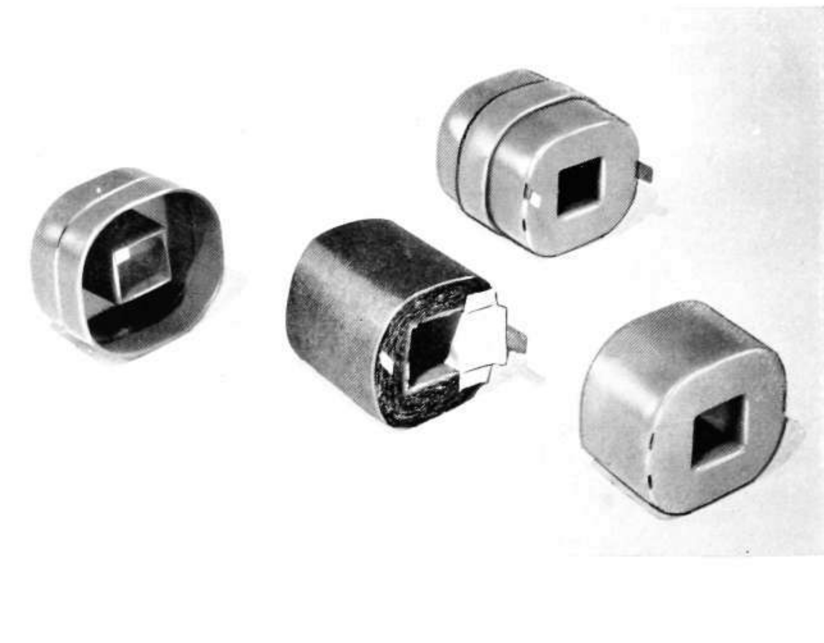
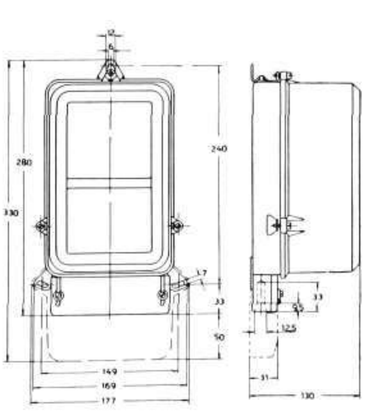


Fig. 18 X 8107

The coil with paper insulation between the layers of windings is effectively protected against over-voltages by a split cover of polythene, which enables it to withstand a surge voltage of about 14 kV.

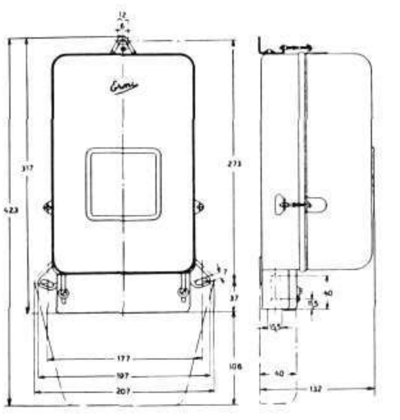
Data

		3-phase 3-wire			3-phase 4-wire		
		whole-current		transformer-operated	whole-current		transformer-operated
Current rating	A	5, 10, 20	50	1, 2, 5	5, 10, 20	50	1, 2, 5
Type	—	VGN 14 VGN 14 B	VGN 14	VGN 14 T	VKN 14 VKN 14 B	VKN 14	VKN 14 T
Measurement limit, % of rated current	%	300	250	200	300	250	200
Thermal limit, % of rated current	%	5A: 400 10A: 400 20A: 300	260	300	5A: 400 10A: 450 20A: 375	260	300
Torque at rated load	pcm	7.3	7.3	8.0	9.5	10	8.5
Speed " " "	r.p.m.	12—14	12—14	15—18	12—14	12—14	15—18
Rotor weight	g	52	52	52	52	52	52
Starting power, % of rated load	approx. %	0.4	0.4	0.3	0.3	0.3	0.3
Internal loss in							
voltage circuits	W	0.9	0.9	0.8	0.9	0.9	0.7
current circuits	VA	0.4	1.0	0.4	0.3—0.4	1.0	0.3
Max. conductor size	mm^2	25	50	16	25	50	16
Voltage error at 100 % load							
Voltage % of rated voltage / Cos φ							
60 / 1	%	— 1.3		—	+ 0.3		—
90 / 1	%	— 0.3		— 0.3	+ 0.2		— 0.2
110 / 1	%	— 0.3		+ 0.2	— 0.5		+ 0.2
60 / 0.5	%	— 0.2		—	+ 1.9		—
90 / 0.5	%	+ 0.2		+ 0.2	+ 0.7		— 0.2
110 / 0.5	%	— 0.7		— 0.3	— 1.4		— 0.3
Frequency error at 100 % load							
Frequency variation / Cos φ							
— 5 % / 1	%	+ 0.6		+ 0.6	+ 0.5		+ 0.8
+ 5 % / 1	%	— 1.0		— 1.0	— 0.5		— 0.9
— 5 % / 0.5	%	— 0.5		— 0.5	— 1.1		— 0.3
+ 5 % / 0.5	%	+ 0.1		+ 0.1	+ 0.9		+ 0.1
Temperature coefficient at 100 % load %/10° C from — 10° C to + 40° C	approx.						
cos φ = 1.0	%	0.5			0.5		
cos φ = 0.8	%	0.2			0.2		
cos φ = 0.5	%	0.5			0.4		



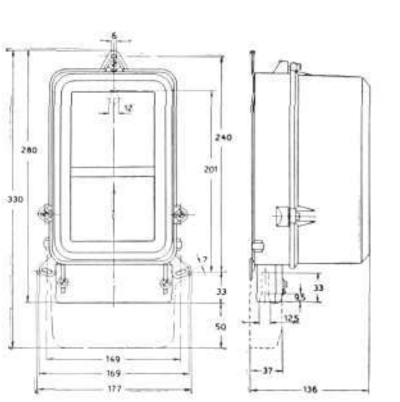
X 2441

VGN 14 and VKN 14: 5—20 A



X 2439

VGN 14 and VKN 14: 50 A



X 2440

VGN 14 B and VKN 14 B: 5—20 A

Rodent Attack on Rubber- and Plastic-Insulated Wires and Cables

B LIZELL, J ROOS, SIEVERTS KABELVERK AB & G BJÖRCK, K. VETERINÄRHÖGSKOLAN, STOCKHOLM

UDC 621.315.211.2
620.193.86

Rodent attack on different rubber and plastic materials has been investigated. The tests were made partly on cylindrical samples, partly on insulated cables with and without various additives tried as rat repellents. White rats were used in the tests, and the animals had normal supply of fresh water and feed. All rubber and plastic materials under test were attacked, the degree of attack increasing with the softness of the materials. A thick aluminium or steel tape gave the only complete protection. Z. A. C. had some rat-repelling effect.

Introduction

In Sweden, as in most European countries, the production of plastic-insulated cables has rapidly increased, mainly at the expense of paper-insulated cables. Signal and control cables are manufactured to a very large extent with PVC or polyethylene insulation and sheathing. In less than two years low tension PVC-insulated power cables have conquered more than 60 per cent of the market. The introduction of PVC-insulated cables with a rated voltage of 10 kV is in full progress. It may be expected that polyethylene-insulated telephone cables will soon replace paper-lead cables to a large extent. Simultaneously there is a clear trend towards rubber-insulated cables for more qualified applications. It is therefore obvious that the economical consequences of failure of rubber- and plastic-insulated wires and cables are of steadily increasing importance.

Among the presumptive causes of cable failure, damage by rodents has been much discussed in Sweden. Some cases of severe damage by rats have directed attention to the fire hazard resulting from rodent attack. Previously it had been found that complete protection against rodent attack could only be achieved by using a brass or steel armor. But this method is hardly feasible with rubber and plastic cables, since, if they are to be armored, they will lose their three chief advantages of economy, low weight and non-corrodibility.

An investigation has therefore been undertaken by Sieverts Kabelverk, in cooperation with Kungliga Veterinärhögskolan, Department of Animal Husbandry, in order to determine the extent of rodent attack and to clarify the possibilities of making rubber- and plastic-insulated cables resistant to rodents.

Considerable attention has been paid to rodent attack on cables over the past years. In a farmyard building in Norway the destruction by rats of a rubber-insulated lead-sheathed cable, with an outer covering of impregnated jute braid, resulted in a recommendation to use steel-armored cables in areas where rodents are abundant (1). In an investigation concerning »Cable Damage by Gophers», Livingston (2) found a ten-mil copper tape »to be a reasonable risk» as gopher protection on coaxial cables. Rats were reported to prefer a rubber-insulated cord to poultry feed in Norway (3). A short article in 1952 by

Dyrendahl & Björck (4), followed by a second publication in a Swedish Insurance Bulletin (5), roused considerable interest. The articles were even quoted in an Egyptian newspaper in order to convince subscribers that the frequent power failures in an Egyptian town could actually be caused by rodent attack on cables as claimed by the officials. The experiments had proved that PVC and lead were no hindrance to the rats. Barail (6) states in "The Biology of Plastics" that several animals are repelled by the smell of perfume, transpiration and certain chemicals, but also that efficient rodent repellents are often detrimental to the color, smell, and other properties of plastics. Unfortunately, several plastic materials can serve as feed for rodents. Gibling & King (7) gave a review of the literature in a paper entitled "Damage to Lead-Sheatled Cables by Rodents and Insects". In Switzerland 71 cases of damage by rodents had been reported between 1927 and 1936 as compared with 110 cases of corrosion and 1 663 cases of failure of the same types of cables from all kinds of faults. The rodents were thought to cause damage due to their normal habit of gnawing in order to keep their teeth in condition. In an article on polyethylene tubing, Vinding (8) concludes that rats are capable of damaging polyethylene, but no evidence has been given that they actually do so. Cooke (9) has found rats to attack polyethylene- and PVC-insulated cables and discusses various defensive measures.

Scope of Investigation

The experimental work covered rat attack on the following main groups of materials:

1. Some different types of cables
2. PVC compounds containing different ingredients without rat repellent
3. PVC compounds containing various rat repellents
4. PVC-insulated and PVC-sheathed cables with an outer protection of rat repellent
5. Rigid PVC
6. PVC-insulated and PVC-sheathed cables covered with emery cloth

The experiments were carried out in the rat laboratory at Kungliga Veterinärhögskolan, using albino rats. In all experiments the animals were given fresh water and a standard diet, which had been used for many years in the laboratory and was known to fulfill the requirements for normal growth and reproduction of the rats. The animals were kept in their cages, which were made of galvanized wire netting. Parallel tests were run on individual rats and on rats in groups. The cylindrical samples used in some of the tests were moulded from compounds mixed in a laboratory plastics mill.

Experiments and Results

1. Rat Attack on Different Types of Cable

In order to determine the degree of rat attack on the different materials used in our cable designs, sixteen different cables and cords were tested for two days in a cage containing 10 female rats. In Table 1 the materials used for insulation and sheathing are listed.

Results

The results of these tests are evident from Fig. 1 and Table 1. An attack to such an extent that the serviceability of the cables would be affected was observed on all types which were not protected by an outer layer of aluminium or steel. Aluminium did not seem to be as effective as steel, however. Samples which had an outer sheath of a relatively hard PVC-compound (no.

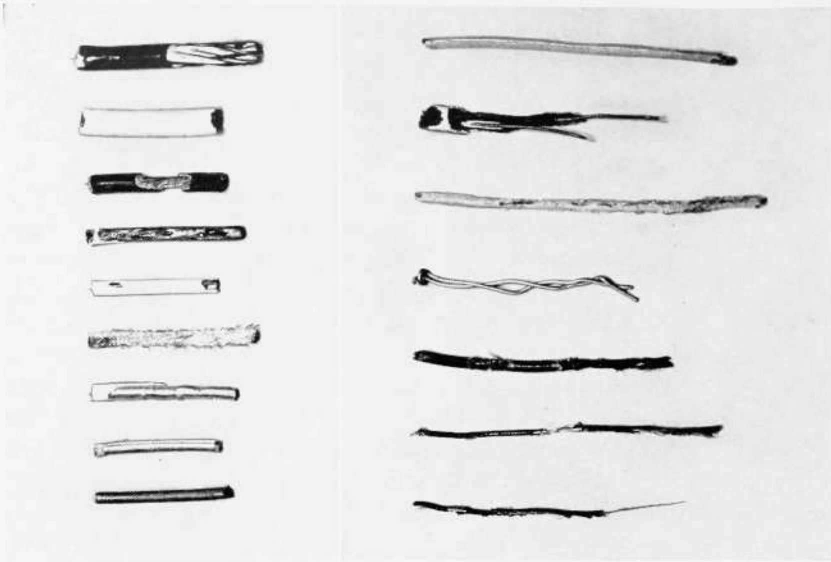


Fig. 1 X 7743

Rat attack after two days on various cables. Group test.

For explanation see table 1.

2 and 5) or an insulation of polyurethane (no. 10) were not as severely attacked as samples with an outer sheath of a soft rubber or plastic material. DLN (WD-1) was severely attacked in spite of the outer nylon sheath. The nylon was obviously too thin (0.17 mm) and easy for the rats to destroy. It is worth noting that the lead sheath in samples nos. 4 and 13 did not prevent attack.

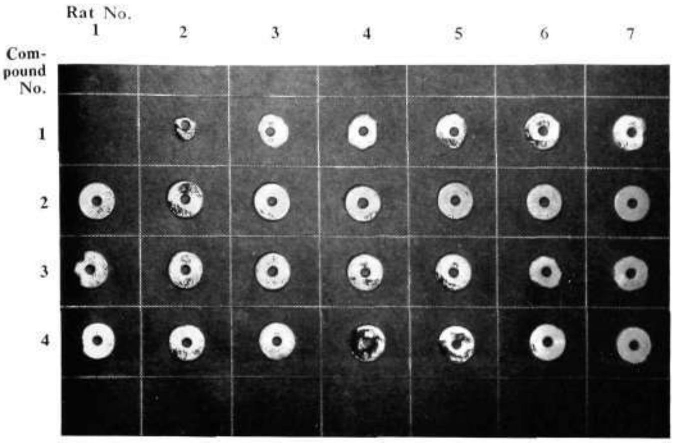
The following materials can be said to be vulnerable to rat attack: PVC, polyethylene, nylon, polyurethane, natural rubber, butyl, neoprene, silicone rubber and lead. It would appear highly probable that other soft plastic and rubber materials, not tested in this investigation, would also be vulnerable to rodent attack.

Table 1.

Cable types tested and results of tests

E = solid conductor. F = stranded conductor. R = multiwire stranded conductor. Cross sectional areas in mm^2

Cable designation area in mm^2	Conductor	Insulation	Inner sheath	Outer sheath	Remarks
1. EKKR 27 × 1.5	Cu (E)	PVC	—	PVC	Severe attack Copper visible
2. FKK 4 × 10	Cu (F)	PVC	butyl reclaim	PVC hard grade	Moderate attack
3. RDOM 1 × 35	Cu (R)	butyl	—	neoprene	Severe attack Copper visible
4. EKKL 4 × 1.5	Cu (E)	PVC	butyl reclaim	lead-PVC	Severe attack Copper visible
5. EKK 3 × 1.5	Cu (E)	PVC	butyl reclaim	PVC hard grade	Severe attack Copper visible
6. RTTA 1 × 25	Cu (R)	silicone rubber	—	glass braid	Severe attack Copper visible
7. Building cable (exp.) 4 × 2.5	Cu (E)	PVC	Al (0.25 mm)	PVC	PVC-sheathing almost removed. Al not destroyed
8. Exp. cable 4 × 2 × 0.7	Cu (E)	polyethylene	steel (0.20 mm)	polyethylene	Polyethylene almost removed. Steel not destroyed
9. EKR 2 × 1.5	Cu (E)	PVC	—	steel (0.20 mm)	Not destroyed
10. Exp. cable 2 × 0.5	Cu (E)	polyurethane	—	—	Slight attack
11. EKK (exp.) 2 × 1.5	Cu (E)	PVC	butyl reclaim	PVC soft grade	Severe attack Copper visible
12. RKXA (exp.) 2 × 0.5	Cu (R)	polyethylene	—	—	Severe attack Copper visible
13. EDKL 2 × 1.5	Cu (E)	natural rubber	natural rubber	lead-PVC	Only copper remained
14. RK (exp.) 1 × 2.5	Cu (R)	PVC	—	nylon (Akulon) 2A	Severe attack Copper visible
15. DLN (WD-1)	Cu-steel (F)	polyethylene	—	nylon (Akulon) 2A	Severe attack Copper visible
16. DLN (WD-1) without nylon	Cu-steel (F)	polyethylene	—	—	Severe attack Copper visible



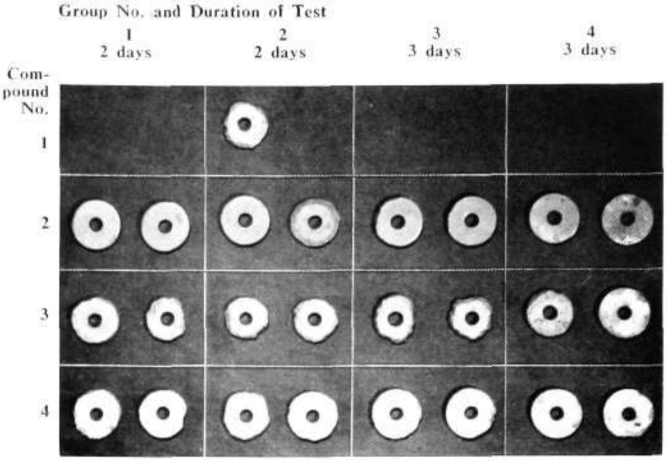


Fig. 2 X 8092

Rat attack after four days on PVC compounds 1 to 4. Individual tests.

Fig. 3 X 8093

Rat attack on PVC compounds 1 to 4. Group tests.

2. Rat Attack on PVC Compounds Containing Different Ingredients Without Rat Repellent

The influences of the hardness of the compound and of the type and quantity of PVC resin and plasticiser used were investigated. Two resins were tried: a pure emulsion type polyvinyl chloride resin and a chloride acetate copolymer containing about 3.5 per cent polyvinyl acetate. The plasticisers consisted of dioctyl phthalate (DOP) and tricresyl phosphate (TCP). The tests with the copolymer were carried out in order to check certain statements that the acetate-containing polymer was less liable to attack than pure PVC. TCP was compared with DOP, as phosphoric acid derivatives have been known to decrease fungus attack. Cylindrical samples 8 mm thick and 48 mm in diameter were made in the laboratory from the compounds nos. 1–4. Number-plates of metal were attached to the samples for identification.

Table 2. Formulæ of compounds 1 to 4 (parts by weight)

	Compound No.			
	1	2	3	4
PVC	100	100	—	—
PVC/PVA	—	—	100	100
DOP	50	—	—	33
TCP	—	33	50	—
Tribasic lead sulphate	7.0	7.0	7.0	7.0
Dibasic lead stearate	0.4	0.4	0.4	0.4
Calcined clay	10	10	10	10
Hardness Shore A	86	97	87	95

The tests were carried out as a Latin Square arrangement with three variables on two levels. Seven individual tests and four group tests were made. (Groups 1–3 consisted of seven female rats each; group 4 of five male rats.)

Results

The degree of attack on the various samples is evident from Figs. 2 and 3. Empty spaces signify that the samples were destroyed or consumed. The attack on the compounds decreased in the order 1, 3, 4, 2, clearly indicating that increased hardness resulted in decreased attack. A mathematical analysis of the results was not necessary to conclude that this was the only significant result.

3. Rat Attack on PVC Compounds Containing Various Rat Repellents

A systematic investigation of the effectiveness of chemical compounds as rat repellents would be a giant task, and no clear principles can be laid down for the work. The tests listed in Table 3 were therefore carried out with the sole intention of testing certain commercial rat repellents (nos. 10 and 13), some rubber accelerators earlier considered to have some rat-repelling effect (no. 11 and 12), and finally to try out a few other substances chosen fairly at random. Sample no. 5 contained no rat repellent and was included as control. All additions were made with a concentration of 4 parts per 100 parts of polymer. The following composition was used:

Ingredients	Parts by weight
PVC	100
DOP	50
Tribase E	7
Dibasic lead stearate	0.4
Calcined clay	10
Additive (variable)	4

All compounds were mixed in a laboratory mill and the cylindrical samples were prepared as in the previous tests. The experiment comprised 8 individual tests and 4 group tests (3 groups with ten female rats in each group and one group with seven male rats).

Table 3. Additives used in test 3

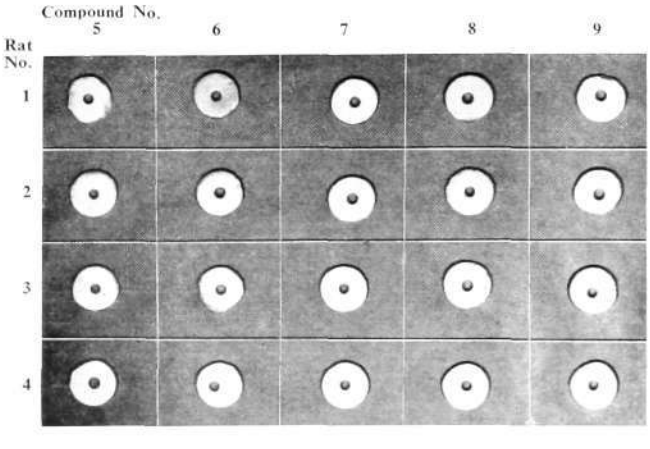
Compound No.	Additive
5	—
6	Valeric acid
7	Perfume
8	Cat urine
9	RPA (Xylyl mercaptan)
10	Sodium silicofluoride
11	Rapid TE (Tetraethylthiuram disulfide)
12	GMF (p-chinondioxime)
13	Z.A.C. (complex of cyclohexylamine and zinc dimethyldithio-carbamate)
14	Hand lotion

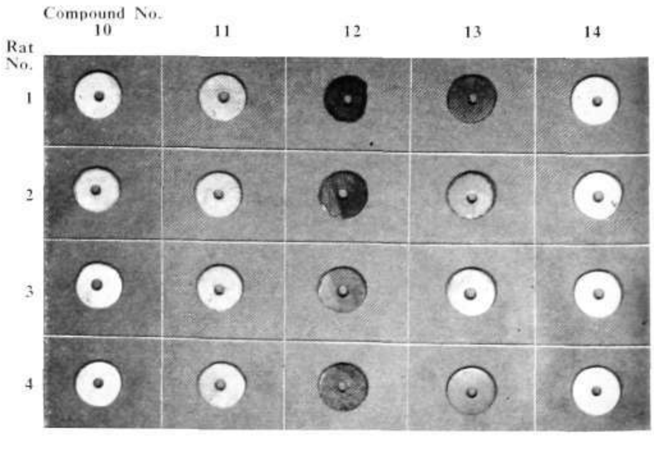
Fig. 4 X 8094

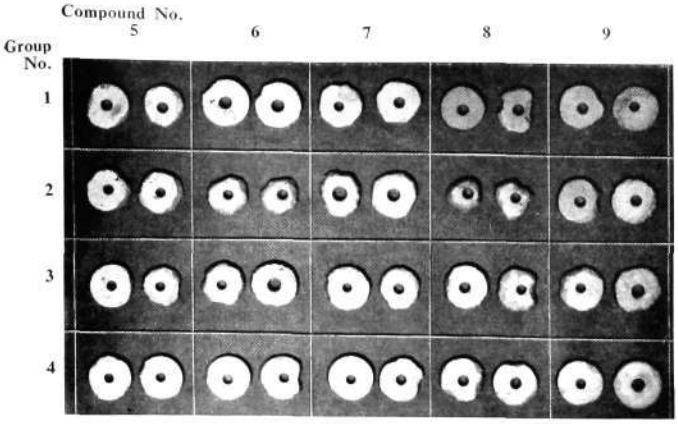
Rat attack after two days on PVC compounds containing "rat repellents". Individual tests.

Fig. 5 X 8095

Rat attack after two days on PVC compounds containing "rat repellents". Individual tests. (Contd.)







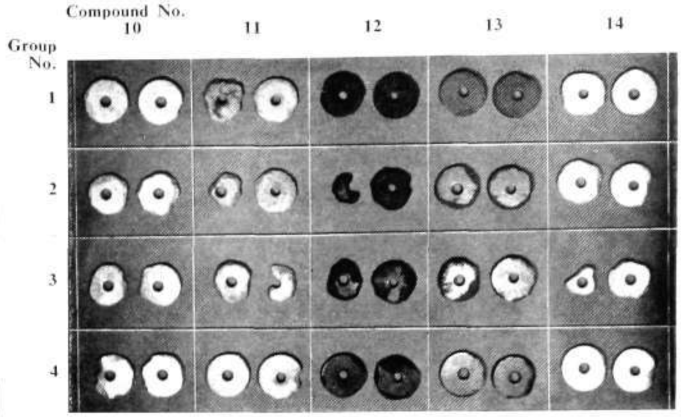


Fig. 6 X 8096

Rat attack after two days on PVC compounds containing "rat repellents". Group tests.

Fig. 7 X 8097

Rat attack after two days on PVC compounds containing "rat repellents". Group tests. (Contd.)

Results

The degrees of attack in the various tests are seen from Figs. 4–7. None of the additives tested can be considered to have the desired rat-repelling effect. An interesting result was that the samples containing valeric acid and cat urine (nos. 6 and 8) were considerably attacked. The rat repellent Z. A. C. had a certain repelling effect, as is evident from sample no. 13. The results are also shown in Fig. 8, which is based on a visual determination of the degree of attack on the various samples.

4. Rat Attack on PVC-Insulated and PVC-Sheathed Cables with an Outer Protection of Rat Repellent

As Z. A. C. mixed into a PVC compound had shown some rat-repelling effect, it was thought that an external coating of Z. A. C. on PVC would be even more effective. Two pastes were therefore prepared from Z. A. C. mixed into lacquers, one using a commercial rubber lacquer (Black Out), the other a solution of PVC in cyclohexanone. Samples of a PVC-insulated and PVC-sheathed cable were painted with the two pastes. The dried samples were tested together with control samples in a cage containing ten female rats for two days.

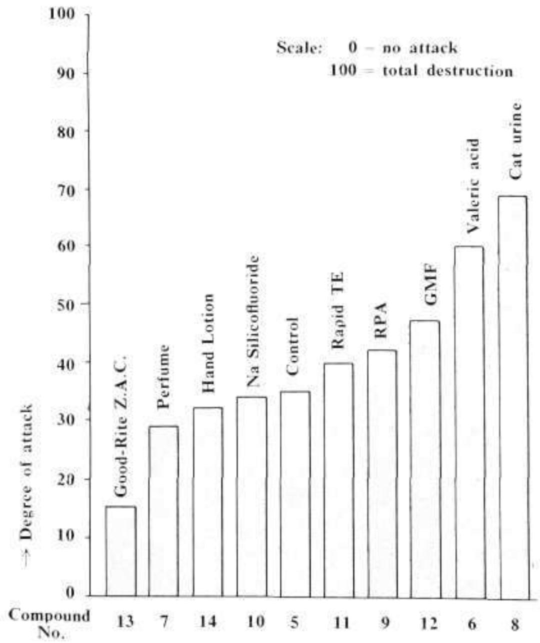


Fig. 8 X 2357

Rat attack on PVC compounds containing various rat repellents. Visual evaluation of the degree of attack.

Control

Black Out

PVC Lacquer

Black Out + 5 % Z.A.C.

Black Out + 10 % Z.A.C.

Black Out + 25 % Z.A.C.

PVC Lacquer + 5 % Z.A.C.

PVC Lacquer + 10 % Z.A.C.

PVC Lacquer + 10 % Z.A.C.

Fig. 9 X 2370

Rat attack after two days on a PVC-insulated and PVC-sheathed signal cable with and without an outer protection of the rat repellent Z.A.C. Group test.

Results

From Fig. 9 it is concluded that Z. A. C. does not give complete protection against rodent attack, although it considerably reduces the degree of attack. The lacquers in themselves had no effect either way. Varying the amount of Z. A. C. in the lacquer over the 5 per cent level caused no significant difference.

5. *Rat Attack on Rigid PVC*

The tests reported under 2 above had indicated a decreased attack with increased hardness of the PVC compound. A series of tests was therefore carried out on rigid PVC. Fig. 10 shows the various pieces tested. As previous experiments had shown that the rats preferred the ends of the cable samples, special arrangements were made in this series to protect the ends with steel clamps or discs. The EKKR cable used was white but otherwise of the same type as utilized und 4 above. All samples were tested for 5 days in a cage containing 7 young female rats.

Fig. 10 X 7744

Rat attack after five days on various samples of rigid PVC.

For further explanation see table 4.

17 EKKR

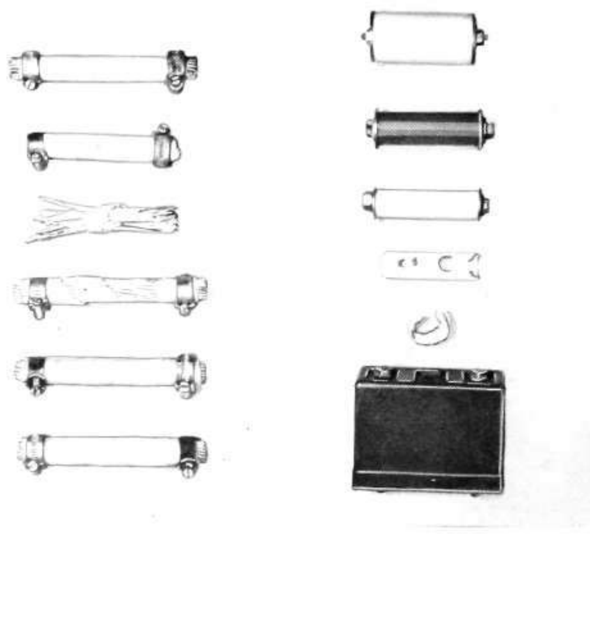
18 EKKR

19 EKKR

20 EKKR taped with 0.3 mm rigid PVC tape O.D. 23 mm

21 EKKR taped with 0.4 mm rigid PVC tape O.D. 23 mm

22 EKKR taped with 0.5 mm rigid PVC tape O.D. 23 mm



23 Rigid PVC tubing O.D. 40 mm

24 Rigid PVC tubing O.D. 29 mm

25 Rigid PVC tubing O.D. 22 mm

26 Rigid PVC tubing O.D. 22 mm

27 Rigid PVC tubing O.D. 40 mm length 10 mm

28 Rigid PVC box (no sharp corners)

Results

The results will be found in Table 4 and Fig. 10. The difficulties encountered in this type of research are clearly indicated. The control (no. 17), which in previous tests had been heavily damaged, was this time attacked only at the free ends. Simultaneously a cable similar to the control, but covered with a 0.3 mm rigid PVC tape, (no. 19), was severely attacked.

The following could be concluded:

Rigid PVC was vulnerable to rodent attack.

Sharp edges and ends were preferred by the rats.

The tubes with large diameters were difficult for the rats to handle.

Increased thickness reduced but did not prevent the gnawing on the tapes.

Table 4. Rat attack on various samples of rigid PVC

Sample No.	Type of sample	Preparation of sample ends	Remarks
17	EKKR	10 mm free at both ends	Free ends attacked, main part not attacked
18	EKKR	One end protected, 10 mm free at other end	Only free end attacked
19	EKKR	Boths ends free	Severe attack
20	EKKR taped with 0.3 mm rigid PVC tape, O.D. 23 mm	10 mm free at both ends	Severe attack
21	EKKR taped with 0.4 mm rigid PVC tape, O.D. 23 mm	10 mm free at both ends	Moderate attack
22	EKKR taped with 0.5 mm rigid PVC tape, O.D. 23 mm	10 mm free at both ends	Moderate attack
23	Rigid PVC tubing, O.D. 40 mm	Both ends protected	No attack
24	Rigid PVC tubing, O.D. 29 mm	Both ends protected	No attack
25	Rigid PVC tubing, O.D. 22 mm	Both ends protected	Minor scratches
26	Rigid PVC tubing, O.D. 22 mm	Both ends free	Severe attack
27	Rigid PVC tubing, O.D. 40 mm, length 10 mm	Both ends free	Severe attack
28	Rigid PVC box (no sharp corners)	—	Minor scratches

6. Rat Attack on PVC-Insulated and PVC-Sheathed Cables Covered with Emery Cloth

Two samples were prepared from signal cable EKKR, one supplied with a helically wound strip of fine emery cloth, the other with a strip of coarse grade-cloth. The strips were about $^3/_4''$ wide and were wound on the cables with about 25 % overlap.

Results

Both samples were attacked and pieces of the emery cloth were removed by the rats. The emery cloth could therefore not be considered to give adequate protection. A better result might have been obtained if the strips had been glued to the cables, as the attack was concentrated to the edges of the strips. This was not tried, however.

Conclusions

Rats, being playful and inquisitive animals, attack materials which have no function as food or which can be used as teeth-sharpeners. None of the materials tested were rat-proof. Hard or rigid materials resisted attack better than soft ones. No soft rubber or plastic materials are likely to resist attack, while rigid types in thick sections will probably be damaged only to a small extent. Metal sheathing is required for the complete protection of cables. Lead, however, is no hindrance to attack. The rat repellent Z. A.C. has some effect.

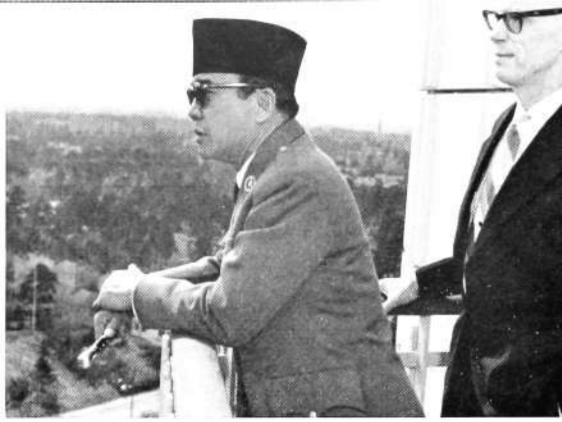
Discussion

The investigation presented above is not complete, and criticism can be raised concerning the number of samples, the experimental animals chosen etc. It seems to be certain, however, that rubber and plastic materials are not and cannot be made rodent-resistant at present. The above results are also being checked in a test series using wild Norwegian rats (Rattus Norvegicus). These tests, carried out at Statens Skadedyrlaboratorium, Denmark, are not yet complete but seem to verify the conclusions drawn from the tests with albino rats, the only difference being that the attack was more intense with the albino rats, probably because the animals were kept in small cages in which the samples were readily available. With the extremely rapid expansion in the production of, especially, plastic-insulated telephone and power cables, the development of rodent-resisting rubber and plastic materials rapidly becomes more urgent. It has been shown that a decreased attack by rodents can be achieved by using certain additives in the compounds. It seems probable that chemicals of far greater efficiency than those used in this investigation can be found. We therefore wish to conclude with a challenge to the chemical industry to tackle and solve this intriguing problem.

Bibliography

1. Sotaaen, C S: *Elektrisitet og brandfare.* [Electricity and Fire Hazard.] Elektrotekn. T *48*(1935): 4,pp. 45—46.
2. Livingston, F B: *Cable Damage by Gophers.* Bell Lab. Record *24*(1946): 4, pp. 157—160.
3. *Grådige gnagere.* [Greedy Rodents.] Elektrotekn. T *59*(1946): 34, pp. 385—386.
4. Dyrendahl, S & Björck, G: *Kan råttor orsaka eldsvåda?* [Can Rats Cause Fire?] Försäkr.-tidn. 1952: 5/12.
5. *Råttor och bränder.* [Rats and Fires.] Försäkr.-tidn. 1954: 4—5/12.
6. Barail, L C: *The Biology of Plastics.* SPE J *9*(1953): 1, pp. 14—15.
7. Giblin, J F & King, W T: *Damage to Lead-Sheathed Cables by Rodents and Insects.* ATE J *11*(1955): 27.
8. Vinding, J: *Kan rotter æde polyethylen-rør?* [Can Rats Eat Polyethylene Tubes?] Plastic *8*(1956): pp. 113.
9. Cooke, E I: *Enemies of Electric Cables.* Telcon House Mag. 1956: 32, p. 1.

Ericsson LM NEWS *from All Quarters of the World*



In the course of his tour of the L M Ericsson workshops the technically interested President, Dr. Sukarno, made a halt in the wiring department. Mr. Sven T. Åberg demonstrates the process of cable forming.

President of Indonesia visits L M Ericsson

During his three-day stay in Sweden as the guest of the Swedish government, President Sukarno of Indonesia paid a visit to L M Ericsson at Midsommarkransen on May 4. With Mr. Sven T. Åberg as guide, the President accompanied by a suite of some twenty persons was taken on a tour of the plant and showed a lively interest in the firm's products and manufacturing methods.

(Top photo) President Sukarno admires the view from the balcony of Mr. Åberg's room in the new 13-storey wing at Midsommarkransen.

(Left) President Sukarno and Mr. Åberg study the photograph album which was presented to him before his departure. It contains shots taken during his tour of the workshops a few minutes before. On the left is Mr. J. Malling, former Swedish Ambassador to Indonesia.

The Ericofon approved by Swedish Telecommunications Administration

The Swedish Telecommunications Administration has now approved the Ericofon as standard equipment either as subscriber's main or extension station or as extension to a private switchboard.

This decision, which was announced at a press conference in early April, was preceded by a nation-wide survey of subscribers' opinions on the Ericofon and on their desires concerning the telephone in general. The survey was based on a random sample of 1000 subscribers. It was carried out by the Institute of Applied Psychology of the University of Stockholm at the joint request of the Administration and of L M Ericsson. A later article in Ericsson Review will contain a detailed account of the survey, but a few figures of interest are presented here.

The 1000 subscribers had their ordinary telephone replaced by an Ericofon. They were interviewed on two occasions during a period of six months. At the first interview 92 per cent preferred the Ericofon, and 94 per cent at the second interview.

It was found that 78 per cent of respondents would choose an ivory Ericofon, 6 per cent pale grey, 6 per cent green, 4 per cent red, 3 per cent blue, and only 1 per cent prefer the dark grey finish.

The Administration will be supplying the Ericofon in the abovementioned colours with the exception of dark grey.

The standard outlet for the Ericofon will be a plug and jack arrangement; the bell will be locatable at choice, and facilities for regulation of the signal will be provided. At the press conference at which the approval of the Ericofon was notified, Dr. Håkan Sterky, Director General of the Board of Telecommunications, concluded his announcement with the following words:

"Sweden has always taken a leading position in telephony, and L M Ericsson in particular has been a pioneer in the design of telephone instruments. I need merely recall that Ericssons were the first firm to sell the handset telephone on the general market, that is, with transmitter and receiver combined in one unit. In the thirties they followed with the plastic-encased telephone with its entirely novel and streamlined form. We have now reached a stage further, and the Swedish Administration must be the first telephone operating enterprise in the world to introduce a telephone which has transmitter, receiver and dial in a single unit.

When L M Ericsson started to search for a new idea in telephones nearly ten years ago, there were many problems to solve, particularly in the matter of external design. The culmination of their work lies before you today, the Ericofon, or as it is popularly called, the Cobra. The engineers and designers have undoubtedly experimented with many a tune, before – like the snake-charmer – they could draw forth the best from the materials available to technicians today. It is now our hope, at the Administration, that the Cobra in turn will charm the telephoning public in their homes and offices."

Dr. Håkan Sterky, Director General of the Swedish Board of Telecommunications, tries out the Ericofon. In the foreground the 1885 model of Ericsson telephone.

The former Chief Marshal at the Court of Sweden, Birger Ekeberg, and the Minister of Agriculture, Gösta Netzén, have the Ericofon demonstrated to them by Mr. Bejkeby of L M Ericsson.

New 500-switch Exchange Opened in Curaçao

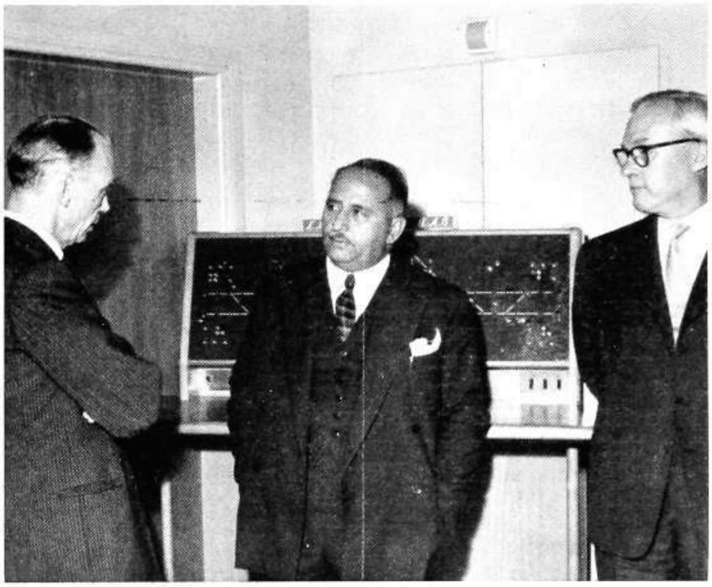
In April a new automatic telephone exchange was opened at Santa Rosa, the sixth to be installed on the island of Curaçao in the Dutch West Indies. Like the remainder of Curaçao's public automatic exchanges, the equipment for Santa Rosa was delivered by L M Ericsson. This was the first installation to be completely undertaken by the Telephone Administration itself.

North Electric Co., L M Ericsson's subsidiary in Galion, Ohio, took part in April in the exhibition "Communications Serving the Nation" in the Department of Commerce building at Washington, D.C. North Electric, one of the oldest telephone companies in the United States, celebrated its 75 years jubilee with a diorama display. Many thousands of visitors viewed models of systems produced by North for American industry, public utilities and national defence. With the help of Ericofons they could obtain information about the different products shown (Photo right).

(Below) Mr. William Tucker, president of North Electric, presented the Secretary of Commerce, Mr. Lewis L Strauss, with a gold Ericofon during the opening ceremony.

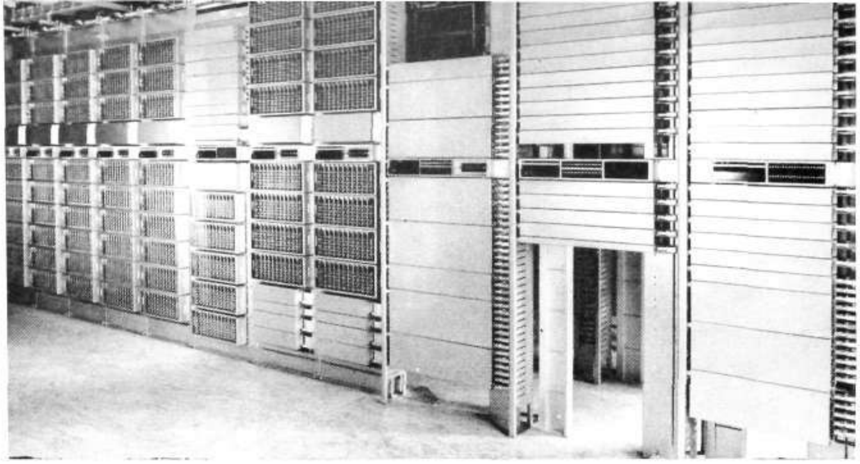
The diorama was an interesting feature at the visit of nearly 60,000 scientists, engineers and buyers to the exhibition of the Institute of Radio Engineers in New York.

A member of the Pakistan government, Rehabilitation Minister Azam Khan, visited the head factory of L M Ericsson on May 5. He is seen below in the Demonstration Room with (from left) Mr. Sven T Åberg, head of the Ericsson Group, and Mr. Håkan Insulander, head of L M Ericssons Signalaktiebolag. Behind them is seen an Ericsson control panel for a relay interlocking plant.



During the visit of Prince Bernhard of Holland to Brazil, he and the President of the Republic, Dr. Juscelino Kubitschek, made a tour to the new capital, Brasilia, which is in course of building. The occasion was taken for Prince Bernhard to officiate at the opening of the 260-line automatic exchange just installed by L M Ericsson, which for the time being will provide for Brasilia's rapidly growing requirements of telephone service. The Prince and President (right) are seen below.

A group of Brazilian economists recently visited L M Ericsson at Midsommarkransen. In the photograph below are seen (from right) the head of the Economic Department of the Brazilian Foreign Office, Edmundo P Barbosa da Silva, the President of Banco Nacional de Desenvolvimento Económico, Roberto Campos, and the Commercial Secretary of the Brazilian Embassy at Paris, Vilar de Queiroz, in discussion with Messrs. Göte Fernstedt (left) and Sven Friberg of L M Ericsson.



Full Automatization of Odense Telephone Exchange

The 23,000-line Ericsson crossbar exchange opened at Odense, Denmark, in June, 1958, became fully automatic on March 14, 1959, with the cut-over of the Odense automatic trunk exchange. Odense Trunks is the third point of the triangle formed by the main centres of the Danish long-distance network, comprising automatic trunk exchanges at Copenhagen, Aarhus and Odense. All these three exchanges are of Ericsson manufacture.

The Odense trunk exchange has a capacity of 1,200 two-wire and 1,200 four-wire junctions to local and remote areas. For services requiring the attention of an operator the trunk exchange has 46 operators' positions and 4 monitoring positions.

The exchange was officially opened by a conference telephone call between Odense, Aarhus and Copenhagen. Mr. J. V. Rasmussen, Director of Telephones at Odense, rang up the head of the Telephone Maintenance Service at Copenhagen, Mr. Axel Petersen, the Director General of the P. T. T. in Copenhagen, Mr. K. J. Jensen, and the Director of Telephones at Aarhus, Mr. Poul Draminsky. The suppliers were represented by Mr. Malte Patricks of L M Ericsson, Stockholm, Mr. L. C. Nørrelund of L M Ericsson A/S, Copenhagen, and Mr. E. Nyegaard of Telefon Fabrik Automatic A/S of Copenhagen.

The new trunk exchange prepares the way for further automatization of the Danish telephone service and represents a large step forward in the automatization of international connections.

Part of local equipment at Odense exchange.

Extension of Ericsson Exchange in Chile

An extension of the Arica telephone system in Chile was inaugurated on March 10. The extension comprises automatic equipment for 500 lines and outside plant for 1,500 lines. The Mayor of Arica, Adolfo Arenas Córdova, presided at the ceremony.

The Ericofon Appreciated in Kuwait

When Mr. S. T. Thomasen, Regional Director of Scandinavian Airlines System, was called to an audience by Emir Abdulla Al Mubarak Al Subah, and considered the choice of a suitable gift, he decided on a pair of Ericofons. The Emir expressed his great appreciation of the two instruments which bore the Kuwait national colours, red and white.

C.T.C. Model Railway for India

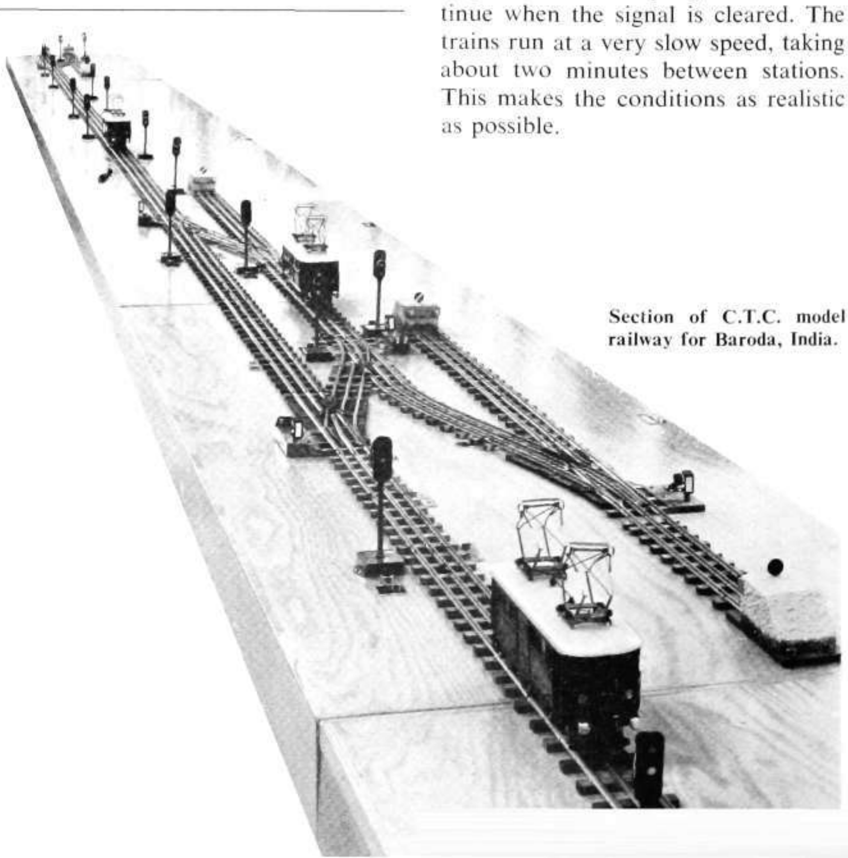
At the beginning of this year a C. T. C.-equipped model railway supplied by L M Ericsson was set up at the Railway University at Baroda, 400 kilometres north of Bombay.

India's widely ramified railways stand unrivalled as the most important means of transport in the sub-continent. They are being constantly re-equipped, and, among other items, modern relay interlockings are now being installed.

The model railway with gauge of 32 mm is about 11 metres long. It comprises three stations, all of which have complete relay interlockings with electric light signals and electrically operated points. The signalling equipment is made up of miniature relays. One end of the intermediate station has also been equipped with signal interlocking relays of plug-in type.

The entire installation is remote-controlled on Ericsson's standard C. T. C. system. The control can be effected either from the track diagram by the Line-To-Line method or from a separate keyset. This enables the Railway Administration to try out two different methods of operation.

The electric trains are controlled automatically by the signals. They stop in front of stop signals and continue when the signal is cleared. The trains run at a very slow speed, taking about two minutes between stations. This makes the conditions as realistic as possible.



Section of C.T.C. model railway for Baroda, India.

UDC 621.395.44
621.395.5

TANGEN, N: *L M Ericsson's 960-Circuit System for Coaxial Cables. III. Terminal Equipment (cont.)* Ericsson Rev. *36*(1959): 2, pp. 38—49.

In Ericsson Review No. 4, 1958, the parts of the terminal equipment which are directly concerned with the transmitted signal band were described.
In this second and final article on the arrangement of the coaxial terminal, the oscillator equipment is described. Its part in the system consists of the generation and distribution of the carrier frequencies and pilots for the system. The article concludes with a brief description of the power supply for the terminal equipment.

UDC 621.317.785.025.3

LINDBERG, S E: *Long Range Polyphase Meters.* Ericsson Rev. *36*(1959): 2, pp. 50—57.

Ericsson Review No. 3, 1958, contained a description of ERMI's singlephase meter VEN 23 designed to operate under conditions of widely varying load. ERMI manufactures long range polyphase meters also, and the present article deals with their design and general properties.

UDC 621.315.211.2
620.193.86

LIZELL, B, ROOS, J & BJÖRCK, G: *Rodent Attack on Rubber- and Plastic-Insulated Wires and Cables.* Ericsson Rev. *36*(1959): 2, pp. 58—66.

Rodent attack on different rubber and plastic materials has been investigated. The tests were made partly on cylindrical samples, partly on insulated cables with and without various additives tried as rat repellents. White rats were used in the tests, and the animals had normal supply of fresh water and feed. All rubber and plastic materials under test were attacked, the degree of attack increasing with the softness of the materials. A thick aluminium or steel tape gave the only complete protection. Z. A. C. had some rat-repelling effect.

The Ericsson Group

Associated and co-operating enterprises

• EUROPE •

Denmark

L M Ericsson A/S *København F*, Finsens Vej 78, tel: Fa 6868, tgm: ericsson

Telefon Fabrik Automatic A/S *København K*, Amaliegade 7, tel: C 5188, tgm: automatic

Dansk Signal Industri A/S *København F*, Finsens Vej 78, tel: Fa 6767, tgm: signaler

Finland

O/Y L M Ericsson A/B *Helsinki*, Fabianinkatu 6, tel: A8282, tgm: ericssons

France

Société des Téléphones Ericsson *Colombes (Seine)*, Boulevard de la Finlande, tel: CHA 35-00, tgm: ericsson

Paris 17e, 147 Rue de Courcelles, tel: Carnot 95-30, tgm: eric

Germany

Ericsson Verkaufsgesellschaft m. b. H. *Düsseldorf 1*, Worringer Strasse 109, tel: 84 461, tgm: erictel

Great Britain

Swedish Ericsson Company Ltd. *London*, W. C. 1, 329 High Holborn, tel: Holborn 1092, tgm: teleric

Production Control (Ericsson) Ltd. *London*, W. C. 1, 329 High Holborn, tel: Holborn 1092, tgm: productrol holb

Italy

Setemer, Soc. per Az. *Milano*, Via dei Giardini 7, tel: 662241, tgm: setemer

SIELTE, Soc. per Az. — Società Impianti Elettrici e Telefonici Sistema Ericsson *Roma*, C. P. 4024 Appio, tel: 780221, tgm: sielte

F. A. T. M. E. Soc. per Az. — Fabbrica Apparecchi Telefonici e Materiale Elettrico »Brevetti Ericsson» *Roma*, C. P. 4025 Appio, tel: 780021, tgm: fatme

Netherlands

Ericsson Telefoon-Maatschappij, N.V. *Rijen (N. Br.)*, tel: 01692-555, tgm: erictel

den Haag—Scheveningen, 10, Palacestraat, tel: 55 55 00, tgm: erictel-haag

Norway

A/S Elektrisk Bureau *Oslo NV*, P.B. 5055, tel: Centralbord 46 18 20, tgm: elektriken

A/S Industrikontroll *Oslo*, Teatergaten 12, tel: Centralbord 335085, tgm: indtroll

A/S Norsk Kabelfabrik *Drammen*, P. B. 205, tel: 1285, tgm: kabel

A/S Norsk Signalindustri *Oslo*, P. B. Mj 2214, tel: Centralbord 56 53 54, tgm: signalindustri

Portugal

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

Spain

Cía Española Ericsson, S. A. *Madrid*, Conde de Xiquena 13, tel: 31 53 03, tgm: ericsson

Sweden

Telefonaktiebolaget L M Ericsson *Stockholm 32*, tel: 19 00 00, tgm: telefonbolaget

AB Alpha *Sundbyberg*, tel: 282600, tgm: aktiealpha-stockholm

AB Ermex *Solna*, tel: 82 01 00, tgm: elock-stockholm

AB Ermi *Bromma 11*, tel: 262600, tgm: ermibolag-stockholm

AB Rifa *Bromma 11*, tel: 26 26 10, tgm: elrifa-stockholm

AB Svenska Elektronrör *Stockholm 20*, tel: 44 03 05, tgm: electronics

L M Ericssons Driftkontrollaktiebolag *Solna*, tel: 27 27 25, tgm: powers-stockholm

L M Ericssons Signalaktiebolag *Stockholm Sv*, tel: 68 07 00, tgm: signalbolaget

L M Ericssons Svenska Försäljningsaktiebolag *Stockholm 1*, Box 877, tel: 22 31 00, tgm: ellem

Mexikanska Telefonaktiebolaget Ericsson *Stockholm 32*, tel: 190000, tgm: mexikan

Sieverts Kabelverk AB *Sundbyberg*, tel 282860, tgm: sievertsfabrik-stockholm

Svenska Radioaktiebolaget *Stockholm 12*, Alströmergatan 14, tel: 22 31 40, tgm: svenskradio

Switzerland

Ericsson Telephone Sales Corp. AB, Stockholm, Zweigniederlassung Zürich *Zürich*, Postfach Zürich 32, tel: 325184, tgm: telericsson

• ASIA •

India

Ericsson Telephone Sales Corporation AB *New Delhi 1*, P.O.B., 669, reg. mail: 1/3 Asaf Ali Road (Delhi Estate Building), tel: 28512, tgm: inderic

Bombay, Manu Mansion, 16, Old Custom House, tel: 254130 tgm: inderic

Calcutta, P. O. B. 2324, tel: 45-4494, tgm: inderic

Indonesia

Ericsson Telephone Sales Corporation AB *Bandung*, Djalan Dago 151, tel: 2135, tgm: javeric

Djakarta, Djalan Gunung Sahari 26, tel: Gambir 50, tgm: javeric

Lebano[n]

Telefona[...]son, Technical Office *Beyrouth*, Rue du Parlement, Immeuble Bisharat, tel: 33555, tgm: ellem

Turkey

Ericsson Türk Ltd. Şirketi *Ankara*, Âdil Han, Zafer Meydani, Yenişehir, tel: 23170, tgm: ellem

Istanbul, Istanbul Bürosu, Liman Han, Kat 5, No. 75, Bahçekapi, tel: 228102, tgm: ellemist

• AFRICA •

Union of South Africa

L M Ericsson Telephone Co. Pty. Ltd. *Johannesburg*, 70, Loveday Street, tel: 33-2742, tgm: ericofon

• AMERICA •

Argentine

Cía Sudamericana de Teléfonos L M Ericsson S. A. *Buenos Aires*, Belgrano 894, tel: 332071, tgm: ericsson

Corp. Sudamericana de Teléfonos y Telégrafos S. A. *Buenos Aires*, Belgrano 894, tel: 332071, tgm: cartefe

Cía Argentina de Teléfonos S. A. *Buenos Aires*, Perú 263, tel: 305011, tgm: cecea

Cía Entrerriana de Teléfonos S. A. *Buenos Aires*, Perú 263, tel: 305011, tgm: cecea

Cía Comercial de Administración S. A. *Buenos Aires*, Perú 263, tel: 305011, tgm: cecea

Industrias Eléctricas de Quilmes S. A. *Quilmes FCNGR*, 12 de Octubre 1090, tel: 203-2775, tgm: indelqui-buenosaires

Brazil

Ericsson do Brasil Comércio e Indústria S. A. *Rio de Janeiro*, C. P. 3601, tel: 43-0990, tgm: ericsson

São Paulo C. P. 5677, tel: 36-6951, tgm: ericsson

Canada

Ericsson Telephone Sales of Canada Ltd. *Montreal 8, Que.*, 130 Bates Road, tel: RE 1-6428, tgm: caneric

Toronto 18, Ont., 34 Advance Road, tel: BE 1-1306

[...]csson C.A., [...] Apartado Postal 188, tel: 4989, tgm: ericsson

Chile

Cía Ericsson de Chile S. A. *Santiago*, Casilla 10143, tel: 82555, tgm: ericsson-santiago-dechile

Colombia

Cía Ericsson Ltda. *Bogotá*, Apartado Aéreo 4052, tel: 11-100, tgm: ericsson

Ecuador

Telefonaktiebolaget L M Ericsson *Quito*, Casilla Postal 2138, tel: 33777, tgm: ericsson

Mexico

Cía Comercial Ericsson S. A. *México D. F.*, Apartado 9958, tel: 46-46-40, tgm: coeric-mexico

Industria de Telecomunicación S.A. de C.V. *México 6, D.F.*, Paseo de la Reforma 122, 6° piso, tel: 354814, tgm: industel

Peru

Cía Ericsson S. A. *Lima*, Apartado 2982, tel: 34941, tgm: ericsson

Soc. Telefónica del Perú, S. A. *Arequipa*, Casilla de Correo 112, tgm: telefonica

Uruguay

Cía Ericsson S. A. *Montevideo*, Casilla de Correo 575, tel: 84433, tgm: ericsson

USA

The Ericsson Corporation *New York 17, N. Y.*, 100 Park Avenue, tel: Murray Hill 5-4030, tgm: erictel

North Electric Co. *Galion, Ohio*, P. O. B. 417, tel: Howard 8-2420, tgm: northphone-galionohio

Venezuela

Cía Anónima Ericsson *Caracas*, Apartado 3548, tel: 543121, tgm: ericsson

Teléfonos Ericsson C. A. *Caracas*, Apartado 3548, tel: 543121, tgm: tevela

• AUSTRALIA & OCEANIA •

Australia

L M Ericsson Telephone Co. Pty. Ltd. *Melbourne C 1 (Victoria)*, Kelvin Hall, 55 Collins Place, tel: MF 56 46, tgm: ericmel

Agencies

• EUROPE •

Austria

Inglomark, Industrie-Beliefe-rungs-Gesellschaft Markowitsch & Co. *Wien XV*, Maria Hilferstrasse 133, tel: R 32-0-11, tgm: *inglomark*

Belgium

Electricité et Mécanique Suédoises *Bruxelles 5*, 56 Rue de Stassart, tel: 11 14 16, tgm: electrosuede

Greece

»ETEP», S. A. Commerciale & Technique *Athens*, 41, Stadiou Street, tel: 31211, tgm: aeterathinai

Ireland

Communication Systems Ltd. *Dublin*, 40, Upper Fitzwilliam Street, tel: 61576/7, tgm: crossbar

Iceland

Johan Rönning H/F *Reykjavik*, P. O. B. 45, tel: 14320, tgm: rönning

Yugo-Slavia

Merkantile Inozemna Zastupstva *Zagreb*, Pošt pretinac 23, tel: 25-222, tgm: merkantile

• ASIA •

Burma

Vulcan Trading Co. Ltd. *Rangoon*, P. O. B. 581, tel: S. 878, tgm: suecia

Ceylon

Vulcan Trading Co. (Private) Ltd. *Colombo 1*, 19, York Street, tel: 36-36, tgm: vultra

China

The Ekman Foreign Agencies Ltd. *Shanghai*, P. O. B. 855, tel: 16242-3, tgm: ekmans

Hong Kong

The Swedish Trading Co. Ltd. *Hongkong*, Prince's Building, Ice House Street, tel: 20171, tgm: swedetrade

Iran

Irano Swedish Company AB *Teheran*, Khiaban Sevom Esfand 201-203, tel: 36761, tgm: irano-swede

Iraq

Koopman & Co. T.H.M., N.V., c/o Messrs. Dwyer & Co. (Iraq) Ltd. *Baghdad*, P. O. B. 22, tel: 86860, tgm: havede

Japan

Gadelius & Co. Ltd. *Tokyo*, No. 3-19, Denma-cho, Akasaka, Minato-Ku, tel: 48-5361, tgm: goticus

Jordan

H. L. Larsson & Sons Ltd. Levant *Amman*, P. O. B. 647, tgm: larson-hus

Kuwait

Latiff Supplies Ltd. *Kuwait*, P.O.B. 67, tgm: latisup

Lebanon

Swedish Levant Trading Co. *Beyrouth*, P. O. B. 931, tel: 31624, tgm: skefko

Pakistan

Vulcan Trading Co. (Pakistan) Ltd. *Karachi City*, P. O. B. 4776, tel: 32506, tgm: vulcan

Philippines

Koppel (Philippines) Inc. *Manila P. R.*, P. O. B. 125, tel: 3-37-53, tgm: koppelrail

Saudi Arabia

Mohamed Fazil Abdulla Arab *Jeddah*, P. O. B. 39, tel: 2690, tgm: arab

Syria

Georgiades, Moussa & Cie *Damas*, Rue Ghassan, Harika, tel: 1-02-89, tgm: georgiades

Thailand

Vichien Radio & Television Co., Ltd. *Bangkok*, 299-301, Suriwongse Road, tel: 31 364, tgm: vision

Vietnam

Vo Tuyen Dien-Thoai Viet-Nam, Matériel Radio & Téléphonique du Viêtnam *Saïgon*, 17, Cong Truong Lam-Son, tel: 20805, tgm: telerad

• AFRICA •

Belgian Congo

Société Anonyme Internationale de Télégraphie sans Fil (SAIT) *Bruxelles (Belgique)*, 25, Boulevard du Régent, tel: 125070, tgm: wireless

British East Africa

Transcandia Ltd. *Nairobi, Kenya*, P. O. B. 5933, tel. 3312, tgm: transcanda

Egypt

The Pharaonic Engineering & Industrial Co. *Cairo*, 33, Orabi Street, tel: 4-36-84, tgm: radiation

Ethiopia

Swedish Ethiopian Company *Addis Ababa*, P. O. B. 264, tel: 1447, tgm: eliocomp

Ghana

The Standard Electric Company *Accra*, P.O.B. 17, tel: 2785, tgm: standard

Morocco

Elcor S. A. *Tangier*, Francisco Vitoria, 4, tel: 2220, tgm: elcor

Mozambique

J. Martins Marques *Lourenço Marques*, P. O. B. 456, tel: 5953, tgm: tinsmarques

Nigeria

Scan African Trading Co. *Yaba-Lagos 32*, P. O. B. 1, tgm: swedafrica

Rhodesia and Nyasaland

Reunert & Lenz, (Rhodesia) Ltd. *Salisbury (Southern Rhodesia)* P.O. B. 2071, tel: 27001, tgm: rockdrill

Sudan

TECOMA Technical Consulting and Machinery Co. Ltd. *Khartoum*, P.O.B. 866, tel: 2224, ext. 35, tgm: sutecoma

• AMERICA •

Bolivia

Johansson & Cía, S. A. *La Paz*, Casilla 678, tel: 2700, tgm: johansson

Costa Rica

Tropical Commission Co. Ltd. *San José*, Apartado 661, tel: 3432, tgm: troco

Cuba

Mc Avoy y Cía *Habana*, Apartado 2379, tel: U-2527, tgm: macavoy

Curaçao N. W. I.

S. E. L. Maduro & Sons, Inc. *Curaçao*, P. O. B. 172, tel: 1200, tgm: madurosons-willemstad

Dominican Republic

Garcia & Gautier, C. por A. *Ciudad Trujillo*, Apartado 771, tel: 3645, tgm: gartier

Ecuador

Sociedad Radiotécnica Ecuatoriana *Quito*, Casilla de Correo 414, tel: 12140, tgm: rota

Guatemala

Nils Pira *Ciudad de Guatemala*, Apartado 36, tel: 3311, tgm: nilspira

Honduras

Cía de Comisiones Inter-Americana, S. A. *Tegucigalpa D. C.*, P. O. B. 114, tel: 15-63, tgm: inter

Jamaica and Brit. Honduras

Morris E. Parkin *Kingston*, P.O.B. 354, tel: 4077, tgm: morrispark

Nicaragua

J. R. E. Tefel & Co. Ltd. *Managua*, Apartado 24, tel: 387-1169, tgm: tefelto

Panama

Productos Mundiales, S. A. *Panama, R. P.*, P. O. B. 4349, tel: 3-0476, 3-7763, tgm: mundi

Paraguay

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

El Salvador

Dada-Dada & Co. *San Salvador*, Apartado 274, tel: 4860, tgm: dada

Surinam

C. Kersten & Co. N. V. *Paramaribo*, P. O. B. 216, tel: 2541, tgm: kersten

USA

State Labs. Inc., *New York 12, N.Y.*, 649 Broadway, tel: Oregon 7-8400, tgm: statelabs. Only for electron tubes

• AUSTRALIA & OCEANIA •

New Zealand

ASEA Electric (N Z) Ltd. *Wellington C.1.*, Huddart Parker Building, Post Office Square, tel: 70-614,

ERICSSON Review

3
1959

ERICSSON REVIEW

Vol. XXXVI No. 3 1959

RESPONSIBLE PUBLISHER: HUGO LINDBERG

EDITOR: SIGVARD EKLUND, DHS

EDITOR'S OFFICE: STOCKHOLM 32

SUBSCRIPTIONS: ONE YEAR $ 1.50; ONE COPY $ 0.50

CONTENTS

On cover: Adjustment of Telephone Relays at L M Ericsson's Main Plant, Midsommarkransen, Stockholm.

Program Distribution Equipment for Transmission of Sound in Broadcasting and Television

E PETERSSON, ROYAL BOARD OF SWEDISH TELECOMMUNICATIONS, STOCKHOLM
S ENGSTRÖM & S O JOHANSSON, TELEFONAKTIEBOLAGET L M ERICSSON, STOCKHOLM

UDC 621.395.97

Circuits for the transmission of broadcasting play a very important part in the distribution of sound radio programs. These program circuits are also used for transmission of sound for television programs. The requirements of the circuit as regards quality of transmission, flexibility and operational reliability are high. Two types of distribution equipment included in L M Ericsson's manufacturing program are described. In addition, the possibilities of remote control and routing of the program distribution network are touched upon.

L M Ericsson have previously supplied a large number of systems for small and large stations. Using the experience which has been obtained from these systems, the equipment described in this article has been developed in collaboration with the Royal Swedish Board of Telecommunications. The smaller equipment described in this article is already in operation in a number of stations. Equipment for large stations will be installed in the near future.

1. Program Distribution Network

Ever since the time in the history of the development of sound radio, where the technical equipment consisted of a sender connected to a microphone via a simple telephone line, it has been possible to subdivide sound radio distribution equipment into studio equipment, program circuits and senders. This classification is thus also suitable for use in the complicated technical equipment which is now used to distribute sound radio programs.

Studios are usually located in places of, for example, cultural or economic importance. They often take the form of specially designed radio houses in places where the production of programs is particularly active. Different types of senders are used for example, for long wave, medium wave, short wave, ultra-short wave and wired radio. They have a limited coverage and are sited with regard to the area which is to be provided with the sound radio program. Studios and senders are thus located at different places and program circuits are therefore needed to convey the program from the studio producing the program at the time to the senders. Such circuits, however, also fulfil many other functions. Thus, they are used for program transmission between studios in different places during the recording of programs, international exchange of programs, sound circuits for television programs, etc.

Technical Requirements

In the design of the distribution equipment, faithful reproduction of the program material, which of course normally consists of speech or music, is sought. This objective necessitates stringent technical requirements which as far as the program circuit is concerned become expressed as requirements of large transmitted frequency band, low attenuation and delay distortion, freedom from interference, etc. The requirements should be regarded against the background that the circuits can be of appreciable length. In Sweden it

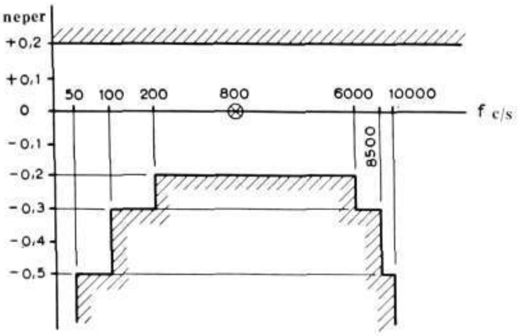


Fig. 1 X 2465

Tolerances on equivalent of a program line in accordance with the recommendations of CCITT

often happens that the program is transmitted about 2 000 km (1 250 miles) before it reaches its destination. Of course, it is also in the nature of radio and television activity that the programs which are of high quality from artistic or musical considerations are those which are most sought after and topical in international exchanges of programs.

The program traffic requirements of circuits can vary rapidly and program items which follow each other often require program circuits of different length and routing. A high degree of flexibility is therefore necessary. Program circuits are set up using lines which terminate in specially designated switching fields in the program distribution equipment. Switching is normally made at audio frequency.

A fault on a program circuit can have wide consequences and hazard possible feeding of the program to several senders. The operational reliability of the program line is therefore an important factor and requires particular attention in the design of the program distribution equipment.

In the CCITT "Green Book", Geneva (1958), recommendations are given for normal program lines for broadcast radio. The recommendations are stated for a hypothetical reference circuit of 2 500 km (1 600 miles) where, however, certain exceptions for intelligible crosstalk and noise are made. The more important points in the recommendations are as follows: —

Frequency band and variation of equivalent

The effectively transmitted frequency band should be at least 50—10 000 c/s.

An arbitrary frequency is considered to be effectively transmitted if the equivalent at the frequency in question does not exceed the corresponding value at 800 c/s by more than 4.3 db.

The tolerances at the end of the line referred to the value at 800 c/s are given in fig. 1.

Phase distortion

The group delay should not exceed the minimum group delay within the transmitted frequency band by values greater than the following:

8 ms at 10 000 c/s
20 ms at 100 c/s
80 ms at 50 c/s

Interference voltage

The relationship between the largest signal voltage and interference voltage measured with a program psophometer should be greater than 57 db. The psophometer curve for program lines is reproduced in fig. 2.

The relationship between the greatest signal voltage and objectively measured (unweighted) interference voltage should be greater than 37 db.

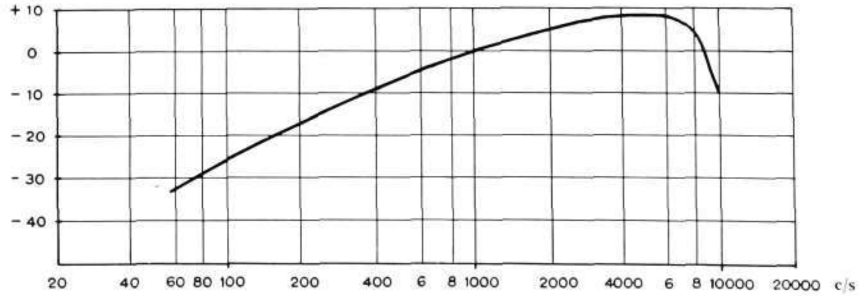


Fig. 2 X 8170

Psophometer curve for a program line

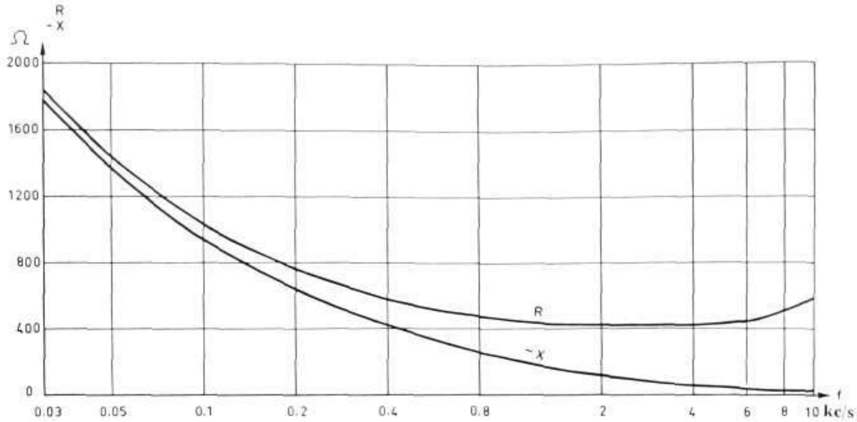


Fig. 3 X 8171

Image impedance for program line of type 8.5 mH — 1 600 m

⌀ = 1.0 mm

Crosstalk

The crosstalk attenuation should be at least 74 db.

Non-linear distortion

The distortion loss measured at the end of the line should be at least 20 db (a proposal has been submitted for making this recommendation substantially more stringent).

The Program Lines

Program lines may be either voice frequency or arranged as channels in carrier systems. In new planning of telephone cables, the voice frequency program lines can be obtained easily by including screened pairs in the respective cables. The program lines which are obtained in such a way satisfy very high quality requirements. The desire for increasing the number of program lines in existing telephone plant may normally be satisfied more easily using carrier techniques. Such an equipment has been described in Ericsson Review No. 1 (1959) (J. Pyddoke and H. Schilling: L M Ericsson Equipment for Carrier Channels of Program (Music) Quality, Type ZAB 1).

As mentioned above, a frequency band of 50—10 000 c/s is required for transmission of a sound radio program. Any loading which may be required should be made so that the cut-off frequency of the line is about 1.4 times the highest frequency which is to be transmitted.

In the Swedish program distribution network there are included cable pairs screened with metallized paper which have been loaded with 8.5 mH coils at 1 600 m (1 mile) intervals. Fig. 3 shows the image impedance for such lines for a conductor diameter of 1 mm. The cable pair parameters *r, l, g* and *c* together with the electrical characteristics of the loading coils are

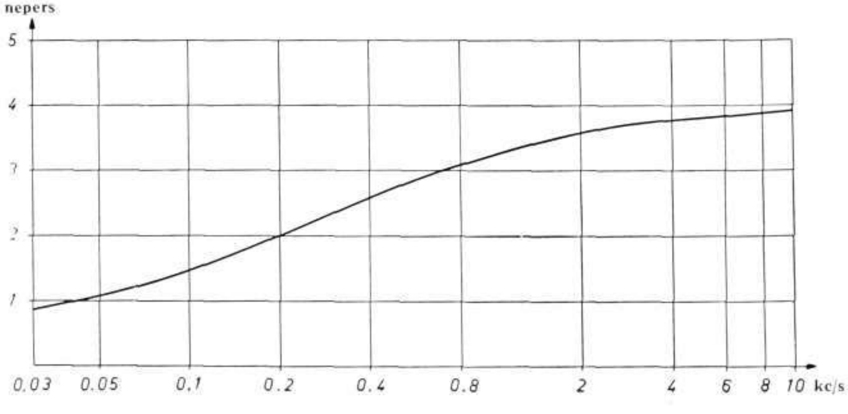


Fig. 4 X 8172

Image attenuation for program line of type 8.5 mH — 1 600 m

⌀ = 1.0 mm. Length of repeater section 70 km

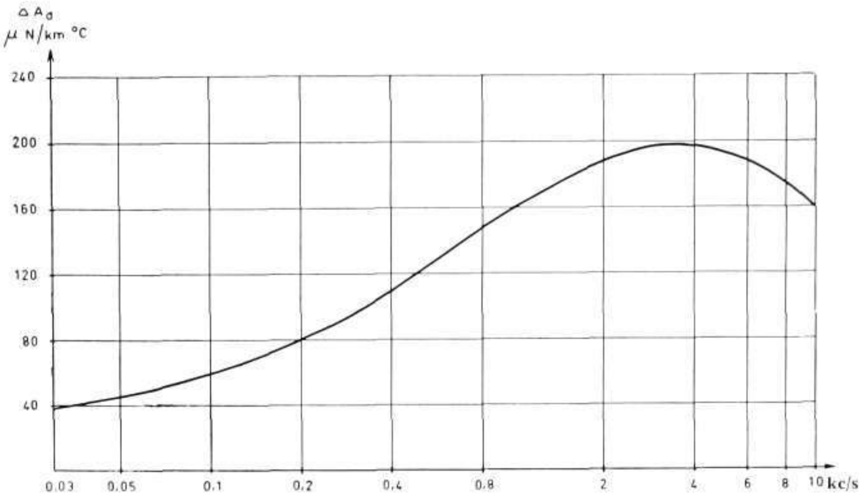
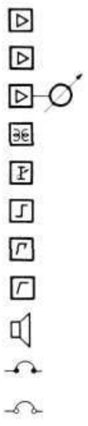


Fig. 5 X 2466

Variation of equivalent with temperature for a program line of type 8.5 mH — 1 600 m ⌀ = 1.0 mm. Length of repeater section 70 km

functions of temperature, and therefore the cable attenuation is dependent on temperature, and in the case of buried cables is affected by the ambient ground temperature. A temperature variation of up to about 20°C occurs in Sweden. Accurate knowledge of the temperature dependence of the cable attenuation is therefore necessary in the design of the requisite equalizers. Fig. 5 shows the calculated data for the type of program line which has been mentioned earlier.

Symbols for figs 6, 12, 14 and 17



- PA = Program amplifier
- LA = Loudspeaker amplifier
- VI = Peak program meter
- Line transformer
- Variable pad
- Matching network
- Line equalizer
- Temperature-loss equalizer
- Loudspeaker
- Distribution
- U-link

Program distribution equipment is inserted in the lines at intervals which in Sweden are up to about 70 km (44 miles).

2. General Principles for Distribution Equipment

The principle design of the distribution equipment is seen in the simplified block schematic in fig. 6.

The incoming program line is first connected to a line equalizer equipment which primarily corrects the attenuation distortion which is caused by the line. The line is then connected to a program amplifier which compensates the total loss of the line and equalizer equipment and has an output power which is sufficient for feeding several outgoing lines. Supervisory arrangements of different types, such as monitoring amplifier with loudspeaker, peak program meter, etc., are also included in the distribution equipment.

The program amplifier has been designed to give sufficient power for feeding up to 24 lines, each of 600 ohms impedance. The output impedance of the amplifier is very low, and the number of outgoing lines may be varied within wide limits without causing any noticeable change in the output level of the amplifier, which would otherwise constitute disturbance of the program. The low output impedance also attenuates such interference which in the event of a fault might enter one of the lines connected in parallel to the output of the amplifier. In this way interference is prevented from being spread to other lines which are connected to the amplifier.

The low output impedance of the program amplifier means that each program line is mismatched with a low impedance at its near end. In order

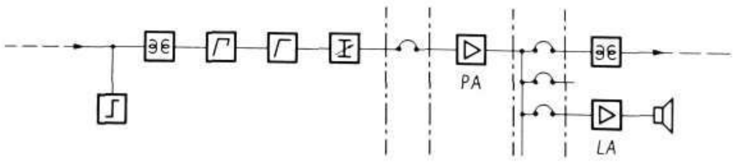


Fig. 6 X 8173

Simplified circuit diagram of the distribution equipment

to prevent repeated reflexion along the line, an accurate match is therefore required at the far-end of the line, i.e. where the incoming line is connected to the next distribution equipment. Matching networks made up of resistors and capacitors are therefore connected at this point. These networks simulate the image impedance of the cable pair. The line equalizer equipment is designed to give an attenuation which together with the attenuation of each incoming line gives a total attenuation which is independent of frequency. The equalizer also contains a correction network which can be switched in steps and is used to compensate for the temperature dependence of the line attenuation mentioned earlier.

A general principle which has been the guide in the design of this equipment is that operational reliability shall be the highest possible. The different types of components have therefore been chosen with the greatest care. The electron tubes which are of the long-life type are duplicated throughout in the program amplifiers. All tube currents can be checked with the help of a selector switch and meter which are built into the bay. In addition, the anode currents of the final tubes are supervised automatically with the help of relays, so that a change in the working point of a tube — which would mean increased distortion — is immediately detected.

Special precautions have been taken in the switching field to prevent involuntary or faulty connexions of the program routes.

It has been possible to keep the crosstalk attenuation high by using special screening and earthing in the distribution equipment. The crosstalk attenuation between two simultaneous programs is better than 90 db.

3. Units of the Program Distribution Equipment

The Program Amplifier

The amplifier is designed with three stages, each of which is duplicated. By duplication, a fault on a single tube does not affect the performance of the amplifier. The amplifier has a large amount of negative feedback, which means that the amplification is affected very little by variations in tubes or other components and the distortion is very low. The large feedback has also been used to give the amplifier its extremely low output impedance. This is of importance when it is used as a distribution amplifier where its load, consisting of a varying number of outgoing lines, must not affect the output level or the response curve.

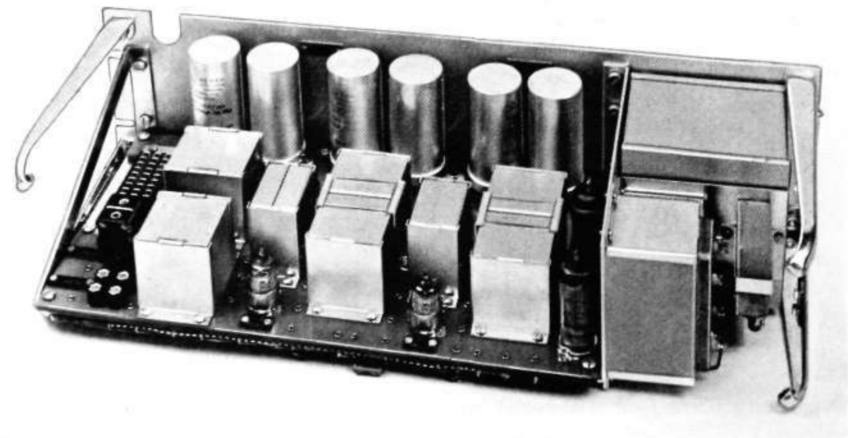


Fig. 7

The program amplifier

X 8174

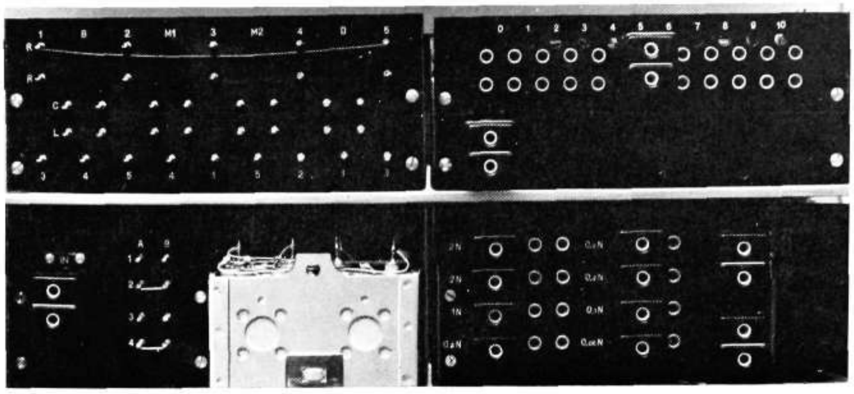


Fig. 8 X 8175

The line equalizer equipment

Top shelf: line equalizer, temperature-loss equalizer

Bottom shelf: transformer unit, matching network, pad unit

For supervision and testing, a selector switch and meter are built into the bay, and separate alarm relays are connected to the final stage of the amplifier. In addition, the basic gain of the amplifier may be checked in a very simple manner by altering a U-link connexion.

The mechanical construction of an amplifier is seen in fig. 7.

Program amplifier data

Input impedance, nominally	500 ohms
Output impedance	< 0.5 ohm
Gain	52 db
Bandwidth	30—15 000 c/s
Gain relative to 800 c/s	
at 30 c/s	+ 0.5 db — 0.2 db
at 100 c/s	± 0.1 db
at 10 000 c/s	± 0.1 db
at 15 000 c/s	± 0.2 db
Output level with max. signal	5.5 V r.m.s.
Distortion at this level	
at 800 c/s	< 0.2 %
at 30 c/s	< 0.5 %
at 15 000 c/s	< 0.5 %
Maximum number of loaded 600 ohms lines	24

The maximum signal voltage is in agreement with the latest recommendations of the CCITT and represents a peak voltage of + 17 db relative to 0.775 volt. This corresponds to a nominal relative level of + 6 dbr with a possibility of a maximum voltage which is 9 db above 0.775 volt in a point of zero relative level and a tolerance in equivalent of ± 2 db.

The tubes in the amplifier are of long-life type, which means that an average life of 30 000 hours (20 000 hours for the final tubes) is guaranteed.

Line Equalizer Equipment

The line equalizer equipment consists of a line equalizer, temperature-loss equalizer, matching network, pads and line transformers. The mechanical construction of the equipment is shown in fig. 8. The line equalizers correct

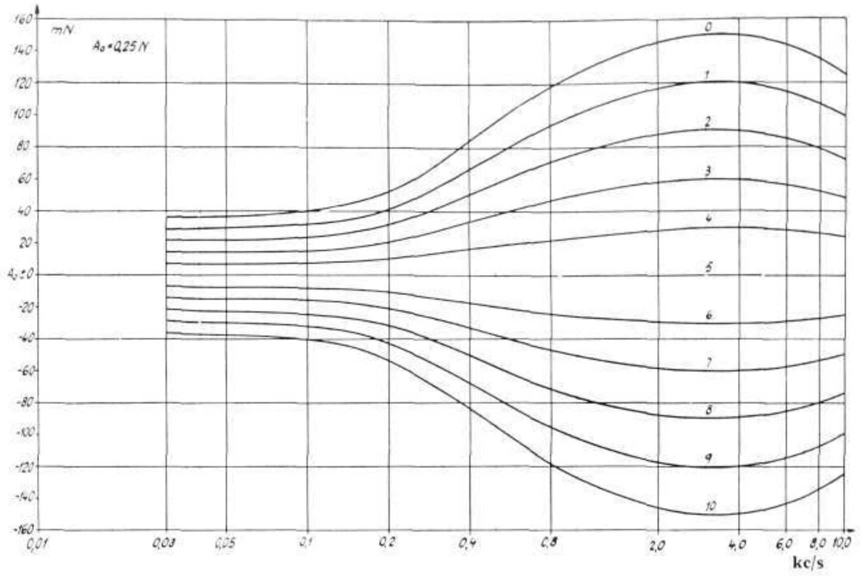


Fig. 9 X 8176

Attenuation curves for the temperature-loss equalizer

Line of type 8.5 mH — 1 600 m

the frequency dependent attenuation of the cables so that a frequency independent response curve is obtained. A typical attenuation curve of a cable is seen in fig. 4. The line equalizer network consists of a frequency dependent two-terminal network which together with the constant impedance following, forms a voltage divider. This frequency dependent voltage divider gives the required correction of attenuation. Adjustment of the equalizer is carried out using soldered straps when the equipment is being installed.

The temperature-loss equalizers compensate the changes in equivalent which arise due to changes of temperature in the cables at different times of the year. The equalizing networks consist of frequency dependent four-terminal networks. Alteration of the attenuation correction is made by moving U-links on the unit. Alteration can be carried out without interfering with traffic. There are various types of temperature equalizing networks available for different types of line. Fig. 9 shows attenuation curves for one of the networks.

The matching network matches the equipment to the impedance of the incoming line. The matching network consists of a frequency dependent two-terminal network. Different networks have been designated for a large number of different types of line.

The pads in the line equalizer equipment match the level of the incoming program to a normalized level before the amplifier input. Adjustment is carried out using U-links.

Supervisory Equipment

Peak program meters and loudspeaker amplifiers are used for supervision of the program distribution.

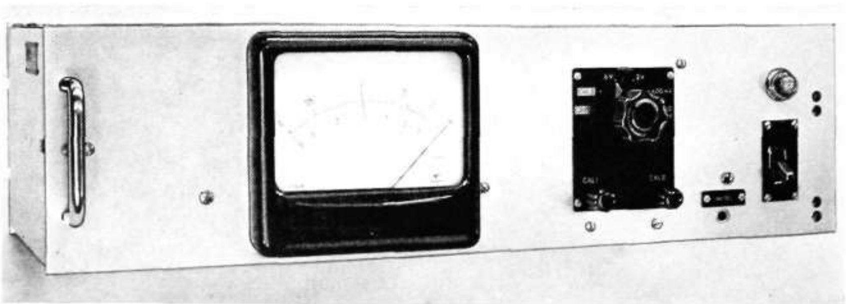


Fig. 10 X 8177

Peak program meter

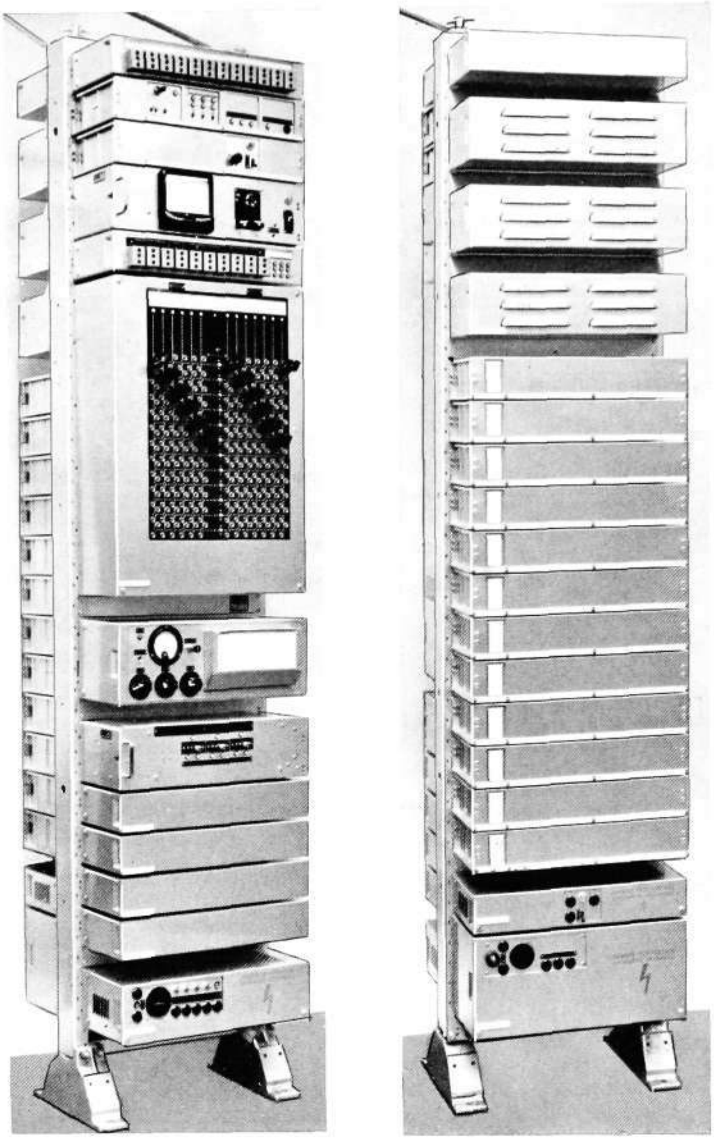


Fig. 11 X 2467 X 2468

Program distribution bay for small stations

Front view (at left) and rear view (at right)

The peak program meter is a peak indicating level meter having a short integration time and long decay time constant in accordance with the recommendations of CCITT (Annexe 24 to Volume III of the Green Book). The integration time is about 10 ms and the decay time constant about 2 s. The frequency response in the range 30—15 000 c/s is so good that the peak program meter may also be used as a level meter. The mechanical construction of the peak program meter is shown in fig. 10.

The peak program meter may be replaced by a v.u. meter which is also recommended by CCITT. The v.u. meter has a longer integration time, about 200 ms. Normally, the peak program meter is used for supervision of the program distribution networks.

The program can be monitored at the program distribution stations by using the loudspeaker amplifier.

Switching Panels

There are two types of switching equipment, the first using manual switching with U-links for small stations and the second which is relay controlled, for large stations. The two types of switching equipment are described in more detail under their respective stations.

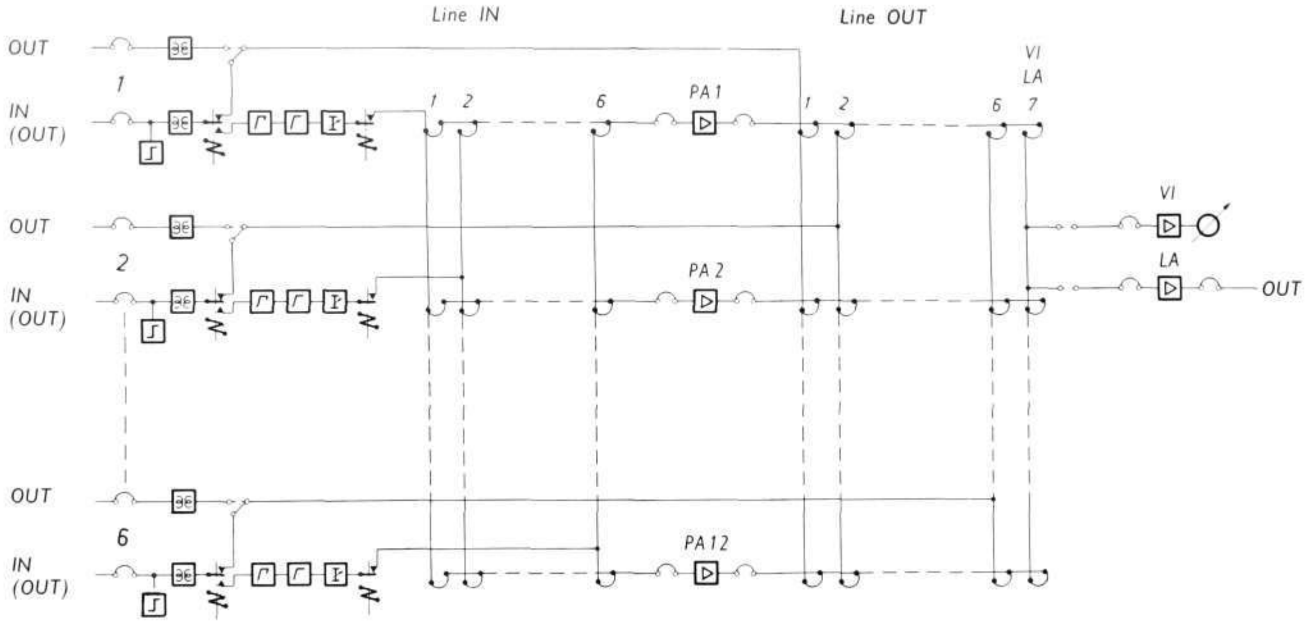


Fig. 12 X 7762

Block schematic of program distribution bay for small stations

4. Program Distribution Equipment for Small Stations

The distribution equipment for small stations is mounted in a bay in such a way that one bay contains complete equipment for distribution of three simultaneous programs from six alternative incoming to six alternative outgoing lines. In certain cases, the same line may be used for either incoming or outgoing line and is then considered as being two-way. The bay is shown in fig. 11. By combining four such bays, an equipment is obtained which covers up to 12 simultaneous programs and 24 incoming and outgoing lines. The block schematic of the bay is shown in fig. 12.

The bay is designed so that all equipment which is needed for service and maintenance is placed on the front. This applies to switching panel, peak program meter, loudspeaker amplifier, equipment for tube current measurement, fuses, alarm unit, U-links and speaker circuit panel. The line equalizers and amplifiers are mounted at the rear. In addition, the bay has space for remote control equipment (see later). Power supply to the bay can be obtained from batteries or from alternating current mains. In the latter case, a mains supply unit is added to the equipment.

Battery voltage	Mains voltage	Power consumption	Bay dimensions		
			Height	Width	Depth*
24, 130 V	110, 127, 150, 220, 240 V	150 VA	2 590 mm (8′6″)	514 mm (20 1/4″)	456 mm (18″)

* Equipment mounted on both sides.

The Switching Panel

Connexions can be made in the switching panel between arbitrary incoming and outgoing lines. Separate programs, however, cannot be connected together. As shown in fig. 13 the switching field is divided into two parts, one for incoming and one for outgoing lines.

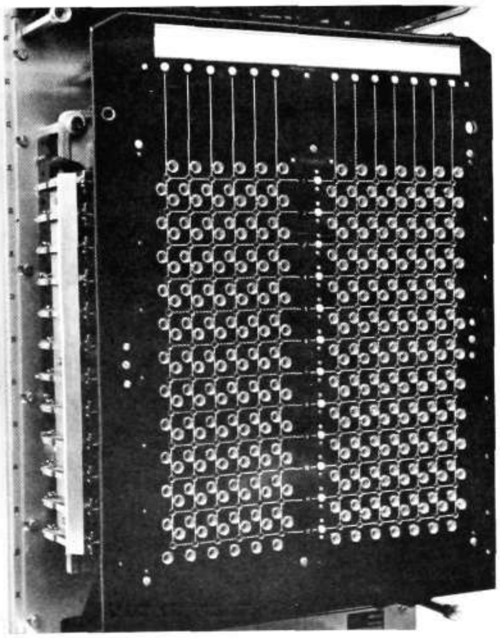


Fig. 13 X 2469

Switching field for manual switching

In one part, each incoming line is connected to a vertical row of contacts while input of each amplifier is connected to a horizontal row. A special U-link plug permits switching of any line to any amplifier, but by special

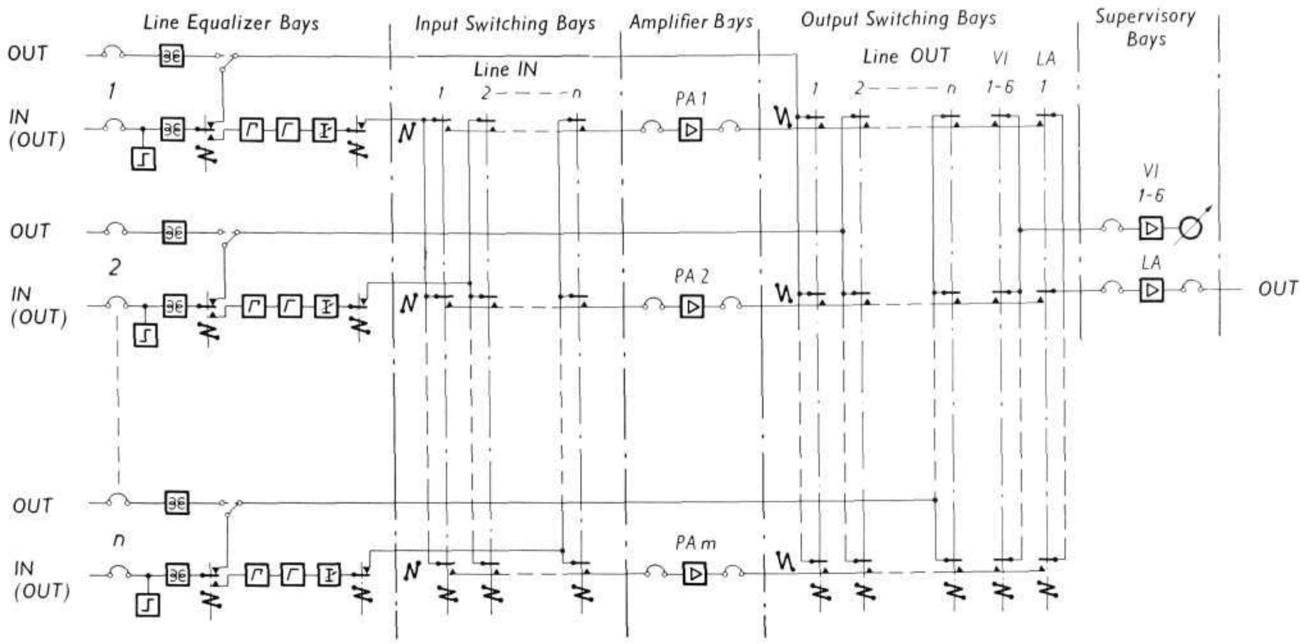


Fig. 14 X 7763

Block schematic of program distribution equipment for large stations

mechanical interlocks prevents more than one line from being connected to a particular amplifier at any time. When more than one bay is used the interlocking is carried out electrically between bays. When a two-way line is connected this is switched in the correct direction by the same U-link jack.

The part of the field for the outgoing lines is controlled in the same manner except that there is no interlocking to prevent the connexion together of several lines as, of course, distribution is made in this field.

There is an extra vertical row of contacts in the latter field which is used for connexion of peak program meters, loudspeaker amplifiers etc.

5. Program Distribution Equipment for Large Stations

The distribution equipment for large stations is subdivided in bays into functional units, i.e. the equipment consists of line equalizer bay, amplifier bay, switching bays and supervisory bay. The function of the different bays is shown in fig. 14.

The maximum capacity of the equipment for large stations is 40 amplifiers (i.e. 40 simultaneous programs) and 120 incoming and 120 outgoing lines (or 120 two-way lines). The fully built-out station contains five line equalizer bays, four amplifier bays, four input switching bays, four output switching bays and two supervisory bays. With different combinations of bays it is possible for example to make stations of 30 amplifiers and 80 lines, 20 amplifiers and 60 lines or 40 amplifiers and 120 lines etc.

Battery voltage	Power consumption				Line equalizer, amplifier and supervisory bays			Switching bays		
	40 amplifiers 120 lines		30 amplifiers 80 lines							
	24 V	130 V	24 V	130 V	Height	Width	Depth*	Height	Width	Depth
24, 130 V	1 100 VA max	650 VA max	800 VA max	480 VA max	2 590 mm (8′6″)	514 mm (20 1/4″)	456 mm (18″)	2 700 mm (8′10 1/2″)	643 mm (2′1 3/8″)	215 mm (8 1/2″)

* Equipment mounted on both sides.

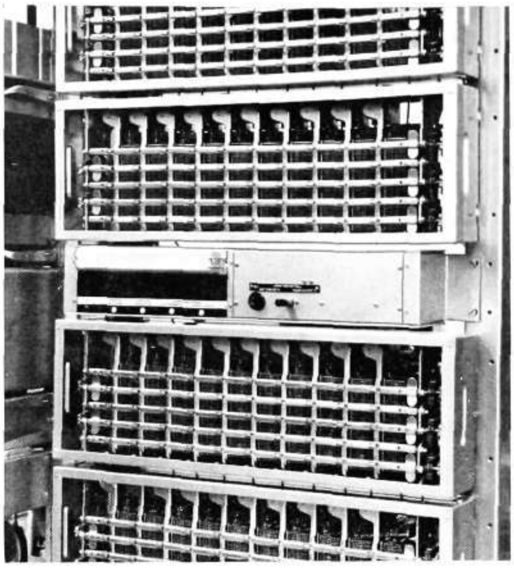


Fig. 15 X 2470

Distribution equipment with crossbar switches

The Distribution Equipment

Connexions between incoming lines and amplifier inputs and between outgoing lines and amplifier outputs respectively are made by relays in the switching bays. Control and testing of the connexions which have been made are carried out on a control panel in the supervisory bay.

The relay connexions in the switching bays are carried out using crossbar switches. Fig. 15 shows a part of a switching bay with crossbar switches. The switch is in some respects a modified type of that used for automatic telephony in that gold is used as contact material on the contacts which connect the programs, and also the screening between the relay springs is improved to give better crosstalk attenuation up to 10 000 c/s. By using the possibilities of switching offered by the crossbar switch the same reliability against faulty switchings has been obtained as in the manual case. To prevent disconnexion of the program in the event of a power failure, the switching bay can be fed from two sources, regular and stand-by. Change-over to the stand-by source is made automatically when the regular supply fails.

Control of the program switching is carried out from the control panel in the supervisory bay which is shown in fig. 16. Each line and each amplifier are represented by a push-button and a lamp on the control panel. In order that switching can take place, both the line push-button and the amplifier push-button must be depressed simultaneously. Completed switching is shown by the lamps lighting. Clearing down is also carried out with double push-button control. In this case a common clearing down button and line button is used. Switching in and out of the peak program meter, loudspeaker amplifier and measuring lines is carried out in the same way as for the lines. In order to locate connexions when there are many lines and amplifiers switched in, a special function has been incorporated in the control panel. For this, all lamps which do not belong to this connexion are extinguished when a push-button for an incoming line or an amplifier is depressed.

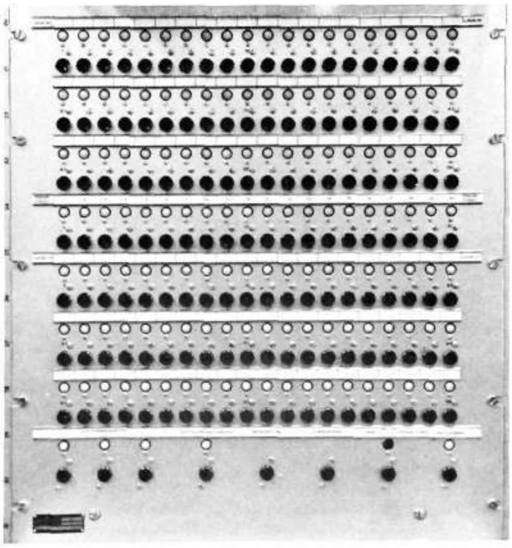


Fig. 16 X 2471

Control panel for equipment for large stations

Remote Control of Program Switchings

It is possible to carry out switching using remote control by supplementing the program distribution equipment for large stations with a relay bay for control of the crossbar switches.

Remote control can be carried out by using, for example, v.f. transmission of decade information which can be done from an arbitrary distance from the switching station.

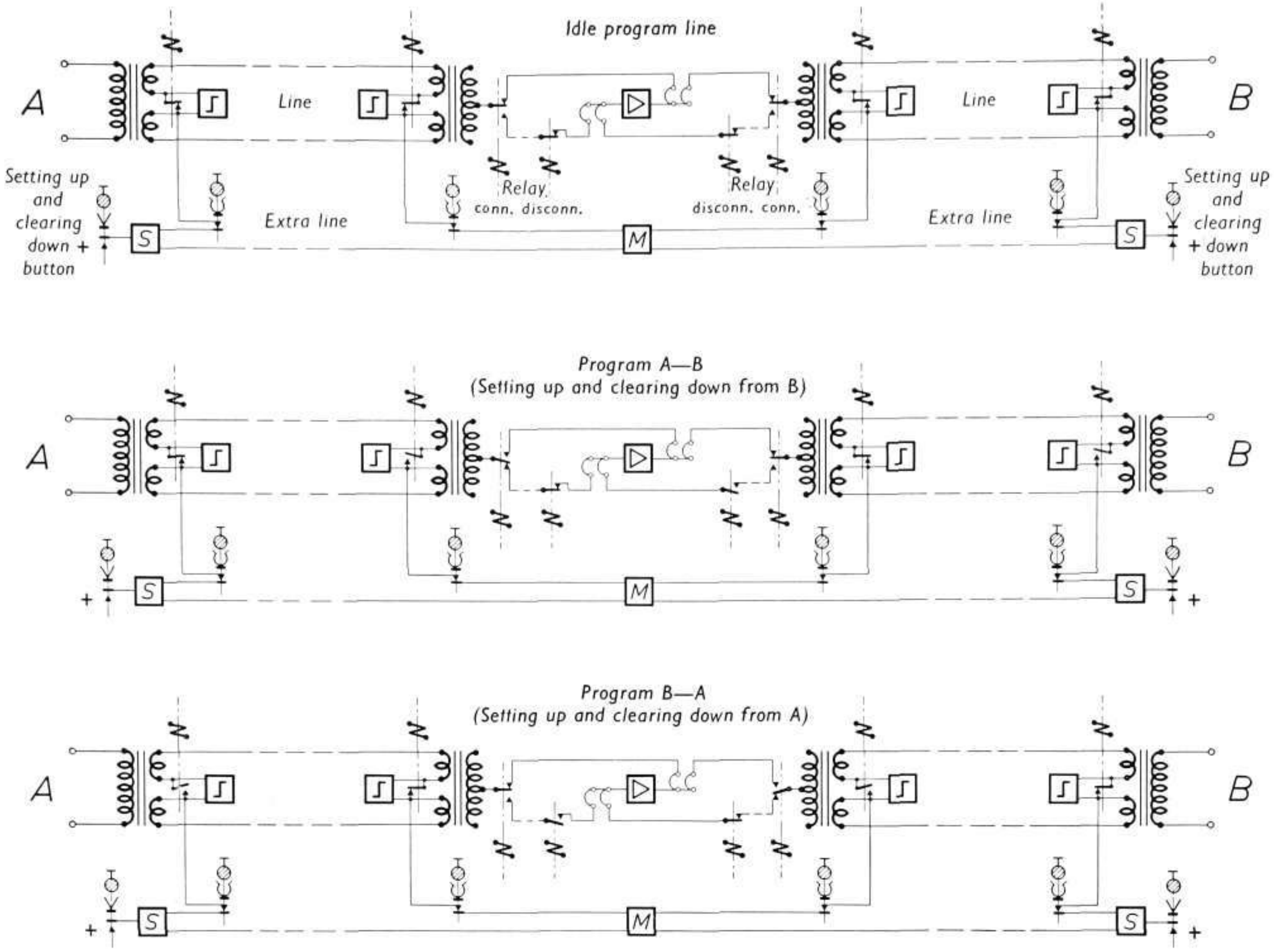


Fig. 17 X 7766

Block schematic of remote control equipment for reversing of program lines

6. Remote Control of Program Lines

The program distribution equipment for small and large stations can be provided with arrangements for remote control of program lines in which are included an arbitrary number of repeater stations.

The principle of the remote control equipment is seen in the block schematic in fig. 17. The intermediate stations (consisting of distribution equipment for small stations) are switched with double U-link plugs on the input and output respectively, and the amplifier is reversed by relay switching in the line equalizer equipment. Control is made by sending out an impulse train from one of the terminal stations. The impulses are then repeated at every intermediate station. Control always occurs so that the line is turned to the controlling terminal station. Indications on lamps are obtained on the completion of switching.

L M Ericsson's Crossbar Systems for Public Telephone Exchanges — a Brief Survey

F SUNDKVIST, TELEFONAKTIEBOLAGET L M ERICSSON, STOCKHOLM

UDC 621.395.344

L M Ericsson's crossbar switching systems have been discussed on numerous occasions in Ericsson Review in conjunction with reports of particular exchange installations, but no complete survey of these systems has yet been published. The present outline will form an introduction to a coming series of articles in which the more important systems will be described in greater detail.

Many years of experience lie behind the design and manufacture of the Ericsson crossbar systems. The first rural exchanges working on the crossbar principle were delivered to Televerket (The Swedish Telecommunications Administration) as early as 1938. They were built to Televerket's design and the crossbar switches were manufactured by Televerket. In the early forties the crossbar switch came to be used in the registers of 500-switch systems. In the mid-forties, following the good results obtained with crossbar both in Sweden and U.S.A., L M Ericsson started to design its own crossbar systems and to manufacture its own switches. The excellent characteristics of this switch – speed, efficient contact performance, freedom from noise, minimum wear, and low maintenance cost – have led to a widespread confidence in L M Ericsson's crossbar systems on the part of a growing number of telephone administrations.

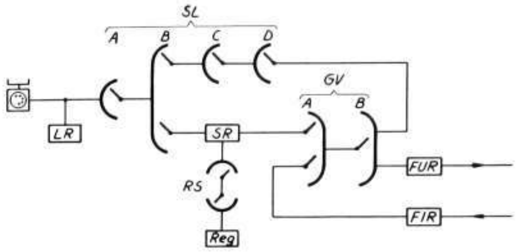
The greatest need for automatic exchange equipment was in large city exchanges. The primary task was therefore to design crossbar systems to meet such requirements. It was not only a matter of conversion from manual to automatic operation, but also of expansion in areas where automatization had already started with equipment of a more mechanical type. Special interworking systems were elaborated in order to be able to compete effectively on projects of this nature. In many countries, where mechanization had started at a fairly early stage, the existing automatic exchanges have now reached an age at which a successive change-over to modern crossbar equipment represents a profitable investment on account of the excessive maintenance required by the earlier systems and the rising cost of labour.

In rural areas and small towns, economy demands that telephone exchanges be left unattended and that their maintenance be centralized. The small amount of maintenance required on crossbar systems, and their high reliability, make them specially suited for such purposes, and L M Ericsson therefore designed a series of small rural exchanges.

The evolution of carrier techniques, and the demand of modern society for increasingly rapid, efficient and cheap long distance connections, and also the higher cost of operators' salaries, has created a need for special forms of switching equipment – automatic trunk or transit exchanges. The speed and excellent transmission properties of the crossbar switch have proved of especial value for such applications. Quickness in setting up connections, the possibility

Fig. 1 X 2456

Trunking diagram of ARF 10 exchange



of building selector stages of practically unlimited capacity, and the principle of alternative routing, are all factors which make for efficient utilization of expensive trunk lines.

In addition to the systems of its own design, L M Ericsson manufactures certain systems designed by Televerket with a special eye for Swedish conditions and for its particular production set-up.

The various crossbar systems manufactured by L M Ericsson, with their catalogue designations, are:

System	Catalogue designation
City exchanges	*ARF*
Rural exchanges	*ARK*
Transit exchanges	*ARM*

The systems made for Televerket are designated *ARK* or *ART*.

City Exchanges *ARF*

L M Ericsson makes three types of city exchange equipment from a few hundred lines and upwards:

Register-controlled system, 48 V	*ARF 10*
System for interworking with step-by-step, 60 V	*ARF 50*
System for interworking with step-by-step, 50 V	*ARF 51*

Fig. 1 shows a typical trunking diagram for an *ARF 10* exchange. It is made up of subscribers' groups for 1000 lines with a combined finder and final selector (connector) stage *SL* consisting of four partial stages. To the *SL* stage are connected link circuits *SR* and inlets from the group selector stage *GV*. The group selectors are made up of two partial stages in units of 80

Fig. 2 X 2457

Trunking diagram of ARF 50 exchange

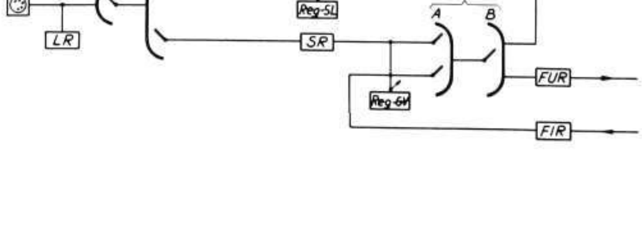


Fig. 3

Crossbar exchange, ARF 10

X 7765

inlets and 400 outlets. Central registers *REG* are connected via register finders *RS* to *SR*, and finally there are the outgoing and incoming junction relay sets *FUR* and *FIR* for lines to and from other exchanges.

Fig. 2 shows the *ARF 50* trunking diagram for interwork with 60 V step-by-step systems. The main difference from *ARF 10* is the absence of central registers, the impulses from the subscriber's dial being received direct by simple registers connected to the various selector stages *SL* and *GV*. The signalling is entirely matched to the step-by-step system, so that any part of the *ARF 50* system, e.g. a group selector, can directly replace the corresponding equipment in the other system.

System *ARF 51* for interwork with 50 V step-by-step systems is built up on roughly the same principles as *ARF 50*.

It has often been found of great advantage to retain the central registers in crossbar exchanges used for interworking with direct-driven systems. The additional requirement of interworking equipment is more than compensated by the advantages rendered by central registers in the form of flexibility in numbering and traffic routing.

The crossbar system best suited for interworking with other register-controlled systems, such as the 500 or Rotary systems, is *ARF 10*. The registers in *ARF 10* are supplemented by circuits for setting the switches of the other system, while for incoming traffic translation equipment is introduced either on the junction lines or – as can often be arranged by simple means – in conjunction with the other system's registers.

For Televerket L M Ericsson manufactures the Televerket A 204 system under the designation *ART 204*.

Rural Exchanges *ARK*

L M Ericsson has for many years supplied rural exchanges of system *ARK 30* to various countries. This system embraces several types for different sizes of terminal exchange and group centre. The terminal equipments are

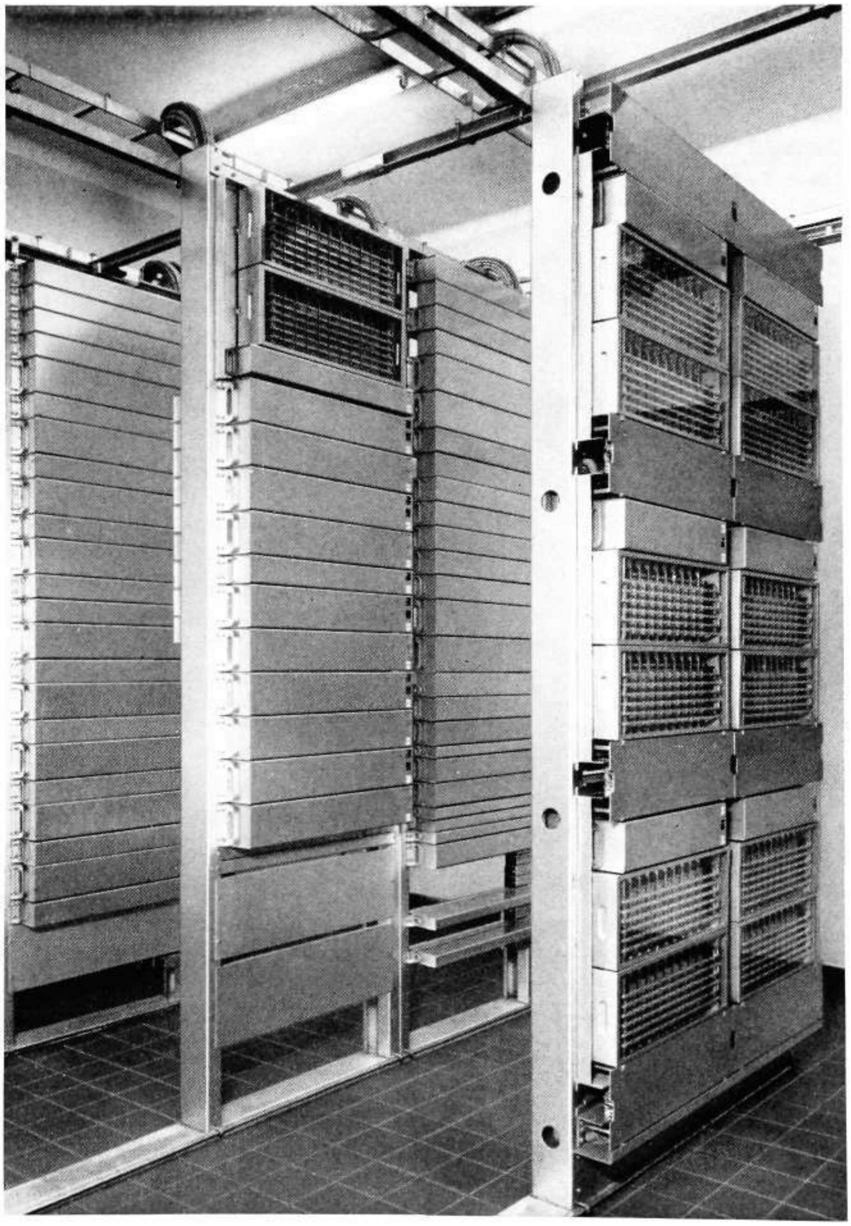


Fig. 4 X 8178

Crossbar exchange type ARK 315

S. Giovanni Lupatoto, Italy

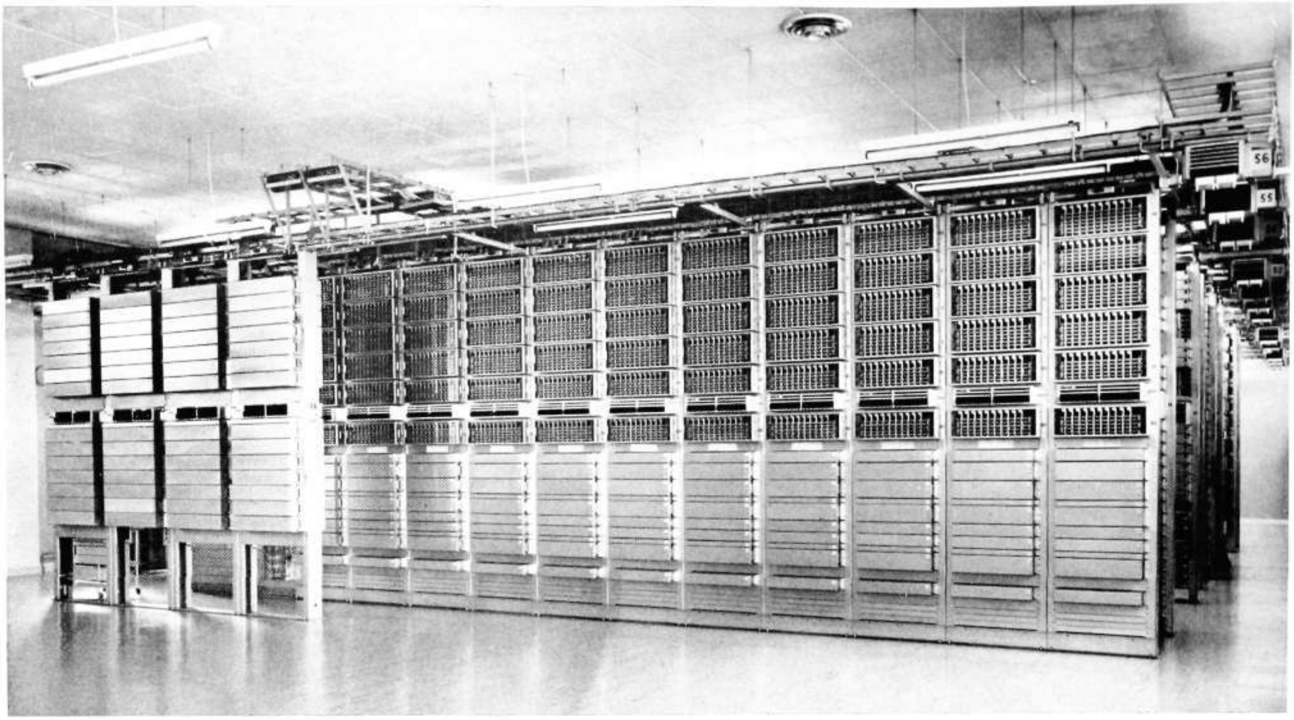


Fig. 5
Crossbar exchange ARM 20
Aalborg, Denmark

X 2461

designed for induced occupation of the superior exchange. Signalling is usually by 100-cycle a.c., but d.c. or v.f. signalling can also be arranged. Digit transmission is decadic.

The *ARK 30* series comprises the following types:

ARK 312	20– 60	line terminal exchange
ARK 314	60– 180	» » »
ARK 315	100–1600	» » »
ARK 335	100–1600	line group centre

A new rural exchange system *ARK 50* has been brought out quite recently. The decadic impulsing from the registers has been replaced by "compelled" v.f. code signalling, which ensures rapid and reliable digit transmission and involves a great simplification of the junction relay sets. *ARK 50* is available in two designs:

ARK 51	terminal exchange for	30– 90	lines
ARK 52	» » »	100–2000	»

The group centres in the *ARK 50* system are made up of a terminal stage *ARK 52* and a transit stage *ARM 50* (see below).

L M Ericsson has manufactured two rural exchange systems for Televerket, *ARK 100* (Televerket system Model 36) and *ARK 101* (Televerket system Standard 41).

Transit Exchanges *ARM*

These exchanges are made in two types:

ARM 50	for	40–2000	lines
ARM 20	»	100–8000	»

ARM 50 is built up of 40-line units, and *ARM 20* of 100- or 200-line units.

The *ARM* systems are normally designed for 4-wire through switching, and different signalling systems can be employed on the various trunks with their registers. In addition to tie lines of different kinds, cordless operators' positions are often connected to *ARM* exchanges. One variant of *ARM 20* has been designed for automanual and automatic international exchanges with signalling in accordance with CCITT's recommendations.

L M Ericsson also manufactures transit exchanges of Televerket's system A 205 under type designation *ART 205*.

As will be apparent from this brief survey, L M Ericsson now has a very complete range of crossbar exchanges for different requirements. The various systems have undergone continuous development based on experience gained in service. More rapid and reliable principles of signalling have been introduced, and valuable new traffic facilities have been successively added. The design of the systems has been influenced by new methods of installation and maintenance and by new component developments; electronic equipment has been employed wherever it would result in tangible benefits. The systems have been adapted to the varying requirements of the increasing number of markets.

Impulse Timer ZYH 20101

B LARSSON & Å B SVENSSON, TELEFONAKTIEBOLAGET L M ERICSSON, STOCKHOLM

UDC 621.373.444

For the testing of selectors and relays in automatic telephone exchanges some simple device is needed for opening or closing a circuit during periods which can be preset to any required value. This article describes the impulse timer ZYH 20101, which generates break and make impulses from milliseconds up to 10 seconds. The settings are decadic, with one switch for each digit.

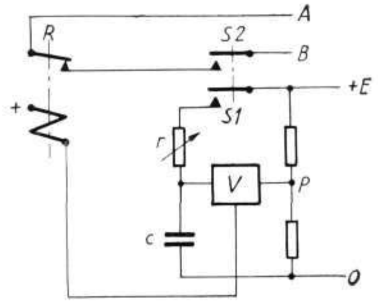


Fig. 1 X 2447
General principle of impulse timer ZYH 20101

General Principle

The general principle of operation of the impulse timer is shown in fig. 1.

On the closure of contact *S1* the voltage (u_c) across the capacitor *c* rises according to the curve

$$u_c = E\left(1 - e^{-\frac{t}{r \cdot c}}\right)$$

V is a comparison circuit which, without affecting the charging of the capacitor, senses the voltage and de-energizes relay *R* when the positive side of the capacitor attains the same voltage as point *P*.

Simultaneously with the closure of *S1*, *S2* closes loop *A–B*. The loop is opened when the relay releases. A make pulse is accordingly generated between *A* and *B*, the duration of which is determined by the time taken to charge the capacitor and the release time of the relay. The capacitor charging time is proportional to the product $r \cdot c$. Variation of *r* produces pulses of different duration.

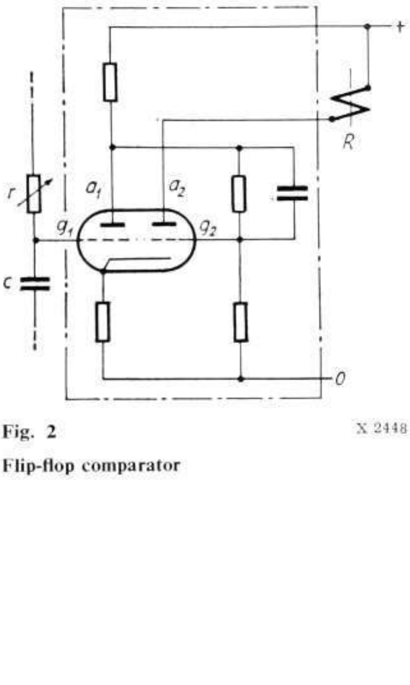
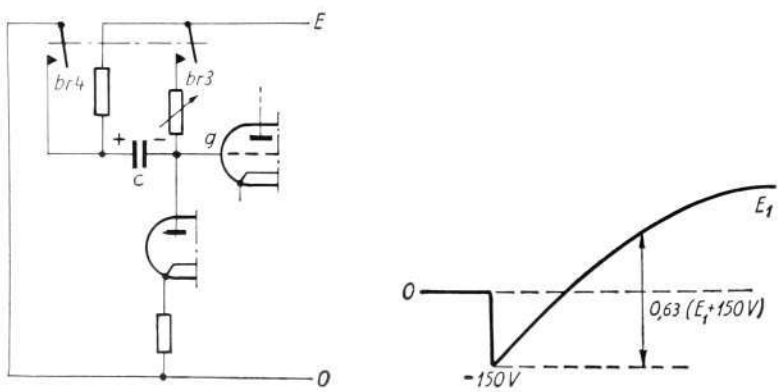


Fig. 2 X 2448
Flip-flop comparator

The comparison circuit consists of a double triode connected as in fig. 2.

Initially, when *c* is discharged, grid g_1 is so negative in relation of the cathode that the current through the corresponding part of the triode is cut off. The voltage on anode a_1 is therefore high, and likewise on grid g_2. Current flows through the relay, which remains operated. When the voltage across the capacitor attains the cut-off value of g_1, the current is switched to a_1. The voltage on a_1 drops, and grid g_2 cuts off the relay current. The switching action is effected very rapidly after g_1 has attained the critical voltage, and is independent of the rate of voltage rise on g_1.



a b

Fig. 3 X 2449 X 2450
Charging of time circuit

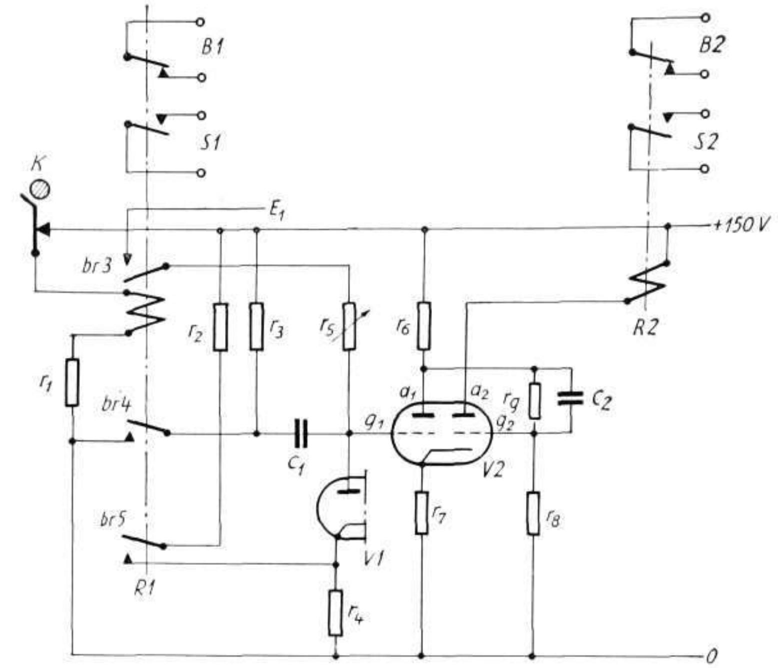


Fig. 4 X 8165

Simplified circuit diagram of impulse timer

For high accuracy the total change of voltage across the capacitor should be as large as possible, for which reason the capacitor is charged (fig. 3 a) before pulsing takes place through the diode with the polarity shown in the figure.

The closure of *br3* and *br4* starts the voltage swing on g_1, commencing at -150 V and rising to $+E_1$ (fig. 3 b). The circuit in fig. 2 has a trigger level of 63 % of the total voltage swing relative to the starting value.

The circuit in fig. 1 is essentially independent of the voltage, the pulsing time being determined solely by the product of $r \cdot c$. This is on the assumption, however, that the voltage is constant during charging. For this reason a 150 V voltage stabilizer tube is provided.

Fig. 4 shows the circuit of the impulse timer in simplified form.

Relay *R1* is energized through the break contact of push-button *K*, so that contacts *S1*, *br3*, *br4* and *br5* are open and *B1* is closed. Grid g_1 is kept at zero potential by diode *V1* and resistor r_4. Relay *R2* is energized. On depression of push-button *K*, relay *R1* releases. Contact *br4* closes and reduces g_1 to -150 volts. Capacitor C_1 is charged via *br3* and r_5, and the voltage on g_1 rises. Through r_2 and *br5* the voltage on the cathode of *V1* becomes sufficiently high to prevent the capacitor's charging current from being dissipated through *V1*. When g_1 reaches a voltage of $0.63\,(E_1 + 150)$ V, the circuit flips over and *R2* releases.

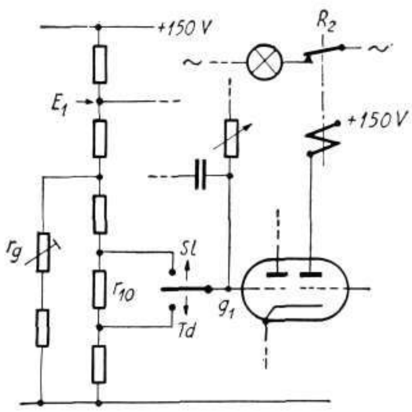


Fig. 5 X 2451

Calibration of impulse timer

Sl Extinguished

Td Ignited

The apparatus contains a calibrating device (fig. 5) which enables a simple check to be made that the circuit flips over at the precise moment at which the grid voltage attains the level corresponding to 63 % of the total charging voltage $(E_1 + 150)$.

When the CAL key is switched to LIGHT ON, grid g_1 is connected to a point on a voltage divider. The voltage at this point should be immediately below the trigger point for the comparison circuit, which is confirmed by the fact that a pilot lamp remains alight. If the key is thrown to LIGHT OFF, g_1 is connected to a slightly higher voltage. The circuit shall then switch over, i.e. *R2* releases and breaks the lamp circuit.

Adjustment is effected with the variable resistor r_g to bring the charging voltage to the correct value in relation to the trigger level.

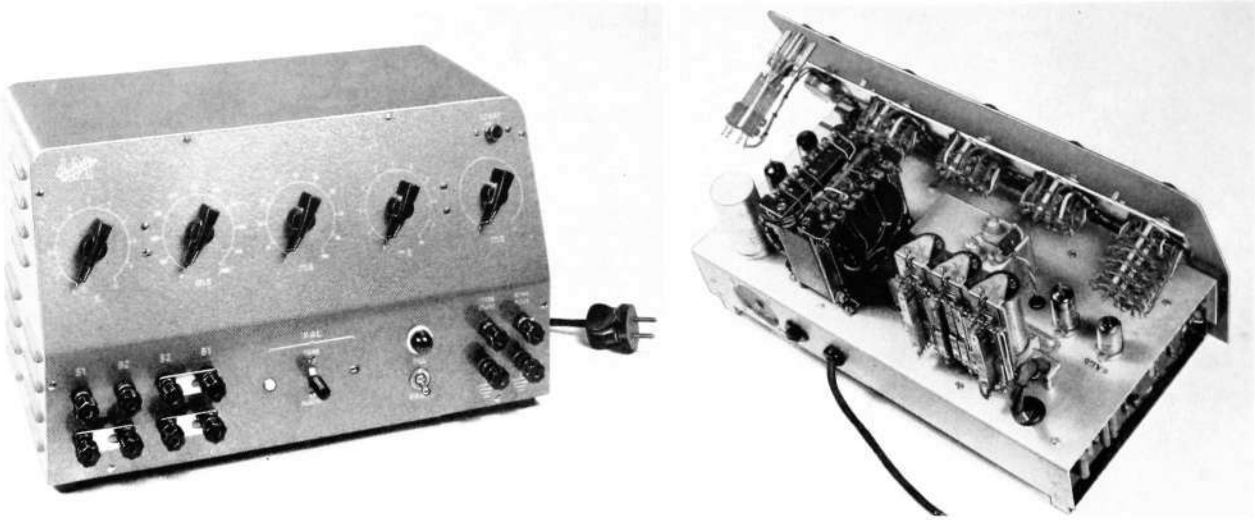


Fig. 6

Impulse timer ZYH 20101

(right) with cover removed

X 7761

Mechanical Construction

The general appearance of the impulse timer is shown in fig. 6. The chassis is attached to the front panel. For inspection or tube replacement the front panel is unscrewed and the cover can then be withdrawn (fig. 6, right).

The front panel carries five knobs with scale graduations of 0–10 s, 0–1000 ms, 0–100 ms, 0–10 ms, and 0–1 ms. The latter knob is continuously variable. In the top right-hand corner is a START button. Above the mains switch is a pilot lamp which lights when the switch is on and the mains voltage connected.

At the far right are two terminals marked SYNC PULSE. From these terminals a –50 V sync pulse is obtainable about 0.5 ms before the start of contact action, in order to trigger an oscilloscope. The apparatus can be remote controlled from a make contact connected to the two EXTERNAL START terminals.

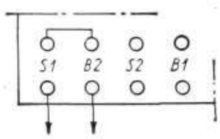
In the centre of the front panel is a lever key with a pilot lamp on its left.

The terminals in the bottom left corner, marked *S1*, *B2*, *S2* and *B1*, are for the contact pulses. *S1* and *B1* are contacts which make and break, respectively, at the start of the process. *S2* and *B2* make and break after a preset time.

Applications

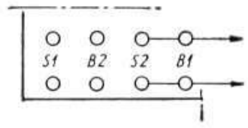
A few examples of the different applications are given below.

1. Connection for make impulse.



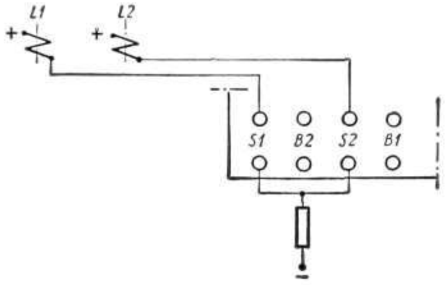
X 2452

2. Connection for break impulse.

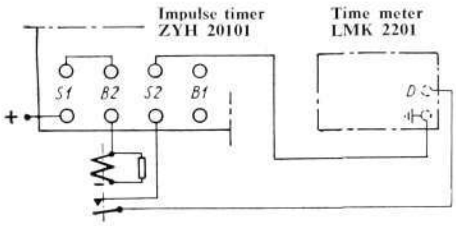


3. Parallel test check.

   The risk of two relays operating when testing simultaneously on the same outlet is often greatest if one is energized slightly after the other. The circuit can be arranged as shown below, and the most critical case is found by varying the time difference.



4. Measurement of relay's release lag as function of excitation time.



An output pulse, the length of which is determined by the time difference between *S1* and *B2*, is applied to the relay. At the same time as *B2* opens the relay circuit, *S2* closes and starts the time meter so that the release lag alone is measured.

Auxiliary Set ZYY 10101

The contacts of the impulse timer are rated for currents of not more than 0.4 A, but with an auxiliary set, designated *ZYY 10101* (fig. 7), it is possible to handle loads of 5 A 500 V (max. 250 VA).

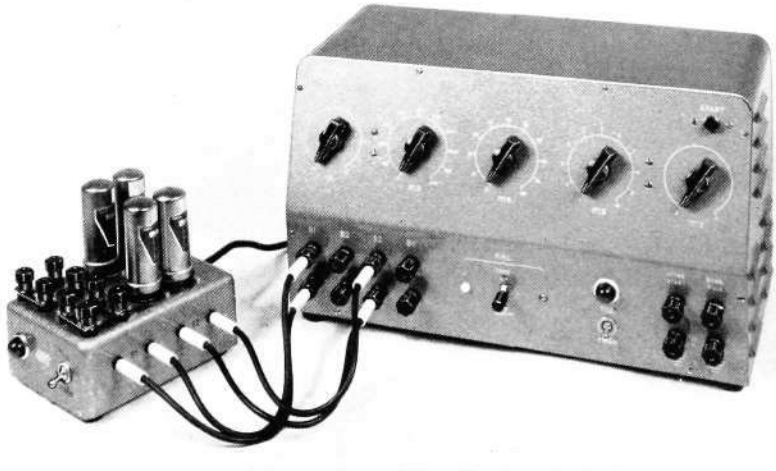


Fig. 7 X 8164

Impulse timer ZYH 20101 coupled to auxiliary set ZYY 10101 for working with high currents and voltages

The auxiliary set consists of four mercury relays and a power unit to feed them. The mercury relays repeat the pulses from the impulse timer without distortion.

Electrical Data, Tubes, Dimensions of Impulse Timer ZYH 20101

Time settings:	0–11111 ms
Accuracy:	0–1000 ms ± 2 % ± 0.3 ms 1–11 s ± 3 %

Min. recuperating time for repetition of pulse within range:

	0–1000 ms = 150 ms 1–10 s = 500 ms

Max. contact loading 0.4 A, max. voltage 60 V. Contacs of silver-palladium

Power consumption:	35 W
Power supply:	110, 127, 220 or 240 V, 50 c/s
Dimensions:	400 × 240 × 230 mm
Weight:	approx. 9 kg
Tubes:	*6J6, 6AL5, 6X4, OA2*

Electrical Data and Dimensions of Auxiliary Set ZYY 10101

Max. pulse contact loading (with spark quenching on inductive loads):

	5 A 500 V (max. 250 VA)
Power consumption:	10 W
Power supply:	110, 127, 220 or 240 V, 50 c/s
Dimensions:	160 × 120 × 150 mm
Weight:	approx. 2 kg

Ericsson LM NEWS *from All Quarters of the World*

President Eisenhower was delighted with the Ericofon when he tried it out at the World Trade Show in New York. The new all-in-one telephone is now available to subscribers of more than 200 U.S. telephone companies.

L M Ericsson Equipment to Tunisia

Radical Reconstruction of Tunis Telephone System

In stiff competition with eight other international telephone companies L M Ericsson has concluded a telephone contract with Tunisia amounting to 12½ million kronor.

The P.T.T. decided to carry through a radical reconstruction of the Tunis telephone network, which has hitherto comprised 13,000 lines of two different automatic systems. These systems are now to be dismantled and the city is instead to have 21,000 lines of L M Ericsson's modern crossbar system. 4,000 lines in the Tunis suburbs are also to be converted to automatic operation. Tunis will thereby become one of the most modern telephone cities in the world.

The contract also includes automatization of the telephone service at Bizerte (1,000 lines) and the building of a trunk exchange at Tunis with 85 national and 16 international positions. A 10-position trunk exchange is also to be built at Bizerte.

Work on the installations is to start in roughly one year's time and will take three years to complete. Tunisian labour will be trained in the course of the installation work, which will be supervised by Ericsson staff. Twenty-five Tunisian technicians are also to receive telecommunications training in Sweden.

This is the first time L M Ericsson has done business with Tunisia.

H.M. King Gustaf Adolf took the opportunity of making acquaintance with the Ericofon at the National Agricultural Meeting at Jönköping, Sweden, where he is seen with two officers in attendance.

Ericsson Deliveries to Ecuador soon 38 000 Lines

L M Ericsson has recently received an order for extension of the automatic telephone system in the town of Guayaquil, Ecuador, from 8,000 to 14,500 line capacity. The contract is worth about 11½ million kronor. Ericsson is to supply automatic exchange equipment, outside plant and telephone instruments for Guayaquil and the neighbouring communities of Salinas and Milagro, which are to be equipped with crossbar.

In January Ericsson received a similar order for Quito, capital of Ecuador, bringing up the capacity of that city from 14,500 to 21,500 lines.

The first Ericsson switchboard in Ecuador, a manual exchange at Quito, was installed 30 years ago. Since 1945 all deliveries have been of automatic equipment. By the conclusion of the present contract Ericsson deliveries to Ecuador will total 38,000 lines.

Ceylon Railways to Install C.T.C. and Relay Interlockings

Ceylon Government Railway network

- ◉ Control office for relay interlocking plant and C.T.C.
- ▬ C.T.C., single-track Ragama—Ja-ela
- ▬ C.T.C., *double-track Panadure—Colombo—Veyangoda*

The Ceylon Government Railway, a nationalized enterprise of nearly 100 years' standing, has decided to modernize the service on the lines to and from Colombo. One stage in the programme is the introduction of relay signal interlockings and centralized traffic control (C.T.C.), for which L M Ericsson recently received an order, comprising equipment and supervision of its installation, amounting to some 7½ million kronor.

The area of Ceylon is about 66,000 sq. kilometres, and its population numbers 9 million. The railway network within this small country covers 1,500 kilometres of track, and the railways are of extreme importance for the economy of the country, carrying a heavy traffic both of goods and passengers.

The present project will be completed in three stages. The first stage will be the provision of a single relay interlocking plant for the two Colombo stations of Colombo Fort and Maradana including intermediate shunting yards, with the control room in the railway administration building at Maradana. This installation will comprise no less than 114 electrically operated points, 93 light signals and 84 track circuits. Signals and points will be operated on Ericsson's Line-To-Line method (LTL). The control office will have a miniature track diagram depicting the track system, on which train movements, signal aspects, point conditions etc. are indicated. The LTL method implies that all points and signals governing train routes can be controlled at one time by simultaneous throwing of two keys on the track diagram, one at the start and the other at the end of the route.

The second stage will comprise relay interlocking plant and automatic block for the double-track line between Colombo and Veyangoda, a distance of some 36 kilometres, and on the single-track branch line between Ragama and Ja-ela, about 10 kilometres. This installation will comprise 52 electrically operated points, 132 signals and 207 track circuits. The entire line will be equipped with C.T.C., the interlocking machine being in the same office as that for the Colombo stations. The C.T.C. operation will also be on the LTL principle.

The third stage will cover the double-track line to Panadure southward (about 30 kilometres). This will comprise 35 electrically operated points, 88 signals and 161 track circuits. This line as well will be equipped with C.T.C.

L M Ericsson's stand at the last German Industrial Fair at Hanover, at which the Ericofon took a prominent place.

L M Ericsson Contract with Venezuela

L M Ericsson recently signed a contract with Venezuela for the delivery and installation of telephone equipment for some 11 million kronor. The equipment will give the capital city of Caracas modern telephone communications with several places of importance in the eastern parts of the country. In particular, the communications with Ciudad Bolívar, centre of a large mining district, and with the ore shipment port of Puerto Ordaz will be extended and brought up to date.

These new facilities will consist of a carrier telephone system operating on radio links. By this method a large number of telephone conversations can be conducted simultaneously on one route. The terminal equipment of the carrier telephone system is to be manufactured by the L M Ericsson Telephone Company, and the company will also take care of the radio link construction. The radio links will be manufactured by the Elektrisk Bureau in Oslo, Norway, a company associated with the Ericsson Group.

The first exchange delivered by L M Ericsson to Venezuela was in 1916, a manual switchboard at Ciudad Bolívar. Since then the firm has supplied automatic exchange equipment to some twenty Venezuelan towns.

One Million Crossbar Lines in Ten Years

An order was recently received for crossbar exchange equipment for Petersham, Sydney, Australia. With this order the Ericsson group has passed the million mark in terms of crossbar lines installed and on order for public automatic exchanges. This remarkable result has been achieved within a ten-year period. The first L M Ericsson crossbar exchange installed abroad was cut over at Helsinki in 1950. Ericsson crossbar exchanges are now installed on every continent and, as the order book shows, the interest in this automatic telephone system is constantly increasing.

(Below) The new heavyweight champion, Ingemar Johansson, with the Ericofon presented to him after his sensational victory over Floyd Patterson.

L M Ericsson exhibited some of its products at the Polish Industrial Fair at Poznań June 7—21. Among the visitors at the opening ceremony was the Polish President, J. Cyrankiewicz, who had the Ericofon demonstrated to him by Mr. Nils Berglind.

The Midsommarkransen plant was visited earlier this year by the Diplomatic Women's Club. Twelve ladies, representing eleven diplomatic missions in Stockholm, who wished to see what was going on at L M Ericsson's, are seen above in the demonstration room.

During the British naval visit to Stockholm in June L M Ericsson entertained a group of officers. Capt. F.N. Millins, on the staff of the Chief of the Home Fleet, is seen above with two officers from HMS Tyne.

The Ericofon played a prominent role at the annual Students' Carneval in Stockholm. It was presented by the picturesque quartette (left) to a hundred thousand spectators.

Bernhard Wahlqvist in memoriam

Bernhard Wahlqvist, President of Mexikanska Telefon AB Ericsson, has passed away at an age of 72 years.

In Bernhard Wahlqvist Telefon AB L M Ericsson has lost one of its foremost representatives. He had been active in the company for more than 50 years, principally in connection with telephone operations. The Polish and Argentinean concessions were developed under his management. His greatest achievement, however, was in the build-up of the Mexican telephone service. As chief in Mexico during the difficult years 1936–1948 he consolidated the position of the Swedish telephone industry in that country and laid the foundations for the great expansion that followed.

Wahlqvist combined a thorough knowledge of telephone engineering with an almost unbelievable capacity for assessing and planning the future development of telephone operations. His budgets held good. Through his unceasing thoroughness and trustworthiness he won respect both within the company and in the countries in which he worked. Wahlqvist was an outstanding personality, upright and true to his opinions. At the same time he was unassuming, a helpful and constant friend, liked by all who came into contact with him.

Marcus Wallenberg

After passing through the Technical School and studying as a special pupil at the Stockholm Institute of Technology, Bernhard Wahlqvist was taken on as exchange engineer by Stockholms Allmänna Telefon AB, where he advanced to the post of Traffic Inspector. He retained that appointment when the private telephone network in Stockholm was taken over by the Swedish Administration in 1918. In 1919 he left the government service to become sales manager of Allmänna Industri AB H T Cedergren. When Cedergrens was taken over by L M Ericsson, Wahlqvist joined the latter and, in 1922, was appointed president of Compañía Española de Teléfonos Ericsson. In 1925 he became head of L M Ericsson's foreign telephone operations and in 1936 president of Mexikanska Telefon AB Ericsson.

Honourable Award to L M Ericsson Engineer

Hans S Andersson, L M Ericsson, has been awarded a grant of 1,000 kronor by the Swedish Society of College Engineers. This grant, which is being made for the first time this year, is intended as an award for an important technical achievement by a Swedish college engineer.

The work for which the award has been made is the system of maintenance of automatic telephone exchanges recommended by L M Ericsson and adopted by most of the company's customers. Hans Andersson had an active and decisive part in the elaboration of this system, in which he drew upon his experience from his previous employment with the Swedish Telecommunications Administration and from many service assignments on behalf of Ericsson customers in different parts of the world.

New Director of Production

Hans Werthén has been appointed vice-president of Telefonaktiebolaget L M Ericsson as from September 1, 1959.

He will spend some time studying the production units of the group at home and abroad prior to taking over the post of Director in charge of production.

Torsten A Lundell in memoriam

Torsten A Lundell died on June 4, 1959, after some time of illness. In him the Ericsson group has lost a highly valued colleague of many years' standing, who leaves many friends behind him in the company.

Lundell's career with L M Ericsson started in 1926 after he had spent some time in Germany and U.S.A., including three years at Bell Telephone Laboratories, which were to prove invaluable for his future work. For two years he was at Svenska Radio AB in charge of sales of carrier telephone equipment. He returned to the parent company in 1931 and, up to 1940, was engaged on questions concerning sales and agreements. Following a reorganization in 1940 Lundell was appointed director in charge of sales and agreements. From 1946 to 1952 Lundell was head of L M Ericsson's company in London, being responsible for the maintenance of the group interests in the United Kingdom. He returned to Stockholm in 1952 and, from that time on, devoted himself wholeheartedly to the complicated questions connected with agreements and patents, for which, with his long experience, he was so admirably fitted.

In every enterprise with international interests there always arises the problem of finding persons who combine both technical ability and legal insight with a sound knowledge of languages and the ability to express themselves in a concise legal form. Torsten Lundell possessed these attributes to a marked degree and his achievements will be of lasting value.

Sven T Åberg

UDC 621.395.97

PETERSSON, E, ENGSTRÖM, S & JOHANSSON S O: *Program Distribution Equipment for Transmission of Sound in Broadcasting and Television.* Ericsson Rev. *36*(1959): 3, pp. 72—83.

Circuits for the transmission of broadcasting play a very important part in the distribution of sound radio programs. These program circuits are also used for transmission of sound for television programs. The requirements of the circuit as regards quality of transmission, flexibility and operational reliability are high. Two types of distribution equipment included in L M Ericsson's manufacturing program are described. In addition, the possibilities of remote control and routing of the program distribution network are touched upon.

UDC 621.395.344

SUNDKVIST, F: *L M Ericsson's Crossbar Systems for Public Telephone Exchanges—a Brief Survey.* Ericsson Rev. *36*(1959): 3, pp. 84—89.

L M Ericsson's crossbar switching systems have been discussed on numerous occasions in Ericsson Review in conjunction with reports of particular exchange installations, but no complete survey of these systems has yet been published. The present outline will form an introduction to a coming series of articles in which the more important systems will be described in greater detail.

UDC 621.373.444

LARSSON, B & SVENSSON, Å B: *Impulse Timer ZYH 20101.* Ericsson Rev. *36*(1959): 3, pp. 94—98.

For the testing of selectors and relays in automatic telephone exchanges some simple device is needed for opening or closing a circuit during periods which can be preset to any required value. This article describes the impulse timer, *ZYH 20101*, which generates break and make impulses from milliseconds up to 10 seconds. The settings are decadic, with one switch for each digit.

The Ericsson Group

Associated and co-operating enterprises

• EUROPE •

Denmark

L M Ericsson A/S *København F,* Finsens Vej 78, tel: Fa 6868, tgm: ericsson

Telefon Fabrik Automatic A/S *København K,* Amaliegade 7, tel: C 5188, tgm: automatic

Dansk Signal Industri A/S *København F,* Finsens Vej 78, tel: Fa 6767, tgm: signaler

Finland

O/Y L M Ericsson A/B *Helsinki,* Fabianinkatu 6, tel: A8282, tgm: ericssons

France

Société des Téléphones Ericsson *Colombes (Seine),* Boulevard de la Finlande, tel: CHA 35-00, tgm: ericsson

Paris 17e, 147 Rue de Courcelles, tel: Carnot 95-30, tgm: eric

Germany

Ericsson Verkaufsgesellschaft m. b. H. *Düsseldorf 1,* Worringer Strasse 109, tel: 84 461, tgm: erictel

Great Britain

Swedish Ericsson Company Ltd. *London, W. C. 1,* 329 High Holborn, tel: Holborn 1092, tgm: teleric

Production Control (Ericsson) Ltd. *London, W. C. 1,* 329 High Holborn, tel: Holborn 1092, tgm: productrol holb

Italy

Setemer, Soc. per Az. *Milano,* Via dei Giardini 7, tel: 662241, tgm: setemer

SIELTE, Soc. per Az. — Società Impianti Elettrici e Telefonici Sistema Ericsson *Roma,* C. P. 4024 Appio, tel: 780221, tgm: sielte

F. A. T. M. E. Soc. per Az. — Fabbrica Apparecchi Telefonici e Materiale Elettrico »Brevetti Ericsson» *Roma,* C. P. 4025 Appio, tel: 780021, tgm: fatme

Netherlands

Ericsson Telefoon-Maatschappij, N.V. *Rijen (N. Br.),* tel: 01692-555, tgm: erictel

den Haag—Scheveningen, 10, Palacestraat, tel: 55 55 00, tgm: erictel-haag

Norway

A/S Elektrisk Bureau *Oslo NV,* P.B. 5055, tel: Centralbord 46 18 20, tgm: elektriken

A/S Industrikontroll *Oslo,* Teatergaten 12, tel: Centralbord 335085, tgm: indtroll

A/S Norsk Kabelfabrik *Drammen,* P. B. 205, tel: 1285, tgm: kabel

A/S Norsk Signalindustri *Oslo,* P. B. Mj 2214, tel: Centralbord 56 53 54, tgm: signalindustri

Portugal

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

Spain

Cia Española Ericsson, S. A. *Madrid-4,* Conde de Xiquena 13, tel: 31 53 03, tgm: ericsson

Sweden

Telefonaktiebolaget L M Ericsson *Stockholm 32,* tel: 19 00 00, tgm: telefonbolaget

AB Alpha *Sundbyberg,* tel: 282600, tgm: aktiealpha-stockholm

AB Ermex *Solna,* tel: 82 01 00, tgm: elock-stockholm

AB Ermi *Bromma 11,* tel: 262600, tgm: ermibolag-stockholm

AB Rifa *Bromma 11,* tel: 26 26 10, tgm: elrifa-stockholm

AB Svenska Elektronrör *Stockholm 20,* tel: 44 03 05, tgm: electronics

L M Ericssons Driftkontrollaktiebolag *Solna,* tel: 27 27 25, tgm: powers-stockholm

L M Ericssons Signalaktiebolag *Stockholm Sv,* tel: 68 07 00, tgm: signalbolaget

L M Ericssons Svenska Försäljningsaktiebolag *Stockholm 1,* Box 877, tel: 22 31 00, tgm: ellem

Mexikanska Telefonaktiebolaget Ericsson *Stockholm 32,* tel: 190000, tgm: mexikan

Sieverts Kabelverk AB *Sundbyberg,* tel 282860, tgm: sievertsfabrik-stockholm

Svenska Radioaktiebolaget *Stockholm 12,* Alströmergatan 14, tel: 22 31 40, tgm: svenskradio

Switzerland

Ericsson Telephone Sales Corp. AB, Stockholm, Zweigniederlassung Zürich *Zürich,* Postfach Zürich 32, tel: 325184, tgm: telericsson

• ASIA •

India

Ericsson Telephone Sales Corporation AB *New Delhi 1,* P.O.B., 669, reg. mail: 1/3 Asaf Ali Road (Delhi Estate Building), tel: 28512, tgm: inderic

Bombay, Manu Mansion, 16, Old Custom House, tel: 254130 tgm: inderic

Calcutta, P. O. B. 2324, tel: 45-4494, tgm: inderic

Indonesia

Ericsson Telephone Sales Corporation AB *Bandung,* Djalan Dago 151, *tel: 8294, tgm:* javeric

Djakarta, Djalan Gunung Sahari 26, *tel: Gambir 50, tgm: javeric*

Leban

Telefonaktiebolaget L M Ericsson, Technical Office *Beyrouth,* Rue du *Parlement,* Immeuble Bisharat, tel: 33555, tgm: ellem

Turkey

Ericsson Türk Ltd. Şirketi *Ankara,* Âdil Han, Zafer Meydani, Yenişehir, tel: 23170, tgm: ellem

Istanbul, Istanbul Bürosu, Liman Han, Kat 5, No. 75, Bahçekapi, tel: 228102, tgm: ellemist

• AFRICA •

Union of South Africa

L M Ericsson Telephone Co. Pty. Ltd. *Johannesburg,* 70, Loveday *Street, tel: 33-2742, tgm: ericofon*

• AMERICA •

Argentine

Cia Sudamericana de Teléfonos L M Ericsson S. A. *Buenos Aires,* Belgrano 894, tel: 332071, tgm: ericsson

Corp. Sudamericana de Teléfonos y Telégrafos S. A. *Buenos Aires,* Belgrano 894, tel: 332071, tgm: cartefe

Cia Argentina de Teléfonos S. A. *Buenos Aires,* Perú 263, tel: 305011, tgm: cecea

Cia Entrerriana de Teléfonos S. A. *Buenos Aires,* Perú 263, tel: 305011, tgm: cecea

Cia Comercial de Administración S. A. *Buenos Aires,* Perú 263, tel: 305011, tgm: cecea

Industrias Eléctricas de Quilmes S. A. *Quilmes FCNGR,* 12 de Octubre 1090, tel: 203-2775, tgm: indelqui-buenosaires

Brazil

Ericsson do Brasil Comércio e Indústria S. A. *Rio de Janeiro,* C. P. 3601, tel: 43-0990, tgm: ericsson

São Paulo C. P. 5677, tel: 36-6951, tgm: ericsson

Canada

Ericsson Telephone Sales of Canada Ltd. *Montreal 8, Que.,* 130 Bates Road, *tel:* RE 1-6428, *tgm:* caneric

Toronto 18, Ont., 34 Advance Road, tel: BE 1-1306

S. A.

Santiago, Casilla 10143, tel: 82555, tgm: ericsson-santiago-dechile

Colombia

Cia Ericsson Ltda. *Bogotá,* Apartado Aéreo 4052, tel: 11-100, tgm: ericsson

Ecuador

Telefonaktiebolaget LM Ericsson, Technical Office *Quito,* Casilla Postal 2138, tel: 33777, *tgm:* ericsson

Mexico

Cia Comercial Ericsson S. A. *México D. F.,* Apartado 9958, tel: 46-46-40, tgm: coeric-mexico

Industria de Telecomunicación S.A. de C.V. *México 6, D.F.,* Calle Londres No 47, Colonia Juárez, tel: 250405, tgm: industel

Peru

Cia Ericsson S. A. *Lima,* Apartado 2982, tel: 34941, tgm: ericsson

Soc. Telefónica del Perú, S. A. *Arequipa,* Casilla de Correo 112, tgm: telefonica

El Salvador

Telefonaktiebolaget LM Ericsson, Technical Office, *San Salvador,* Apartado Postal 188, tel: 4989, tgm: ericsson

Uruguay

Cía Ericsson S. A. *Montevideo,* Casilla de Correo 575, tel: 84433, tgm: ericsson

USA

The Ericsson Corporation *New York 17, N. Y.,* 100 Park Avenue, tel: Murray Hill 5-4030, tgm: erictel

North Electric Co. *Galion, Ohio,* P. O. B. 417, *tel:* Howard 8-2420, tgm: northphone-galionohio

Venezuela

Cia Anónima Ericsson *Caracas,* Apartado 3548, tel: 543121, tgm: ericsson

Teléfonos Ericsson C. A. *Caracas,* Apartado 3548, tel: 543121, tgm: tevela

• AUSTRALIA & OCEANIA •

Australia

L M Ericsson Telephone Co. Pty. Ltd. *Melbourne C 1 (Victoria),* Kelvin Hall, 55 Collins Place, tel: MF 56 46, tgm: ericmel

Agencies

• EUROPE •

Austria

Inglomark, Industrie-Belieferungs-Gesellschaft Markowitsch & Co. *Wien XV,* Maria Hilferstrasse 133, tel: R 32-0-11, tgm: inglomark

Belgium

Electricité et Mécanique Suédoises *Bruxelles 5,* 56 Rue de Stassart, tel: 11 14 16, tgm: electrosuede

Greece

»ETEP», S. A. Commerciale & Technique *Athens,* 11, Mackenzie King Street, tel: 617041, tgm: aeter-athinai

Ireland

Communication Systems Ltd. *Dublin,* 40, Upper Fitzwilliam Street, tel: 61576/7, tgm: crossbar

Iceland

Johan Rönning H/F *Reykjavik,* P. O. B. 45, tel: 14320, tgm: *rönning*

Yugo-Slavia

Merkantile Inozemna Zastupstva *Zagreb,* Pošt pretinać 23, tel: 25-222, tgm: merkantile

• ASIA •

Burma

Vulcan Trading Co. Ltd. *Rangoon,* P. O. B. 581, tel: S. 878, tgm: suecia

Ceylon

Vulcan Trading Co. (Private) Ltd. *Colombo 1,* 19, York Street, tel: 36-36, tgm: vultra

China

The Ekman Foreign Agencies Ltd. *Shanghai,* P. O. B. 855, tel: 16242-3, tgm: ekmans

Hong Kong

The Swedish Trading Co. Ltd. *Hongkong,* P.O.B. 108, tel: 20171, tgm: swedetrade

Iran

Irano Swedish Company AB *Teheran,* Khiaban Sevom Esfand 201-203, tel: 36761, tgm: iranoswede

Iraq

Koopman & Co. (Iraq) W. L. L. *Baghdad,* P. O. B. 22, tel: 86860, tgm: havede

Japan

Gadelius & Co. Ltd. *Tokyo,* No. 3-19, Denma-cho, Akasaka, Minato-Ku, tel: 48-5361, tgm: goticus

Jordan

H. L. Larsson & Sons Ltd. Levant *Amman,* P. O. B. 647, tgm: larsonhus

Kuwait

Latiff Supplies Ltd. *Kuwait,* P.O.B. 67, tgm: latisup

Lebanon

Swedish Levant Trading Co. *Beyrouth,* P. O. B. 931, tel: 31624, tgm: skefko

Pakistan

Vulcan Trading Co. (Pakistan) Ltd. *Karachi City,* P. O. B. 4776, tel: 32506, tgm: vulcan

Philippines

Koppel (Philippines) Inc. *Manila P. R.,* P. O. B. 125, tel: 3-19-71, tgm: koppelrail

Saudi Arabia

Mohamed Fazil Abdulla Arab *Jeddah,* P. O. B. 39, tel: 2690, tgm: arab

Singapore and Malaya

The Swedish Trading Co. Ltd. *Singapore,* G. P. O. B. 2791, tgm: metlokcast

Syria

Georgiades, Moussa & Cie *Damas,* Rue Ghassan, Harika, tel: 1-02-89, tgm: georgiades

Thailand

Vichien Radio & Television Co., Ltd. *Bangkok,* 299-301, Prasitsin Building, Surawongse Road, tel: 31 364, tgm: ericsson

Vietnam

Vo Tuyen Dien-Thoai Viet-Nam, Matériel Radio & Téléphonique du Viêtnam *Saigon,* 17, Cong Truong Lam-Son, tel: 20805, tgm: *telerad*

• AFRICA •

Belgian Congo

Société Anonyme Internationale de Télégraphie sans Fil (SAIT) *Bruxelles (Belgique),* 25, Boulevard du Régent, tel: 125070, tgm: wireless (For maritim radio and carrier)

British East Africa

Transcandia Ltd. *Nairobi, Kenya,* P. O. B. 5933, tel. 3312, tgm: transcanda

Egypt

The Pharaonic Engineering & Industrial Co. *Cairo,* 33, Orabi Street, tel: 4-36-84, tgm: radiation

Ethiopia

Swedish Ethiopian Company *Addis Ababa,* P. O. B. 264, tel: 1447, tgm: etiocomp

Ghana

The Standard Electric Company *Accra,* P.O.B. 17, tel: 2785, tgm: standard

Morocco

Elcor S. A. *Tangier,* Francisco Vitoria, 4, tel: 2220, tgm: elcor

Mozambique

J. Martins Marques *Lourenço Marques,* P. O. B. 456, tel: 5953, tgm: tinsmarques

Nigeria

Scan African Trading Co. *Yaba-Lagos 32,* P. O. B. 1, tgm: swedafrica

Rhodesia and Nyasaland

Reunert & Lenz, (Rhodesia) Ltd. *Salisbury (Southern Rhodesia)* P.O. B. 2071, tel: 27001, tgm: rockdrill

Sudan

TECOMA Technical Consulting and Machinery Co. Ltd. *Khartoum,* P.O.B. 866, *tel:* 2224, ext. 35, tgm: sutecoma

• AMERICA •

Bolivia

Johansson & Cia, S. A. *La Paz,* Casilla 678, tel: 2700, tgm: johansson

Costa Rica

Tropical Commission Co. Ltd. *San José,* Apartado 661, tel: 3432, tgm: troco

Cuba

Mc Avoy y Cia *Habana,* Apartado 2379, tel: U-2527, tgm: macavoy

Curaçao N. W. I.

S. E. L. Maduro & Sons, Inc. *Curaçao,* P. O. B. 172, tel: 1200, tgm: madurosons-willemstad

Dominican Republic

Garcia & Gautier, C. por A. *Ciudad Trujillo,* Apartado 771, tel: 3645, tgm: gartier

Guatemala

Nils Pira *Ciudad de Guatemala, Apartado* 36, *tel:* 3311, *tgm:* nilspira-guatemala

Haïti

Salon Culturel, Michel Schutt Aîné, *Port au Prince,* P. O. B. 903, tgm: c

Honduras

Cía de Comisiones Inter-Americana, S. A. *Tegucigalpa D. C.,* P. O. B. 114, tel: 15-63, tgm: *inter*

Jamaica and Brit. Honduras

Morris E. Parkin *Kingston,* P.O.B. 354, tel: 4077, tgm: morrispark

Nicaragua

J. R. E. Tefel & Co. Ltd. *Managua,* Apartado 24, tel: 387-1169, tgm: tefelto

Panama

Productos Mundiales, S. A. *Panama, R. P.,* P. O. B. 4349, tel: 3-0476, 3-7763, tgm: mundi

Paraguay

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

Puerto Rico

Splendid Inc. *San Juan,* P. O. B. 4568, tel: 3-4095, tgm: splendid

El Salvador

Dada-Dada & Co. *San Salvador,* Apartado 274, tel: 4860, tgm: dada

Surinam

C. Kersten & Co. N. V. *Paramaribo,* P. O. B. 216, tel: 2541, tgm: kersten

USA

State Labs. Inc., *New York 12, N.Y.,* 649 Broadway, tel: Oregon 7-8400, tgm: statelabs. Only for electron tubes

• AUSTRALIA & OCEANIA •

New Zealand

ASEA Electric (N Z) Ltd. *Wellington C.1.,* Huddart Parker Building, Post Office Square, tel: 70-614,

ERICSSON Review

4
1959

ERICSSON REVIEW

Vol. XXXVI No. 4 1959

RESPONSIBLE PUBLISHER: HUGO LINDBERG

EDITOR: SIGVARD EKLUND, DHS

EDITOR'S OFFICE: STOCKHOLM 32

SUBSCRIPTIONS: ONE YEAR $ 1.50; ONE COPY $ 0.50

CONTENTS

On cover: Ericovox, L M Ericsson's New Loudspeaking Telephone, and (left) the Ericofon.

Ericovox, the One-Piece Loudspeaking Telephone

I MITNITZKY & P AHLSTRÖM, TELEFONAKTIEBOLAGET L M ERICSSON, STOCKHOLM

UDC 621.395.721.4
621.395.623.7

Telefonaktiebolaget L M Ericsson's first loudspeaking telephone for operation on public exchange lines was introduced in 1945. The practical limitations imposed on loudspeaking telephones by the techniques available at that time have been eliminated through the development of semiconductors, in this case represented by transistors and diodes. Semiconductors have opened the way to the entirely new design of loudspeaking telephone which is presented in this article. It is called the Ericovox and consists of a single unit. It can be installed wherever an ordinary telephone is used, being practically independent of room acoustics and length of line. With this telephone the busy office worker, or the housewife in the midst of her chores, can now conduct their telephone conversations with both hands free.

Improved productivity – and the higher standard of living that goes with it – calls for constant rationalization of all fields of activity, among which office organization is an all important one. Efficient communication has long been a subject to which telephone manufacturers have devoted a special interest. In the Ericovox L M Ericsson offers a product which will further ease the work in offices – and also in homes – and so increase productivity, while at the same time giving people greater freedom and wellbeing.

The Ericovox is specially suited for persons

who have many telephone conversations every day,

who during conversation need to use their hands for making notes or looking through files without the encumbrance of a handset,

who regularly have telephone conferences in which other persons in the room take part,

who are physically handicapped so that normal use of the telephone is difficult for them.

Fig. 1 X 2446

The Ericovox, L M Ericsson's loudspeaking telephone, allows the busy office worker to have both hands free

On the other hand, loudspeaking telephones are not suited for communication between noisy locations owing to the difficulty of hearing above the disturbance level.

Among the particularly attractive properties of the Ericovox for the user are

its excellent transmission in both directions,

its sensitivity and volume, equal in all directions (an important point for conference use),

its elegant style and colour.

The Ericovox, consisting as it does of a single unit, takes up little space and can be located at choice, which simplifies its installation. It connects direct to the telephone line, from which all power needed for its operation is obtained. And, last but not least, the Ericovox is extremely simple to use.

All manipulations are effected with the buttons above the dial and a volume control. A light touch on the left-hand button, which causes it to spring up, connects the instrument to the line for incoming or outgoing calls. During conversation the incoming signal level can be raised 9 db by pressing the

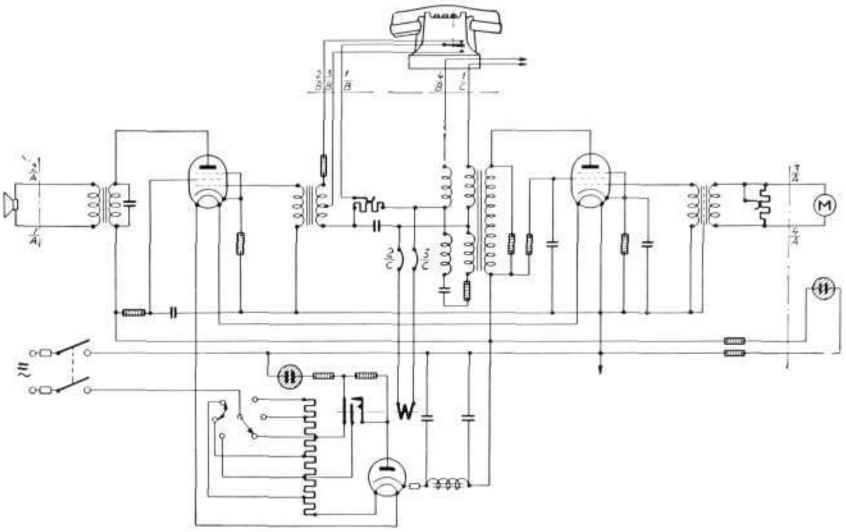


Fig. 2a X 8155

Circuit diagram of LM Ericsson's earlier loudspeaking telephone

centre button. This button can be restored during conversation by momentarily pressing the right-hand button. If the receiving level is too high, it can be reduced with the volume control on the left-hand side of the base. The right-hand button is self-restoring and, when depressed, disconnects the microphone but not the loudspeaker. It thus serves both as release for the centre button and as secrecy button when the user desires to confer with persons in the room without the other subscriber being able to listen.

The circuit diagram used in L M Ericsson's earlier design of loudspeaking telephone (*DBF 11*) is shown in fig. 2 a. The sending unit consisted of a microphone and its amplifier. The receiver consisted likewise of a loudspeaker and amplifier. The two amplifiers were connected to the two-wire line by means of an anti-sidetone coupling, actually a differential transformer. To avoid singing, among other things, a line balance was introduced to imitate the average impedance of a telephone line. The impedance chosen was 600 ohms as recommended by CCITT for international circuits. It is a well known fact, however, that the line impedance varies considerably according to whether the line is long or short, whether the connection is local or long-distance, and whether it is carried on underground cables or overhead lines.

A general study of the problem shows that more refined methods must be employed if the same quality of transmission is to be attained with a loudspeaking telephone as with an ordinary telephone, and without undue limitation in respect to the direction of speech and to the distance between loudspeaker and microphone. With an ordinary low-speaking telephone these requirements are strictly defined and do not permit the subscriber any great freedom of movement.

The primary requirements are:

1. Satisfactory sending level
2. High amplification of incoming speech
3. No singing despite 1 and 2
4. Frequency response curves satisfying modern telephone transmission requirements
5. Low non-linear distortion
6. Normal instrument impedance
7. Virtual independence of temperature
8. Convenience in handling
9. Attractive appearance

Fig. 2 a is reproduced as a block diagram in fig. 2 b.

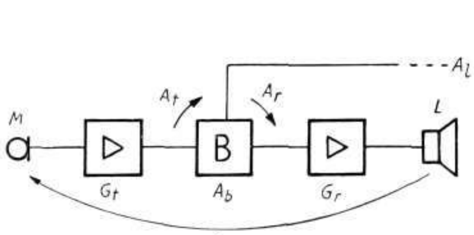


Fig. 2b X 2442

Block schematic of conventional loudspeaking telephone circuit

A_a = acoustic attenuation
A_t = composite sending attenuation
A_r = composite receiving attenuation
A_l = attenuation of connected line
A_b = composite sidetone attenuation
G_t = sending gain
G_r = receiving gain
L = loudspeaker
M = microphone

The notations for attenuation and gain are set out in the legend. Either an ordinary telephone or a second loudspeaking telephone may be connected to the line.

To calculate the stability, use is made of Nyquist's criterion for the two acoustic loops, namely, the short loop within the local loudspeaking station and the long loop out to the other loudspeaking station and back.

In the most unfavourable case the short loop at phase angle 0° is

$$G_t + G_r < A_a + A_b$$

After dividing by 2 the long loop gives

$$G_t + G_r < A_a + A_l + A_t + A_r$$

On closer consideration of the condition for the short loop, it is found that A_b is small during dialling on an open circuit or when conversing over very short lines. This means that the limits for sending and receiving gain are entirely determined by the acoustic attenuation (A_a) between the loudspeaker and microphone. Accordingly it was the distance and the angle between microphone and loudspeaker, and the room acoustics, which limited the use of the previous loudspeaking telephone. Since A_b is normally fairly high during conversation, it is possible under steady state conditions to increase, for example, G_r in order to obtain better volume. In practice this can be conveniently done by pressing a button, which should provide a gain of 8–10 db.

Analysis of the criterion for the long loop shows that the relationship is independent of A_b. For short lines A_l is small and will therefore be disregarded in the following account. It thus constitutes an additional safety factor. $A_t + A_r$ is at least 6 db. On long lines, on which A_l amounts to more than a few db, these 6 db together with A_l permit an increase of G_r by 8–10 db by the use of a long-line button. In this case, too, it is found that the limit for sending and receiving gain is set by A_a. In both cases, therefore, the location of the microphone relative to the loudspeaker, and the room acoustics, are the determining factors in the performance of the loudspeaking telephone. As regards the distance between microphone and loudspeaker, it should be noticed that an increase of more than about 90 cm is of no account. For greater distances the result is affected purely by the acoustic properties of the room. Even with the most favourable location of loudspeaker and microphone, A_a will be so low as to preclude satisfactory transmission with the conventional anti-sidetone coupling.

L M Ericsson's loudspeaking telephone, the Ericovox, is voice-operated, that is, the direction of speech is determined by the respective speakers. Under idle conditions the gain is low, and the attenuation is about 20 db below the working level, for both amplifiers. Thus a total of 40 db is added to A_a. When one amplifier comes up to the working level, the other is further suppressed, which means that the added attenuation, both during operation and at rest, is constant and not less than 40 db.

This is achieved by the introduction of two pads as shown in fig. 3.

A_1 and A_2 are pads with attenuation A_1 and A_2. Other notations as in fig. 2 b. Assume for the sake of simplicity that

$$A_1 = A_2 = A$$

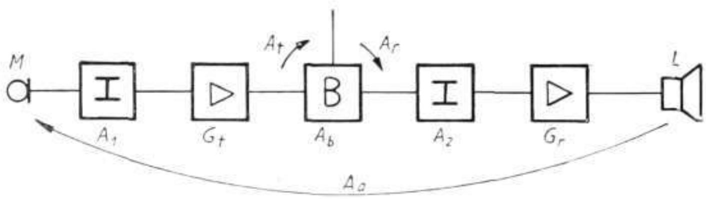


Fig. 3

X 8156

Block schematic of connection with two equal pads

X 8157
X 9147

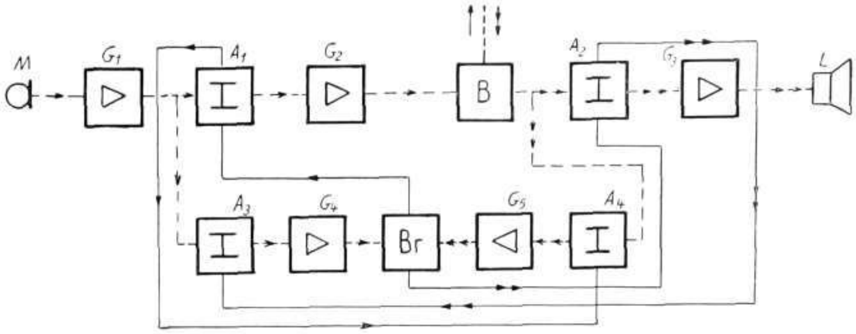


Fig. 4

Block schematic of the new loudspeaking telephone

--→-- Path of signal when sending

--→→-- » » » » receiving

——→—— Path of control current when sending

——→→—— » » » » » receiving

For stability we require

$$G_t + G_r < A_a + A_b + 2A$$

or for two loudspeaking telephones in conversation

$$G_t + G_r < A_a + A_l + A_t + A_r + 2A$$

We here made use of A_b or $A_l + A_t + A_r$ as safety margin and based the design on the following relationship:

$$G_t + G_r = A_a + 2A$$

A_1 and A_2 work on the following principle.

The sender consists of microphone M, amplifier G_1, pad A_1 and amplifier G_2. The receiver consists of pad A_2, amplifier G_3 and loudspeaker L. These units are connected to the line via the anti-sidetone coupling B. The voice-operated amplifier G_4 of the sender is connected to the output of the microphone amplifier G_1 via pad A_3. The voice-operated amplifier G_5 of the receiver is connected to B via pad A_4. The amplifiers G_4 and G_5 are connected to the voice-control bridge Br, which supplies the direct currents to control the pads.

The pads are d.c. connected, two by two in series, to the voice-control bridge (A_1/A_4 and A_2/A_3). Under idle conditions two small and equal currents pass through the pads.

Pads A_1 and A_2 are identical and cause *diminishing* attenuation with increasing current. Pads A_3 and A_4 are also identical and cause *increasing* attenuation with increasing current.

With speech into M, i.e. sending, an amplified alternating voltage is delivered by G_1 to A_1, which has high attenuation, and to A_3, which has low attenuation. The signal is further amplified in G_4, which acts upon Br in such a way that a direct current is sent through A_1 and A_4. This eliminates the attenuation of A_1 and, via amplifier G_2 and B, a signal is received on the line. Pad A_4 is at the same time made highly attenuating for signals from the line. This also means that the part of the signal from G_2 which reaches A_4 after attenuation by A_b is so highly attenuated that it cannot actuate Br even with the help of G_5. In addition, the bias current between Br and A_2 has at the same time been heavily reduced. This means that the attenuation in A_2 increases still further and prevents singing by compensating the loss of attenuation in A_1.

The same applies to receiving. A signal from the line passes B and is fed to A_2 and A_4. As opposed to A_2, A_4 has small attenuation and the signal passes on through the amplifier G_5 and voice-control bridge Br, which then delivers a direct current to A_2 and A_3. The attenuation in A_2 disappears and the received signal is amplified in G_3 and converted into sound waves by the loudspeaker L. At the same time pad A_3 becomes highly attenuating and prevents the received signal, which has been picked up by M and amplified by G_1,

Fig. 5 X 8163

The Ericovox, L M Ericsson's Hands-Free Telephone

from opening the sender circuit and causing singing. The bias current through A_1 is at the same time reduced, which increases the attenuation in A_1 to the same extent as that in A_2 diminishes. The received signal from L via M and G_1 is therefore effectively attenuated both at A_1 and A_2.

The very high attenuations offered by the solution described has made possible a unique location of microphone and loudspeaker, namely within the same housing. In view of the extremely small size of the transistors, it has also been possible to place the entire amplifier unit within the housing. Accordingly the complete loudspeaking telephone consists of a single unit (fig. 5).

The electromagnetic microphone is placed below the slots behind the buttons. The microphone is directed upwards, which means that its sensitivity is equal in all directions in the horizontal plane. Through the slots around the base of the instrument the sound of the loudspeaker is equally distributed in all directions. This makes the Ericovox the ideal conference telephone with equally good facilities for all persons in the room to join in a conversa-

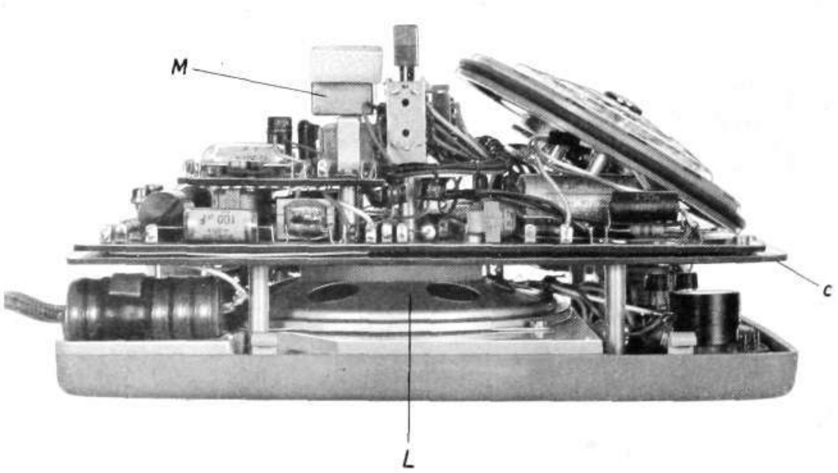


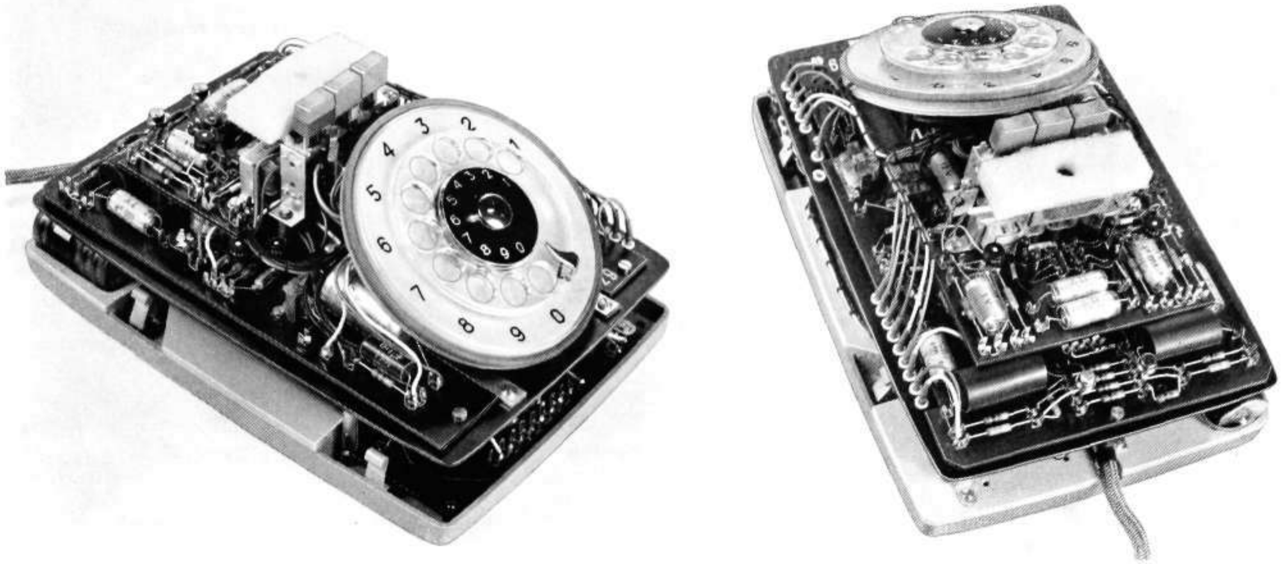
Fig. 6 X 8160

The loudspeaking telephone, side view

L loudspeaker

M microphone

c sound-insulating plate between loudspeaker and microphone



X 8162
Fig. 7 X 8161

The Ericovox viewed from different angles

The photographs show the compact structure and the location of the components

tion. Its omnidirectional character has been made possible by the unusual location of the loudspeaker. Fig. 6 shows a side view of the instrument with the plastic cover removed.

As seen from the figure, the loudspeaker (*L*) is directed downwards. This unusual location of the loudspeaker has several advantages. By making use of the sound which radiates out from the rear of the cone, the sound field from the instrument is symmetrical in all directions in the horizontal plane. In front of the cone is an acoustic load which defines the radiated power of the loudspeaker at low frequencies and determines the bass cut. This ensures that the received signal is comparatively free from low frequency disturbances, e.g. from the electric power supply. The shape of the response curve in the treble region is also determined by the location of the loudspeaker. At higher frequencies the width of the beam becomes smaller and smaller, so that, as the frequency rises, a decreasing part of the beam will pass out through the slots in the casing. With this position of the loudspeaker, moreover, it has been possible to use a large loudspeaker of good quality within a telephone of neat proportions. In fact, it is on the placing of the loudspeaker that the appearance and proportions of the Ericovox have been based. An acoustically insulating plate (*c*) has been placed between the microphone (*M*) and loudspeaker (*L*), as shown in fig. 6. The majority of the components are mounted on this plate. Moreover, since the main axes of the microphone and loudspeaker are in opposite directions (180°), A_a is the most favourable possible.

Fig. 7 shows the compact structure of the instrument and the placing of the components. The Ericovox is entirely transistorized, so that there is no risk of its becoming overheated. Moreover, the circuit is temperature-stabilized for the range 0° C to + 50° C (+ 32° F to + 122° F). This means that the Ericovox can be used in practically any climate provided, of course, that it is not placed in the direct rays of the sun.

The current supply comes from the telephone line, so that no separate power unit or power mains are required. The reason for this is that the transistors consume extremely little power and work at a low voltage. The maximum length of line to which the Ericovox can be connected, counted in ohms, is shown in table 1, which is based on the d.c. supply. As regards the transmission of speech and dial impulses, the usual local regulations governing high efficiency telephone instruments naturally apply also to the Ericovox.

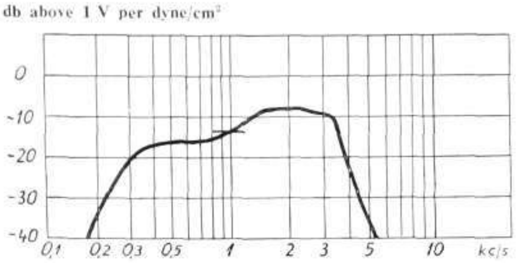


Fig. 8 X 2443

Sending frequency response curve

Sound pressure at point of measurement 2 dynes/cm². 600-ohm termination

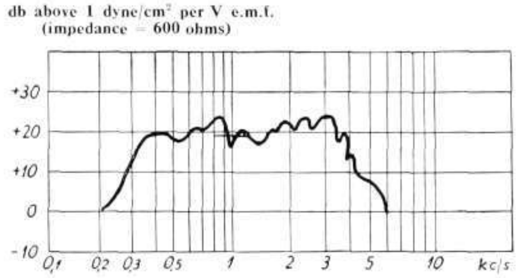


Fig. 9 X 2444

Receiving frequency response curve

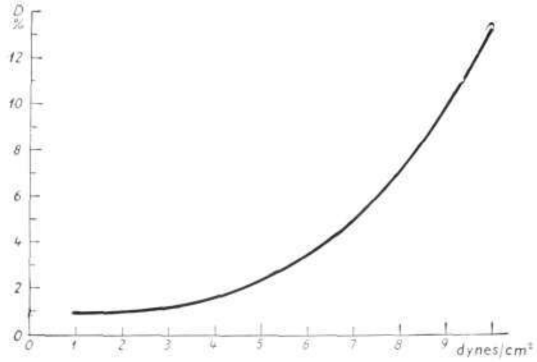


Fig. 10 X 2445

Distortion during sending as function of sound pressure at microphone

Table I

Supply system			*Maximum line resistance*	
60 V	2 × 500 ohms		above 2000 ohms	
50 V	2 × 200	»	» 2000	»
48 V	2 × 200	»	» 2000	»
48 V	2 × 250	»	» 2000	»
48 V	2 × 400	»	» 2000	»
48 V	2 × 600	»	1700	»
48 V	2 × 800	»	1300	»
36 V	2 × 600	»	800	»
36 V	2 × 500	»	1000	»
24 V	2 × 400	»	300	»
24 V	2 × 300	»	500	»
24 V	2 × 250	»	600	»
24 V	2 × 150	»	800	»

In the few instances in which the maximum permissible length of line must be exceeded, the telephone can be connected to mains by means of a suitable bell transformer. The transformer should deliver 11–50 V, including variations in the primary voltage. As a practical means of checking whether the current supply is adequate, the line current can be measured with the loudspeaking telephone connected. If the current exceeds 13 mA, no mains connection is required. A lower current may occur in systems with feed voltage below 48 V. The current supply may be too low also on very long lines in a high voltage system and on certain PAX's and PABX's. In order to cover all applications with a single type of telephone, the present model has been supplied with a switch underneath the instrument, having four positions, namely:

1. Delivery position
   The switch is in this position on delivery
2. Position for line currents above 25 mA
3. Position for line currents between 13 and 25 mA
4. Mains connection position.

During receiving the instrument may temporarily consume up to 50 mA and must therefore be supplied with a device to maintain the working voltage constant. This consists of a nickel-cadmium accumulator which, during conversation, is charged from the line during idle periods and during sending, but supplies sufficient additional energy during the current peaks in the receiving periods. This built-in accumulator makes it possible to use the telephone on longer lines and with lower distortion than would be possible with any other kind of voltage stabilizer. The working characteristics of the accumulator have been found excellent. Even after total discharge, it quickly becomes recharged during conversation to a voltage adequate for use of the telephone. The subscriber is therefore never let down by an occurrence of this kind.

The principles and solutions employed in the design of the Ericovox have meant that its transmission characteristics fulfil extremely high demands. Its performance will be seen from fig. 8–12.

Fig. 8 shows the frequency response curve during sending. As is seen, the curve has the ideal shape required to compensate the higher line attenuation at high frequencies on long lines. The sending gain has been made about 20 db higher than for an ordinary modern type of telephone, in order to compensate for the usually about 10 times greater distance between the microphone and the speaker's mouth. In subjective volume tests the efficiency when speaking at 50 cm from the instrument has been found to be + 10 db relative to ARAEN.* This value may be said to correspond to a sending reference

* 1. CCITT Livre Vert, Tome IV.
2. Ericsson Technics No. 1, 1953; F Markman: Assessment of Transmission Properties of Telephone Instruments Based on Articulation Tests.

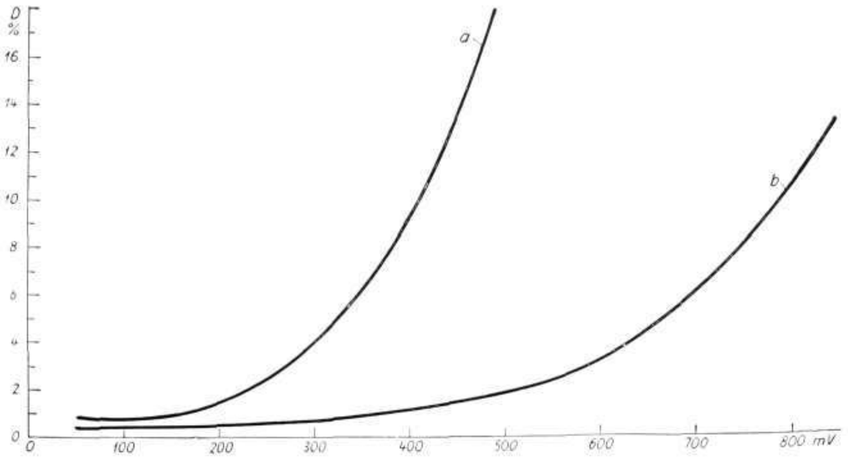


Fig. 11 X 8158

Distortion during receiving as function of line e.m.f. (impedance 600 Ω)

a with extra amplification, i.e. with long-line button depressed
b with normal amplification

equivalent relative to SFERT of + 7 db. Studies of the speech volume measured across the line terminals have shown that a loudspeaking telephone with this sending efficiency delivers virtually the same speech voltages to the line as those obtained from a modern telephone with corresponding line attenuations. This implies that sending will always be satisfactory under the conditions given in table 1. If the transmission performance for a certain connexion is poor, it will be noticed first by the user of the loudspeaking telephone. He notices it in his own reception and can take the necessary action. From the transmission point of view, therefore, a subscriber conversing with an Ericovox user is directly benefited by the loud speaking facility.

The response curve during receiving is shown in fig. 9. This curve holds good from the horizontal plane up to an angle of 45°. It is essentially flat.

The receiving efficiency can be regulated to an agreeable level by the subscriber within wide limits by means of the long-line button and the volume control.

Fig. 10 shows the distortion during sending as function of sound pressure. It should be noticed that the sound pressure at the microphone will in normal cases not exceed 1–2 dynes/cm² compared with 5–10 dynes/cm² for normal handsets. The speaking distance with loudspeaking telephones is normally not less than 40–50 cm.

Fig. 11 shows the distortion during reception as function of line e.m.f.

The instrument impedance *(Z)* is shown within the 300–3400 c/s band in fig. 12. The impedance has been set to 600 ohms (± 10 %) and phase angle 0° (± 15°). This impedance can be easily changed if necessitated by future requirements.

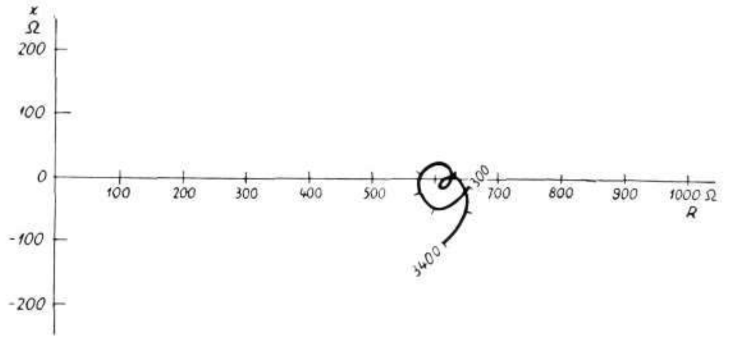


Fig. 12 X 8166

Instrument impedance (Z) within 300—3400 cycle band

Instrument impedance Z = R + jX

The Ericovox meets the requirements of the Swedish Board of Telecommunications as set forth in Document 40, CCITT's Study Group 12, 1957/1960.

In addition to fulfilling the nine primary criteria listed on page 101, the Ericovox possesses the following valuable features:

10. The microphone is equally sensitive in all directions in the horizontal plane.
11. The loudspeaker is omnidirectional.
12. The instrument receives its power from the telephone line.
13. Microphone and loudspeaker are housed in one unit. The user need not trouble to think of their relative positions.
14. The voice operation does away with the unpleasant echo effect in loudspeaking conversations.
15. The secrecy button gives a greater sense of freedom in use of the telephone.
16. The extra amplification button quickly steps up the volume to a much higher level (increase of 9 db). This button can be simply restored during conversation by pressing the right-hand button, and is automatically restored on completion of the call. Accordingly, every conversation starts at the same receiving level. The continuous volume control also permits attenuation of an unnecessarily high receiving level, especially on short lines.
17. The Ericovox is a complete unit and can be used separately or in conjunction with any low-speaking telephone. The Ericofon, owing to its appearance and method of use, is extremely well suited for this purpose.

The Ericovox has been approved by the Swedish Board of Telecommunications for connection to the national network.

An Idea Takes Shape

How L M Ericsson's new loudspeaking telephone came to birth

TORBJÖRN OLSSON, MEMBER OF THE NATIONAL ASSOCIATION OF SWEDISH ARCHITECTS, STOCKHOLM

UDC 745/749:621.395.623.7

The following pages contain an account of some of the principal steps in the work of designing and giving shape to L M Ericsson's new loudspeaking telephone. The account has inevitably had to be abridged and the chronological sequence to some extent rearranged. In actual fact the designers were so pressed for time that on several occasions they had to work on different lines of development simultaneously.

The work described in this article was done by Magnus Ahlgren, Torbjörn Olsson, Sven Silow, Members of The National Association of Swedish Architects, with the assistance of Mr. Dean L. Smith.

Fig. 1 X 2398

Work on the development of L M Ericsson's new loudspeaking telephone

L M Ericsson's earlier loudspeaking telephone was made up of separate parts, a telephone instrument with handset, a loudspeaker and an amplifier (fig. 2). Developments especially within the field of transistors have opened the way for a considerable reduction in the volume of components and in the number of units required. In the new instrument it was desired that the handset should not be tied to the telephone as in conventional types. The handset was to consist of an Ericofon. The new instrument would therefore accommodate a loudspeaker, microphone, amplifier, dial and control buttons.

Grouping of the Components

The first step was to make a preliminary study of a few conceivable groupings for the main components. To start with, the problem was viewed literally from the outside. We asked ourselves what the main shape of the instrument should be, as it appears to the subscriber.

Fig. 2 X 2400 X 2401 X 2402

The apparatus employed in L M Ericsson's earlier loudspeaking telephone

(From left) loudspeaker, telephone, amplifier

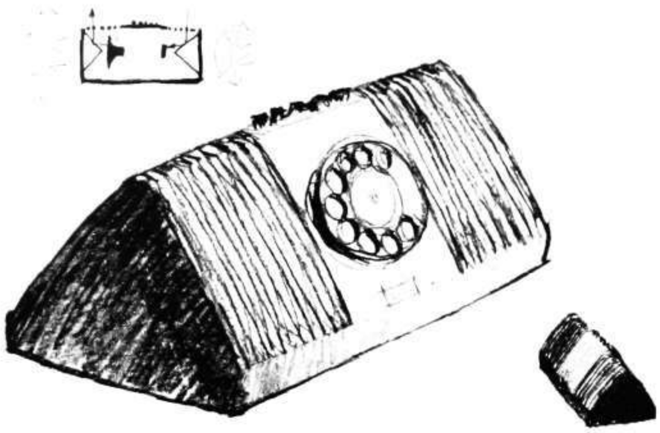


Fig. 3 X 7748

Grouping of components in width

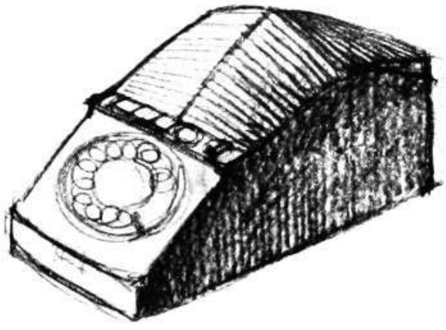


Fig. 4 X 7749

Grouping of components in depth

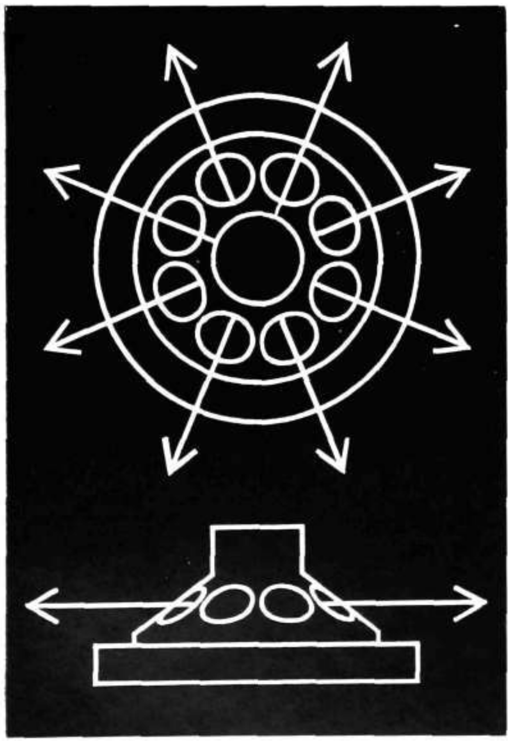


Fig. 5 X 2397

Omnidirectional principle — a step towards the final solution

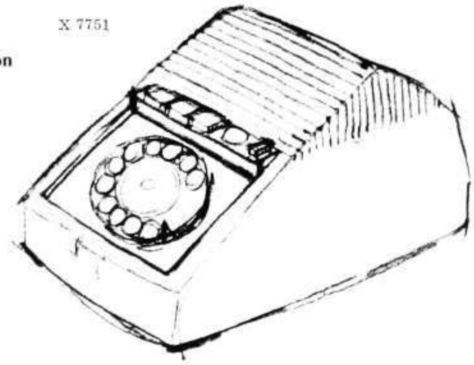
A broad grouping of the components is shown in fig. 3. This design is very similar to the previous loudspeaking telephone, but was considered unsuitable since its breadth would block an unnecessarily large part of the desk area behind it. An attempt at grouping of the components in depth is shown in fig. 4. This was no more satisfactory, however, owing to the exaggeration of a single dimension.

A vertical grouping of the components (fig. 7) brought out the essential character of a loudspeaking telephone compared with an ordinary telephone, namely, that it should be heard in all directions. Previous types of loudspeaking telephone have not been true to character in this respect, but transmit and receive sound principally in one direction. This is also revealed by the methods of loudspeaking telephone measurement employed hitherto. At this stage of the work it was decided that the loudspeaker and microphone should be so placed that the sound would be reproduced as equally as possible in all directions. This omnidirectional function should be emphasized, furthermore, in the very design of the case. A vertical grouping was open to the same criticism as the other two concepts, that an exaggeration of one dimension makes the instrument unduly voluminous.

Finally, a more concentrated, cubiform shape was tried out, in which no dimension unduly overshadowed the others (fig. 6). In the sketch stage the type emerged as a development of the vertical grouping idea. It was considered that the final solution should be along these lines.

Fig. 6 X 7751

An approach to the final solution



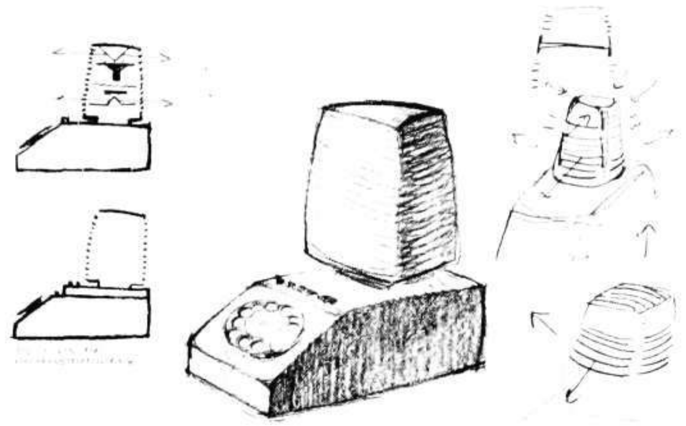


Fig. 7 X 7750

Vertical grouping of components

The following points had now become clear: the new instrument should be omnidirectional and of concentrated shape. The technical method of providing the omnidirectional property still remained an unsolved problem. For a time the development work was diverted into unprofitable channels.

A shallow circular form of loudspeaker proved to offer an apt solution to the omnidirectional problem. Placed in the base of the instrument and with a resonance box about 15 mm high, it was made to transmit backwards (fig. 5). This was an important step towards the final solution.

The Case

Studies of the most suitable form for the case were for a time concentrated to circular shapes (fig. 8). In the illustration the microphone is placed centrally in the top of the instrument and the loudspeaker in the base with the slots arranged round the low, circular envelope. This theoretically ideal form

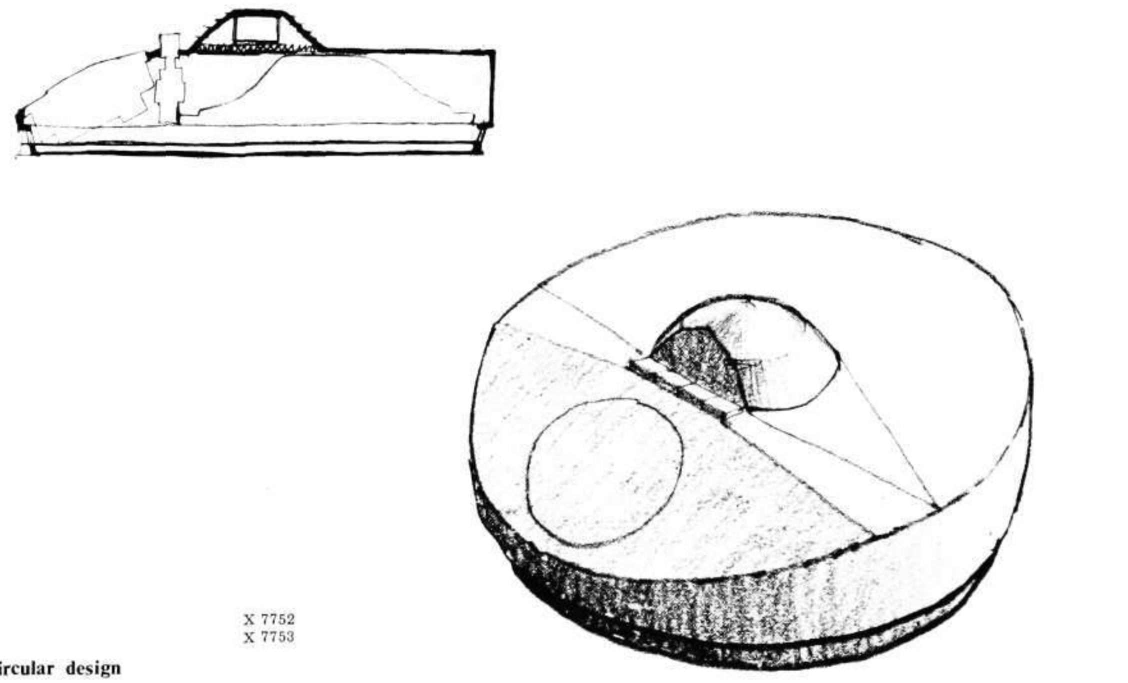


Fig. 8 X 7752 X 7753

Studies in circular design

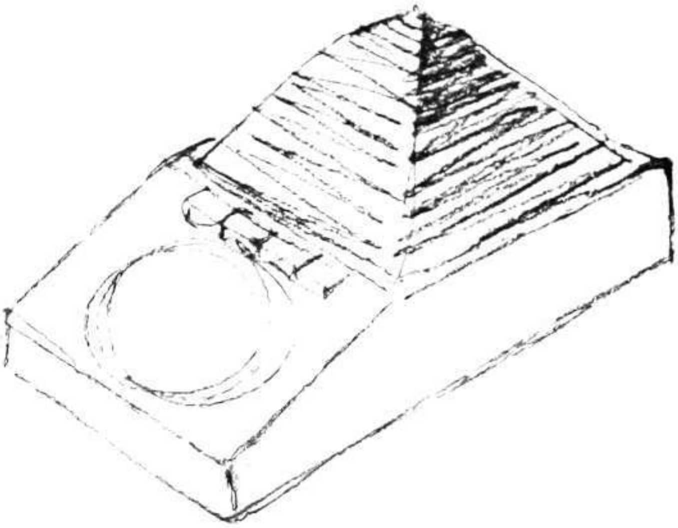


Fig. 9 X 8132

Case with pyramid-shaped top accommodating microphone and loudspeaker

proved unsuitable from the point of view of component location. The assembly area assumed undue proportions and would have made the instrument too large. This line of development was abandoned and the work thereafter directed wholly to case designs with rectangular base, a solution which is better fitted for space-saving assembly.

One of the case designs considered was that in fig. 9. The microphone and loudspeaker were enclosed in a four-sided pyramid on a rectangular base. The sides of the pyramid are shaped to form sound apertures. Yet this variant, like the circular design, proved to be over-spacious and was therefore abandoned despite the form possibilities which it undoubtedly offered.

Fig. 10 shows another pyramidal form which eventually led to the final solution. In this sketch the microphone has now attained its definitive and ideal position in the top of the pyramid, and at the greatest possible distance

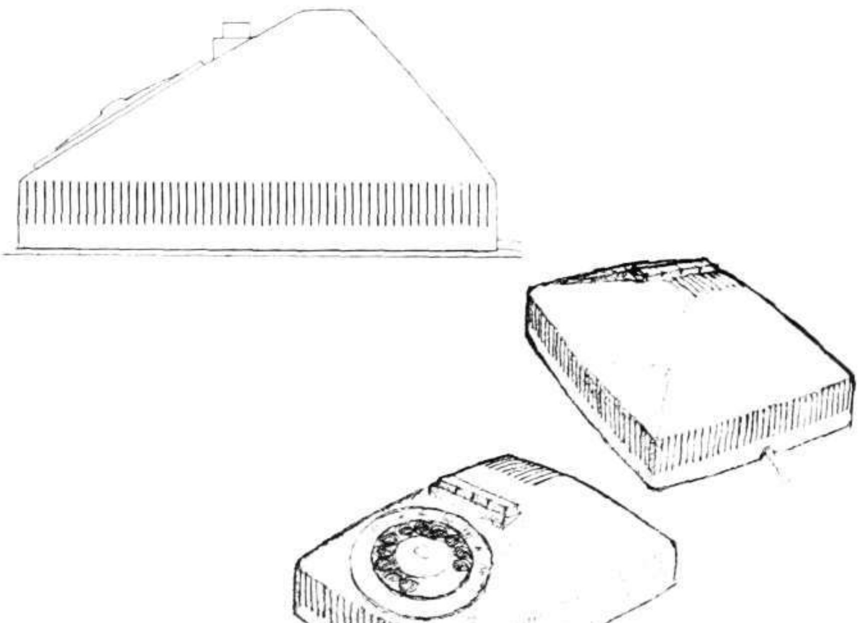


Fig. 10 X 8133

The sketch which led to the final solution

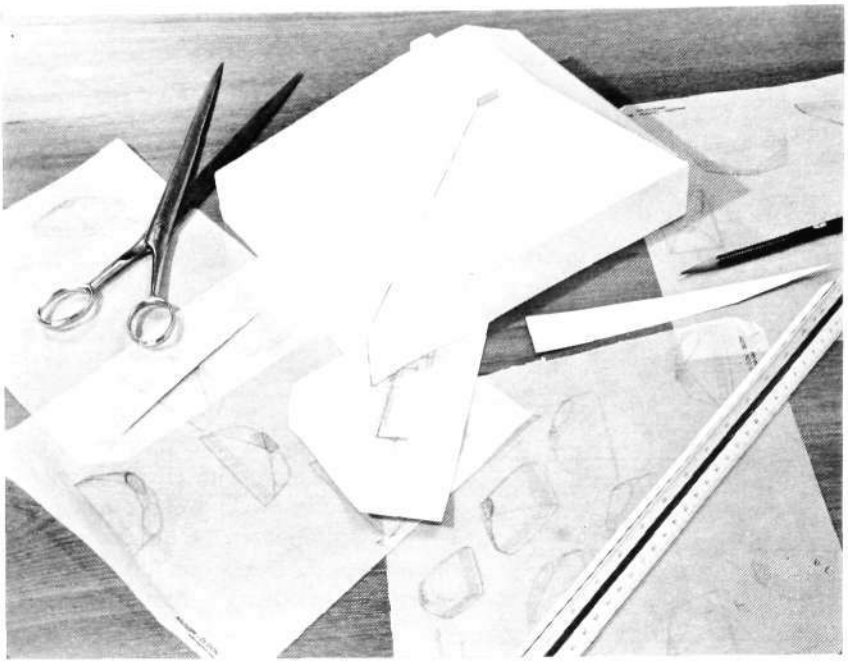


Fig. 11 X 8168

For the space and form studies use was made of cardboard models, perspective sketches, plan and sectional drawings

from the loudspeaker which is placed in the base. The sound inlet for the microphone and the sound outlets for the loudspeaker lie on planes at right angles to one another – the optimal angle under the given assumptions. The control buttons are at the top, immediately behind the dial. This shape of instrument presents the impression of an all-sidedness, an isotropy in sending and receiving. Thereafter the exterior design work was concentrated to certain principal features, laying special stress on the all-sided factor. The attempt was made to keep the four sides of the pyramid as equivalent as possible. A back such as that of an ordinary telephone instrument, for example, was avoided. Another desideratum was that the general appearance should be as simple and clean-lined as possible, with the outside parts of the instrument reduced to a minimum and the case formed from a single moulding with all sound slots integrated in it.

The inner mechanism should be built up on the base in such manner that the case could be lifted off by a simple manipulation. Initially it was calculated that the components could be assembled in two storeys with the "floor" of the upper storey forming a baffle between the loudspeaker and microphone.

The controls should as far as possible consist of standard components.

The cardboard models used in the space and form studies were now supplemented by perspective sketches, plan drawings and, in particular, sectional drawings (fig. 11). The subsequent work was directed essentially to diminishing all dimensions of the instrument and to a detailed study of the form, size and relative placing of the components.

Since no further reduction in the real height of the base was feasible, the base plate was made in the form of a tray (fig. 12) which gave the instrument a more squat appearance. In this connection the push-button set was transferred

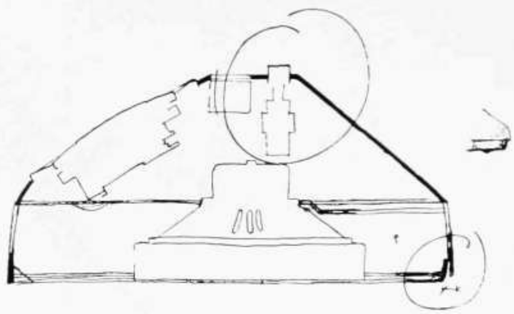


Fig. 12 X 8134

Instrument with base plate in form of a tray

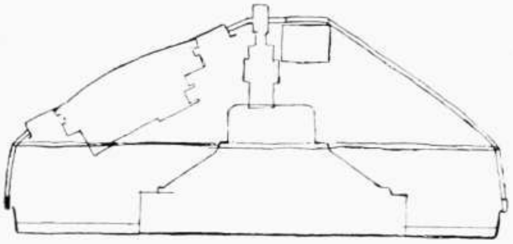


Fig. 13 X 2404

Later development of sketch in fig. 12

to the flat top of the pyramid. This gave the push-button set a more stable position in the general structure and allowed the instrument to be manipulated from all sides with greater ease. At a later stage (fig. 13) the positions of the microphone sound outlet and push-button set were interchanged. The usual manipulation of the buttons would, of course, be from the front. In the final design the line button (the left-hand button) is differently marked from the two other buttons. The centre button regulates the volume. The right-hand button is a secrecy button.

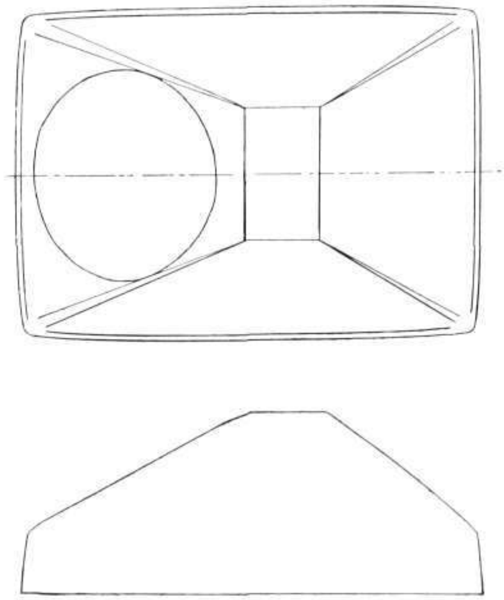
Fig. 14 X 7747

Last in the series came more concrete forms of cardboard or plasticine models

The more concrete shapes of cardboard model were superseded by a plasticine model (fig. 14). The latter was used as the basis for drawings of a wooden pattern which was made by hand (fig. 16). A heated thermoplastic sheet was then pressed over the pattern, using a vacuum-forming process known as draping (fig. 17). The resulting case was dressed off, and slots for

Fig. 15 X 2405

Sketch of the wooden pattern



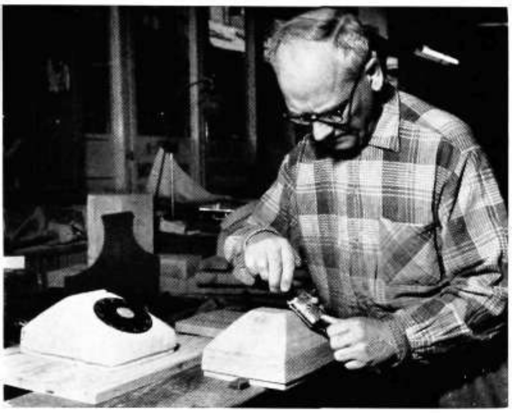


Fig. 16 X 2403

Preparation of the wooden pattern over which the thermoplastic case is pressed

the microphone and loudspeaker were cut out (fig. 18). The tray-shaped base was made of a thermoplastic material by the same method. The dial and other external parts were selected from the standard colour range to match the desired light grey case. The standard push-buttons could be used unmodified. The drawing of the final prototype for industrial production is shown in fig. 19 and the finished Ericovox with Ericofon in fig. 20.

Fig. 17 X 8137

Wooden pattern and thermoplastic case pressed from it

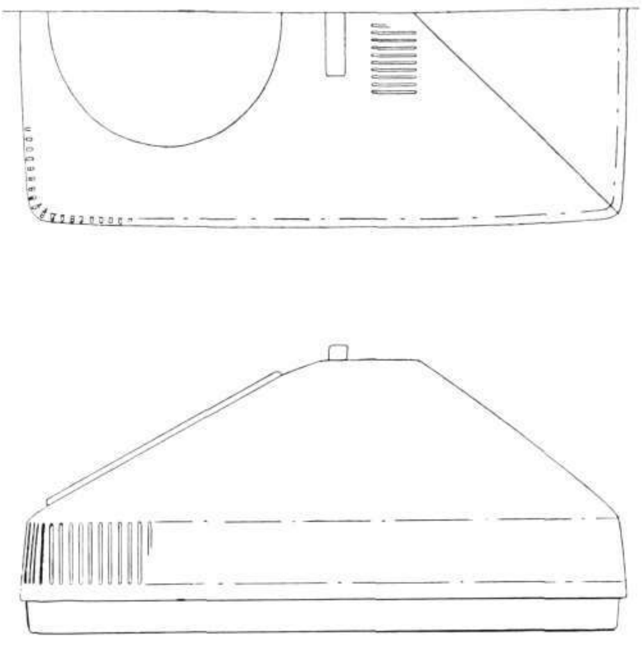


Fig. 18 X 8135

The locations of the milled slots for microphone and loudspeaker

In actual production the vacuum-forming method and milling of slots will be replaced by compression moulding.

Finally, a few words about a designer's working methods in their application to telephony. At least as regards casings and similar types of design, his methods may be fairly similar to those of an architect when planning an industrial installation. If we consider a chemical plant, for example, the architect has to organize the supply systems and other apparatus in consultation with specialists on such problems, and to coordinate the whole within a casing of sound design. This casing is nothing else than the factory building itself. In the planning of telephone equipment, as of industrial buildings, the work should start with a study of component assembly diagrams, followed by the preparation of wiring diagrams and plan drawings, and the compilation of the necessary technical data. The importance of a penetrating study of the programme also within teletechnical design cannot be sufficiently emphasized.

On the groundwork of comprehensive planning work one can proceed to preliminary sketches, consisting of perspective sketches supplemented by plan

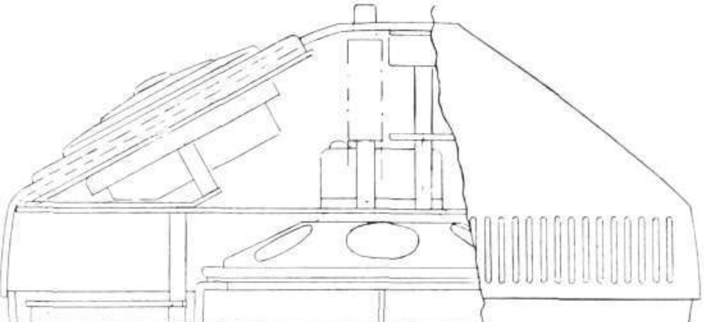


Fig. 19 X 8136

General appearance of the final prototype

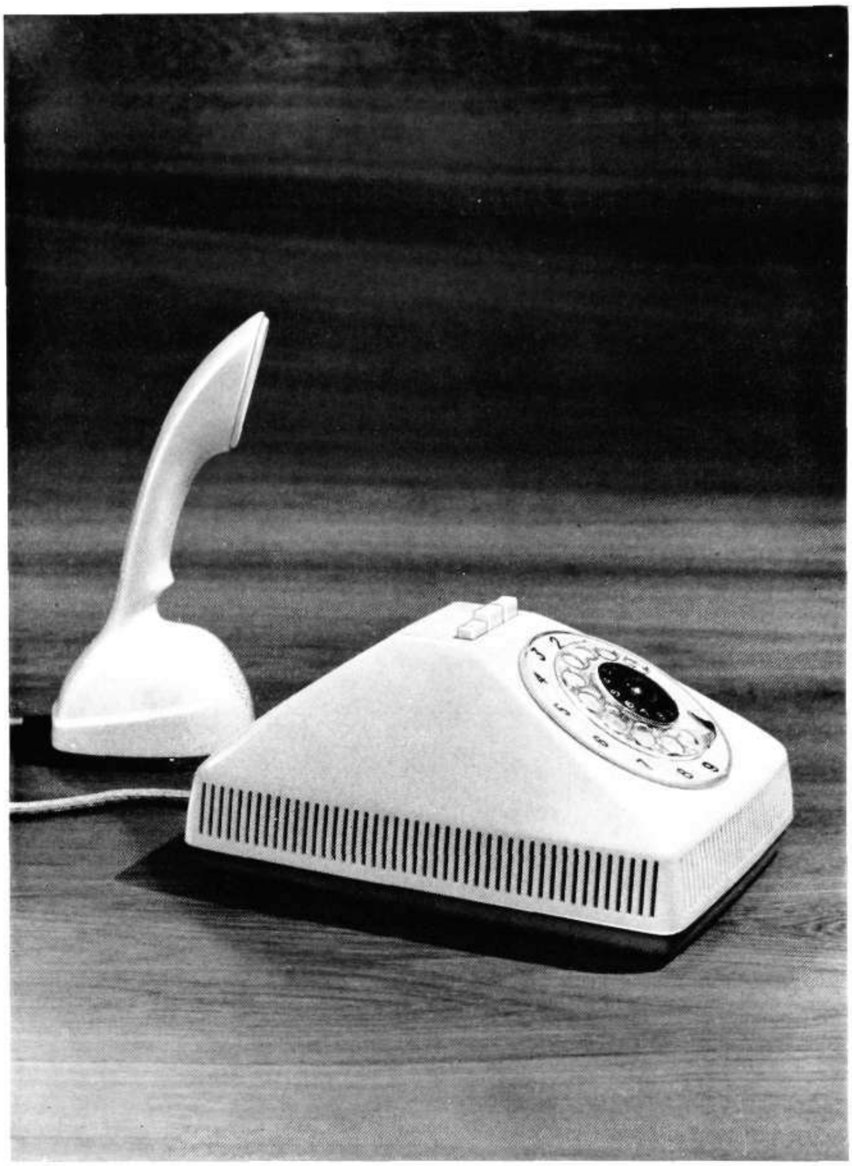


Fig. 20 X 8139

The Ericovox loudspeaking telephone with the Ericofon

and sectional drawings. The sketch proposals are then discussed with specialists from the planning office, and also from the workshop and sales departments.

He then modifies his proposals to take account of the criticism offered and proceeds thereafter to an increasingly penetrating study of different aspects of the product. Detailed and main drawings and clay mock-up models are finally followed by operating models.

Gothenburg Automatic Transit Exchange ART 205

E REHNBERG, ROYAL BOARD OF TELECOMMUNICATIONS, STOCKHOLM

UDC 621.395.722
621.395.34

The Gothenburg transit exchange was ordered from L M Ericsson on March 26, 1956, for cut-over on April 1, 1959. The exchange was designed on the Administration's crossbar system for transit exchanges A-205 (see the Swedish Board of Telecommunications Journal "Tele" No. 1, 1953, English edition). Modifications were introduced to adapt it to existing telephone exchanges in Gothenburg.

The telephone installations in Gothenburg which interwork with the transit exchange, and which place special demands on its design, are the Gothenburg automatic toll exchange, the local automatic exchanges that have been successively extended since 1928, and the Gothenburg manual trunk exchange. The adaptation of system A-205 to these installations necessitated the redesign of a large part of its equipment, i.e. of all link circuits to other existing exchanges, and of the registers and markers. L M Ericsson's designation for the Gothenburg transit exchange system is *ART 205*.

The trunking scheme is shown in fig. 1.

Capacity of the Transit Exchange

The transit exchange will initially contain the following main switching units:

20 group selector units for incoming traffic *GVI* with associated register finders *RS*. Each *GVI* has a capacity of 150 incoming lines, so that the total capacity is 3,000 incoming lines.

Fig. 1 X 8179

Trunking scheme of transit exchange ART 205 (see also figs. 8 and 9)

The heavy lines indicate four-wire routes

GAR, GUR — equipment for connecting marker M to GVI and GVU

GLR — equipment for group testing on outgoing routes

KK — M.D.F.

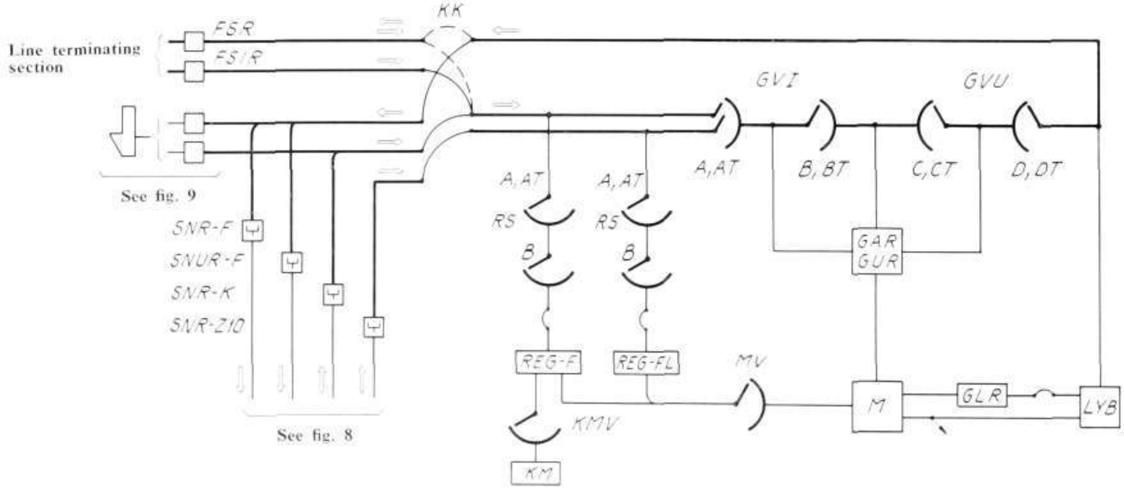


Fig. 2 X 2483

One side aisle in the large automatic switching room with, inter alia, the GV bays in the background

20 group selector units for outgoing traffic *GVU* with total capacity of 4,000 outgoing lines. It should be noted that a two-way circuit requires two multiple positions, one in *GVI* and one in *GVU*. The entire capacity of 4,000 lines will not initially be utilized, but certain levels will be reserved against future additions over and above 20 *GVI* and 20 *GVU*.

2,500 junction relay sets (exchange side) *FSR* for outgoing and two-way trunks and 1,000 junction relay sets (exchange side) *FSIR* for incoming trunks.

990 link circuits *SNR-Z10* and *SNR-K* for originated traffic from exchanges within the Gothenburg zone.

555 link circuits *SNR-F* and *SNUR-F* for terminating traffic to exchanges within the Gothenburg routing area.

410 link circuits for manual traffic.

205 registers, of which 145 *REG-F* and 60 *REG-F-L*.

25 code receivers *KM*.

10 markers *M* and test blocks *LYB* for 4,000 circuits.

3,050 junction relay sets (line side) *FLR* adapted for different signalling system (*FLR* are not shown on the trunking diagram).

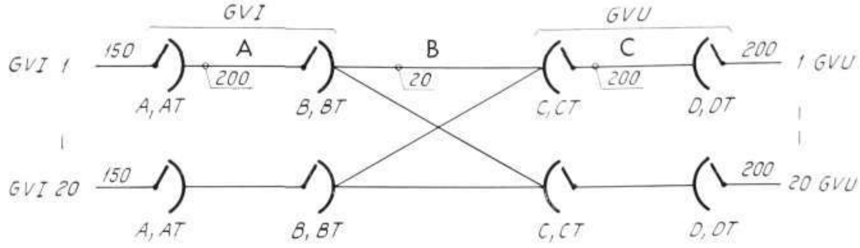


Fig. 3 X 8181

Block schematic of group selector stage

Sub-stages A, B, C and D
AT auxiliary bay in A stage

Group Selector Stage

The group selector stage is composed of crossbar switches with ten horizontal and ten vertical magnets. The crossbar switches are arranged in four sub-stages *A*, *B*, *C* and *D*. Sub-stages *A* and *B* form incoming group selector units *GVI*; *C* and *D* form outgoing units *GVU*. The layout is entirely symmetrical with the same number of links between each *GVI* and *GVU*. The group selector stage at the Gothenburg transit exchange is made up of 20 *GVI* and 20 *GVU*. All four sub-stages are used for establishing a connection. Since the units are designed for one-way traffic, two-way circuits must be introduced in one incoming and one outgoing unit. All lines are connected on a four-wire basis.

The design of the group selector stage allows for variation of the capacity on the inlet side of *GVI* and on the outlet side of *GVU* from a basic capacity of 100 numbers to 150 or 200 numbers by the addition of supplementary racks in the *A* and *D* sub-stages, known as *AT* and *DT* racks.

Fig. 4 X 2482

Outgoing group selector bay

Register Finder

The register finder *RS* is made up of crossbar switches arranged in two sub-stages *A* and *B*. The switches are similar to those in the group selector stage but have an 8-pole instead of 6-pole contact bank.

Every register finder unit is associated with an incoming group selector unit and no intermediate distribution frame is used between the register finders and the tandem stage. The number of register finder inlets can be increased by means of supplementary racks so as to equate the capacity with that of the associated group selector unit. Every register finder unit has 25 outlets, so that every incoming line has access to 25 registers. The outlets of the various register finders can be graded together. Through-connection in the register finder is on 16 wires.

As will be shown, the registers in the Gothenburg exchange must be divided into two groups. And as the register finders terminate directly on the incoming group selector units, they too must be divided into two groups as seen from the trunking scheme in fig. 1.

Register Equipment

The registers are of two types, there being 145 *REG-F*, which are similar to the registers in the A-205 transit exchanges, and 60 *REG-F-L* which are peculiar to the Gothenburg exchange.

Type *REG-F* is used for traffic from all exchanges except Gothenburg local and terminal exchanges. This type of register can receive digits in the form of dial-type pulses, instantaneous signals from keysets at the Gothenburg manual positions, and v.f. signals after translation by a code receiver. The

Fig. 5 X 8185

The crossbar racks are fitted on the back with detachable doors

register is informed, by means of indications from the incoming lines, which type of digit transmission it is to expect.

Type *REG-F-L* is used for traffic from Gothenburg local and terminal exchanges. It receives digits in the form of revertive impulses, which is the only method of transmission possible with the existing registers at these exchanges.

Both types of register at the transit exchange can transmit digits in the form of dial-type pulses or v.f. signals. *REG-F* can operate the switches in the Gothenburg local and terminal exchanges without the mediation of other registers. The latter facility is not required for *REG-F-L*. Information of the type of digit transmission or switching required is sent to the registers in the form of route indications from markers and test blocks.

Some strapping is necessary in the registers in order that they may a) decide after how many digits they shall call a marker, b) distinguish routing code digits, a necessary precaution since the routing code is not always retransmitted, c) determine the setting of switches on traffic to Gothenburg local exchanges and to terminal exchanges and group centres connected to Gothenburg toll.

The registers are mounted on single-sided racks with three registers in each rack.

Code Receivers and Code Receiver Selectors

Code receivers are required for translation of digit information in the form of v.f. signals. They are not connected direct to the registers but via a code receiver selector with ten inlets and ten gradeable outlets. Through-connection is on 8 wires. The selector is made up of crossbar switches.

V.f. signals are transmitted at five frequencies, each digit being in the form of a code consisting of two of the five frequencies. The rate of transmission is 7–8 digits per second. The possibility has been foreseen of inter-exchange transmission of other than digit information by using a sixth frequency.

Bypath Equipment

Marker selector

The registers are connected to a marker via a marker selector. Each marker selector unit has ten inlets and ten outlets. Through-connection is on 40 wires. The marker selector is made up of five normal type crossbar switches with 8-pole contact bank. The marker selector outlets need not be graded since not more than ten markers are installed in any one exchange.

Marker

Every marker consists of four main components: a receiving component which receives information from the register and from the incoming line; a traffic group component which, by group testing of the outgoing routes, is constantly informed of their free or busy condition; a link testing component which tests the *A*, *B* and *C* links; and a supervisory component which supervises the work of the marker.

With the guidance of the information received, the marker determines the fee and immediately sends a fee-determination signal to the debiting link circuit *SNR-Z10*.The mean time of marker occupation is 0.7 sec.

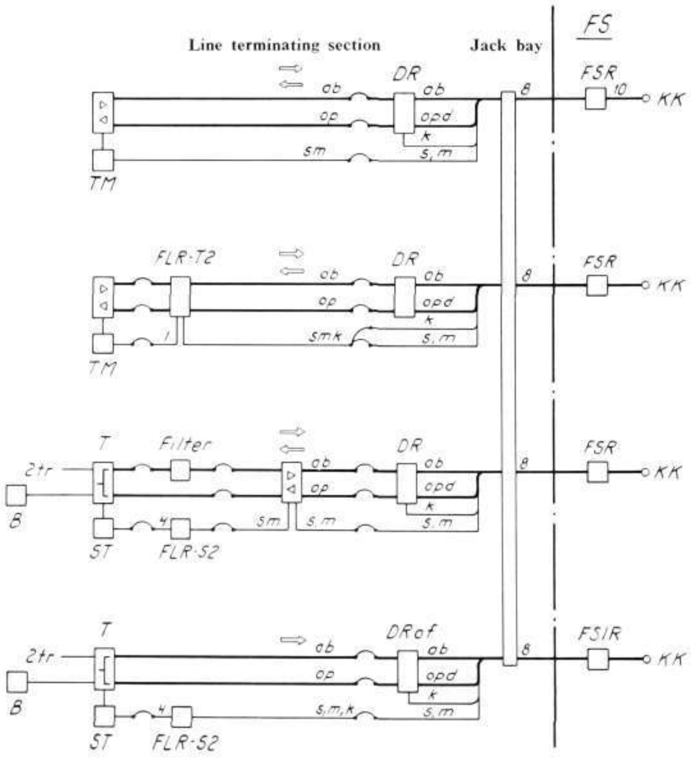


Fig. 6 X 8180

Block schematic of exchange trunk equipment

At the top is seen a circuit designed for continuous signalling

- T Combined line and hybrid transformer
- ST Signal transformer
- TM V.F. receiver
- FLR Junction relay set (line side)
- DR Pad relay set
- DRof Pad relay set for circuits without terminal amplifier. Also contains filter equipment matching the line cut-off frequency
- FSR, FSIR Junction relay set (exchange side)
- KK M.D.F.

Fig. 7

Relay room FSR

X 2484

Trunk Equipment

A block schematic of the trunk equipment is shown in fig. 6.

Every trunk circuit terminates in the transit exchange on an *FSR* which in turn is connected to either *GVI* or *GVU*, or both, according to the direction of traffic and to whether the circuit is one-way or two-way. The same type of *FSR* is used for one-way and two-way outgoing circuits. A two-way circuit requires very little more relay equipment than an outgoing, and there is therefore no reason to use separate relay sets for the two types of circuit. A simpler form of junction relay set *FSIR*, on the other hand, is used for one-way incoming circuits.

The same type of junction relay set may be used on two-wire and four-wire circuits. Matching to existing line signalling systems is effected by the use of different types of *FLR* in the repeater station. Translation of signals between the exchange and line sides of junction relay sets is standardized. Each two-wire circuit is connected to a combined line and hybrid transformer with four-wire connection to the exchange side of the junction relay set.

FSR and *FSIR* perform the functions associated with traffic direction, establishment of line connection, repeating of signals through the exchange, supervision of the circuit and automatic fault indication. They perform no function, however, associated with terminal traffic such as battery supply, signal generation or metering.

In order to ensure the proper attenuation on different types of call, the circuits are equipped with pads which are placed in the line terminating section.

Junction Equipment for Terminal Traffic

By terminal traffic is here meant trunk traffic which does not require compensation of attenuation at the transit exchange, i.e., broadly speaking, trunk traffic to and from exchanges within the Gothenburg zone.

There are four different types of link circuit for the Gothenburg toll and local exchanges (fig. 8).

1. Link circuit *SNR-Z10* is used for originated traffic from the Gothenburg local and terminal exchanges. It contains metering equipment for ten fees. The selection of fee is arranged by the markers in the transit exchange.
2. Link circuit *SNR-K* is used for outgoing traffic from the Gothenburg group centres. It can also be used for terminal traffic put through by Gothenburg operators to the trunk network. The operators may also use for this purpose the direct route from the trunk to the transit exchange, referred to under point 4 on the next page.
3. Link circuit *SNR-F* is used for incoming traffic to Gothenburg local exchanges.
4. Link circuit *SNUR-F* is used for incoming traffic to terminal exchanges and group centres within the Gothenburg zone.

All link circuits have four-wire terminations and are connected on a four-wire basis to the group selectors at the transit exchange.

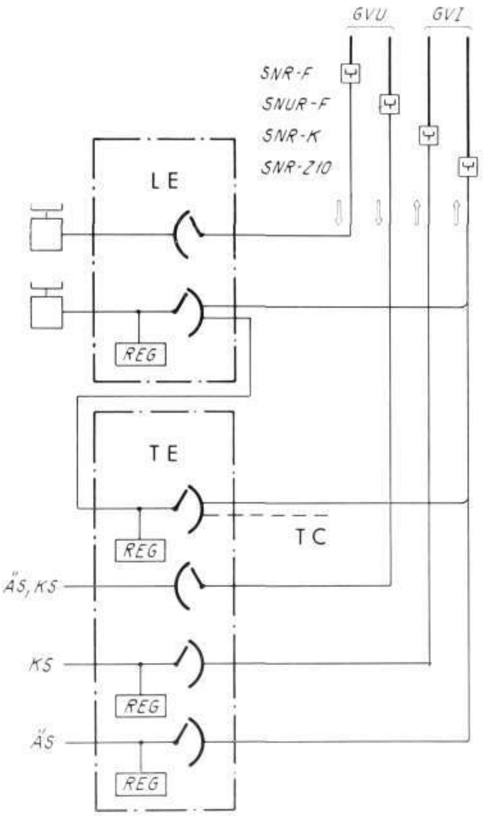


Fig. 8 X 2472

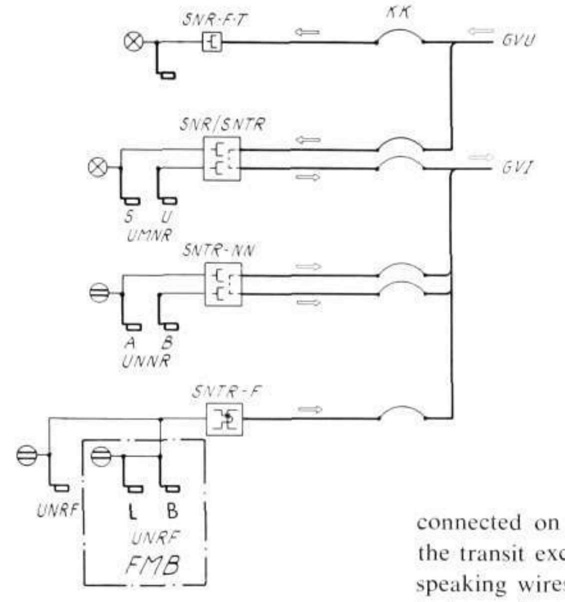
Link circuits for originated and terminating traffic within the Gothenburg zone, and example of routing through local exchanges and trunk exchange

LE local exchanges
TE toll exchange
TC trunk circuits (first choice)
KS group centres
ÄS terminal exchanges

Junction Equipment for Manual Traffic

The manual traffic in Gothenburg requires four kinds of link circuit between the operators' positions and the transit exchange (fig. 9).

1. Link circuit *SNR-F-T* is connected to the transit exchange *GVU* and to the operators' answering field *VAS* and is used for interception service, i.e. if subscribers dial vacant code numbers within the Gothenburg area. In the event of cable faults or similar emergencies, calls can be re-routed to this answering field from a traffic redirection bay. The link circuit may also be connected to an announcing machine.
2. *SNR/SNTR-F* is a double link circuit, the *SNR* part being connected to *GVU* in the transit exchange and the *SNTR-F* part to *GVI*. In the operators' positions the link circuit is connected to a pair of jacks, an answering and a multiple jack. The link circuit is required in order that operators at other exchanges may call Gothenburg operators, a special number being reserved for this purpose. It can also be used for manual trunk connections, in which case the *SNR* section is connected direct to the manual circuit instead of to the transit exchange *GVU*. Calls arriving over the *SNR* section can be forwarded direct through the transit exchange via the multiple jack of the *SNTR-F* section. The two sections are inter-



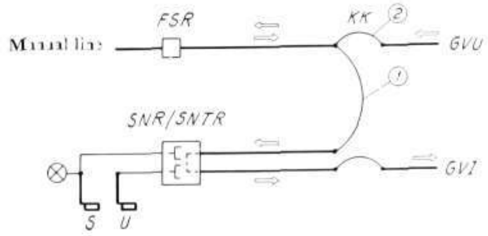


Fig. 9 X 2473

Link circuits for manual traffic

The figure shows how a manual trunk connection terminates in the transit exchange on link circuit SNR/SNTR

L Line
B Balance
① Connection for incoming line
② Connection for outgoing line
① ② Connection for two-way line
KK M. D. F.

connected on a four-wire basis, so that all subsequent switching through the transit exchange is on a four-wire basis. In the conversing position the speaking wires do not pass the switchboard cords (three-conductor cords), but are branched to the cord circuit on a two-wire basis, which is necessary for monitoring of the call.

3. *SNTR-NN* is also a double link circuit. In the transit exchange it is connected to two inlets in *GVI*, and in the switchboards to two multiple jacks *UNNR*. The link circuit is required in order that operators may interconnect two outgoing trunk circuits terminating on the transit exchange *GVU*. The interconnection is effected on a four-wire basis with a two-wire branch to the operators' positions for monitoring purposes.

4. Link circuit *SNTR-F* is connected to an inlet in *GVI* and to the multiple jack field *UNRF* in the existing manual trunk positions. It is required during a transitionary stage, so long as manual trunk circuits terminate directly on the operators' multiple field, so as to connect them to an outgoing circuit terminating on *GVU* in the transit exchange. Later, when automatic operation is introduced, the link circuit can be utilized as a direct route to the transit exchange for switching of terminal calls. For this purpose it is also connected to the multiple field *UNRF* at all trunk operator positions.

Maintenance Equipment

For exchanges of this type which control expensive trunk routes on a fully automatic basis, facilities for simplifying maintenance and fault tracing are of extreme importance. The exchange is therefore equipped with exchange tester, fault indicator, identification equipment and a traffic supervisor's desk.

The exchange tester, which consists of rack-mounted relay and selector equipment, can perform the following operations.

1. Set-up of "directed" connections. By switching manually to an outgoing or incoming repeater in the exchange, the tester can direct a connection through any desired marker, register and *GV* link. If required, it can make repeated connections via this route.

2. Testing of markers. Connection is made to any desired marker. Once the tester is started, it automatically tests the marker's translation and selection

Fig. 10 X 8182

Traffic supervisor's desk and equipment for traffic metering

circuits. On encountering a fault it stops and indicates the position of the fault on a lamp panel at the traffic supervisor's desk.

3. Testing of registers. Any register, of type *REG-F* or *REG-F-L*, can be connected to the tester. All translation circuits of the register, outgoing and incoming register signals, etc., are then tested to a given programme. The course of the test can be followed and faults read off on a lamp panel at the traffic supervisor's desk.

The fault indicator consists of rack-mounted relay equipment and an electrical typewriter. On failure of a register finder or marker to complete a connection, the fault indicator is called. It collects all data from the devices concerned and the typewriter records in code form what units were engaged, e.g. repeater, marker, register, *GV* group, and type of fault.

The fault indicator thus provides a practically complete record of the switching path used when a fault occurs. The same switching path can subsequently be re-established with the exchange tester.

The identification equipment is used for identifying the switching units employed on any established connection. For control of registers from the traffic supervisor's desk, the equipment can be used to indicate what other units were engaged on the connection, which it does by indications on the lamp panel. This greatly facilitates fault tracing. The identification equipment can also be connected to any desired switching unit, and whenever that unit is utilized for traffic the identifier shows what other units were employed on the same connection. In this way faults which re-appear in conjunction with the operation of specific units can be more easily located. The identification is effected by connecting a 2,000 c/s tone generator to the d-wire which is paralleled through all the exchange switches.

The traffic supervisor's desk otherwise contains normal equipment for register control, traffic control, etc.

Private Automatic Exchange for 15 Lines

B CLEMENTZ & C MELIN, TELEFONAKTIEBOLAGET LM ERICSSON, STOCKHOLM

UDC 621.395.24

In order to be able to offer a complete series of P.A.X. units from 10 extensions and upwards, L M Ericsson has designed a relay switchboard AMD 20101. It has a capacity of 15 lines with two link circuits and may be said to replace the popular OL 3511 1 which has now gone out of production.

The capacity of P.A.X. *AMD 20101* makes it well suited for relieving the load on private branch exchanges at business, industrial and similar organizations. The installation of a P.A.X. *AMD 20101* brings two important advantages: it increases the total traffic-handling capacity within the organization and allows the important external traffic to be handled without interference from internal communications.

AMD 20101 operates very silently and can therefore be placed in any suitable position without risk of causing disturbance.

Its numbers run from 2 to 16 for telephones with dial numbered 1 . . . 9,0.

L M Ericsson's normal telephone instruments for automatic systems are used as extensions.

Mechanical Construction

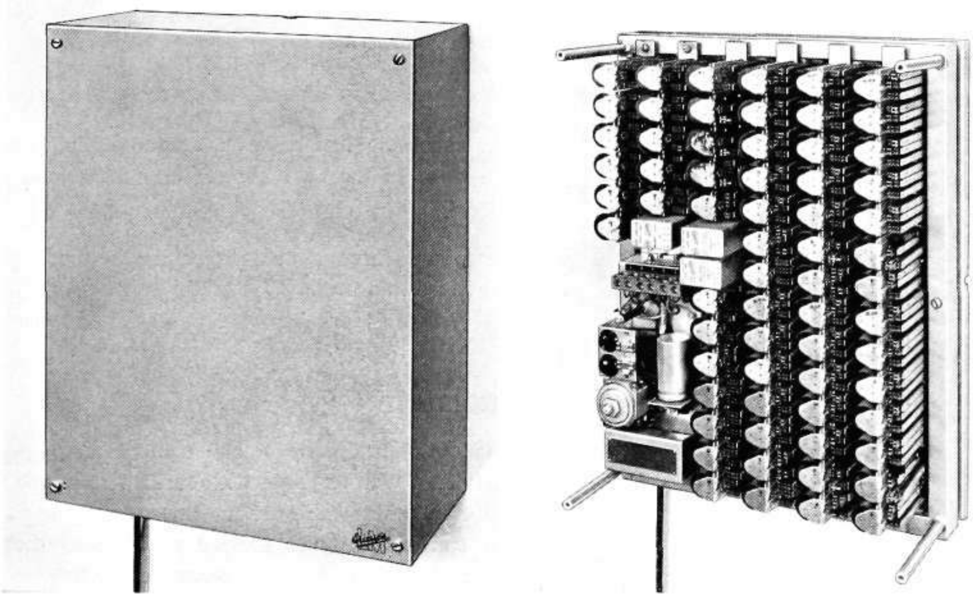
AMD 20101 (fig. 1) is designed for wall mounting.

The switching units consist of RAF relays, the springs of which have twin contacts of L M Ericsson's well proven type. The switchboard is therefore highly reliable in operation. It is supplied by a built-in power unit for 40–60 c/s with tappings for various mains voltages.

Fig. 1 X 2462 X 2463

Relay switchboard AMD 20101

(right) with cover removed
Dimensions: height 507 mm, width 401 mm, depth 197 mm. Weight 43 kg



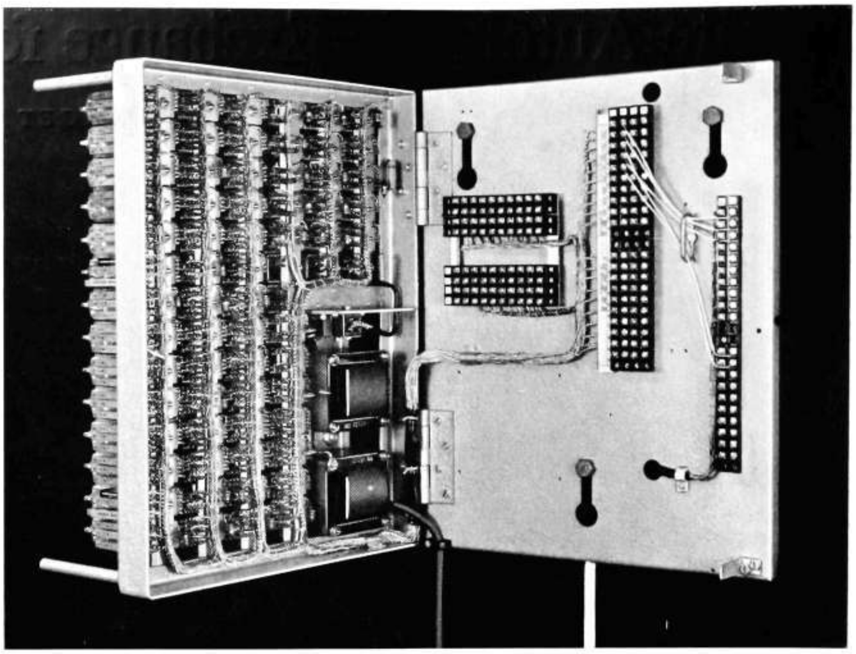


Fig. 2 X 8167

Relay switchboard AMD 20101

with relay frame swung out. On the back plate are the terminal blocks.

The switching elements, consisting of 65 relays and 3 capacitors, are mounted on six vertical bars, four of which carry 14 components each and two 6 components each (fig. 1, right). The bars are screwed to an L-shaped frame which is secured by two hinges to a steel back. The frame can thus be swung out to allow access to the relay soldering tags (fig. 2). The frame is locked to the back by means of a captive screw.

On the back plate are the terminal blocks which serve as the distribution frame. All jumper wires pass through a fanning ring which keeps them in neat order.

The power unit is placed in the bottom left-hand corner of the switchboard, to which it connects by plug and jack. The various components of the power unit are fitted to a steel chassis which is attached to the relay frame by four screws. The power terminals are placed behind a screw-down cover on which is a red warning sign. The power lead, which is connected to the mains supply by a plug, contains an extra conductor for earthing the switchboard. Four spare fuses are fitted to the front of the power unit.

The switchboard components are protected from dust and mechanical damage by a cover which fits over the four bolts projecting from the four corners of the frame.

Back plate, relay frame and cover grey hammer finished.

The incoming line cables are brought in to terminal blocks through two round holes in the back plate. The power lead passes out through a slot in the bottom of the cover.

There are three slotted holes in the back plate for attachment of the switchboard to a wall.

Installation

The only installation work required is to suspend the switchboard on a wall, to fit a wall terminal with earth wire beside the switchboard, and to connect the incoming cables to the line side of the distribution frame. The switchboard can be put into service as soon as the usual installation tests and jumpering work have been completed.

Technical Data

The resistance of extension lines may be up to 500 ohms. Using 0.5 mm conductors this corresponds to a distance between switchboard and telephone of 2.5 kilometres.

The power unit is supplied wired for 220 V and can easily be adjusted for 110, 127 or 150 V after removing the protective cover over the power terminal block. Fluctuations in mains voltage of ± 14 % are permissible. The power unit delivers 24 V operating voltage, 85 V ringing voltage, and a dial tone of about 100 c/s.

Operation

The switchboard contains equipment for 15 extensions and 2 link circuits. The line equipment for each extension consists of two relays, one for link circuit 1 and the other for circuit 2. The link circuits are selected alternately: after one has been occupied, the other is selected on the next call.

In addition to line equipments and link circuits the switchboard contains a common register.

When an extension user calls the switchboard, one of his line relays, corresponding to the link circuit due for selection, operates and connects the extension to that circuit. None of the other line relays associated with the selected circuit can then operate, so that two extensions cannot seize the same link circuit simultaneously.

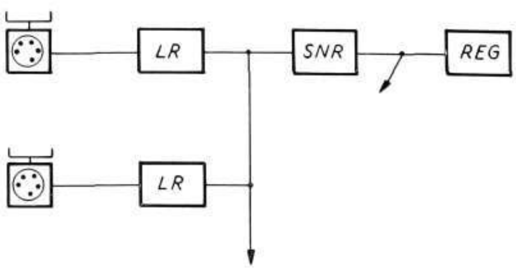
The register is connected to the link circuit and returns dial tone to the extension.

The number dialled by the extension is stored by a relay chain in the register.

On the completion of dialling two ringing signals are emitted in quick succession, provided that the called number is free, and ringing tone is returned to the caller. The called extension is connected to the calling circuit. The register is disconnected and no further ringing signal is transmitted. When the called party answers, speaking conditions are immediately established. For the line to be cleared on completion of conversation both parties must replace their handsets.

If a called extension is engaged, busy tone is returned from the register until the line is cleared, i.e. until the caller replaces.

The register is equipped for time release. Thus, if an extension does not start to dial within about 6 seconds of being connected to the register, the register is disconnected and the extension is locked to the link circuit.



X 2464

Fig. 3

Trunking diagram

LR line relay
SNR connecting circuit
REG register

Priority

The switchboard is designed for secret calls. Extension no. 2, however, has a right-of-way facility permitting entry to an engaged line. The connection is set up, after receipt of busy tone, by the priority extension dialling digit 2, which interconnects the two link circuits. The two conversing parties are warned by a faint tone that a priority extension is on the line. The latter may either request the wanted party to ring back after his conversation is completed or may ask both parties to replace their handsets. In such case the dialled number is automatically rung in the normal manner, and when the party replies an undisturbed conversation can take place.

Extension number 2 should be allotted to the person who most needs to obtain quick contact with other users of the system.

Summary

AMD 20101, with 15 extensions and 2 link circuits,

1. takes up little space
2. operates silently
3. is thoroughly reliable
4. requires no routine maintenance
5. can be connected to all normal mains voltages and frequencies
6. permits secret calls
7. has priority for one extension
8. uses the two link circuits alternately, so ensuring more even utilization of the equipment
9. has forced release of the register, so that a short-circuited extension line does not block the switchboard.

NEWS *from All Quarters of the World*

Important Telephone Contract from United Arab Republic

In stiff competition with two other world telephone enterprises, L M Ericsson has secured a large order from the United Arab Republic. Under this contract Ericsson will deliver automatic telephone exchange equipment for Cairo and five other towns in the Nile Delta, and will also participate in a planned Egyptian telephone factory for the manufacture of certain Ericsson products on licence. The negotiations, which have been in progress for some time, culminated in the signing of the contract at the beginning of November during the visit to Cairo of Mr. Sven T. Åberg.

Automatic telephone exchange equipment will be installed to a value of 26.4 million kronor, catering initially for 44,000 subscribers. In Cairo, 20,000 local lines are to be delivered for the Opera Exchange, and 10,000 lines for the Abassia Exchange. Local exchange equipment is also to be delivered to the towns of Benha, Damanhour, Mehalla El Kobra, Mansoura and Tantah in the Nile Delta.

The contract also includes automatic trunk switching centres for traffic between Cairo, Alexandria and the five Delta towns. The delivery of exchange epuipment is to start in roughly one year's time, and the cut-overs are planned to take place within two to three-and-a-half years. The telephone exchange contract was signed by the Telephone Administration of the United Arab Republic.

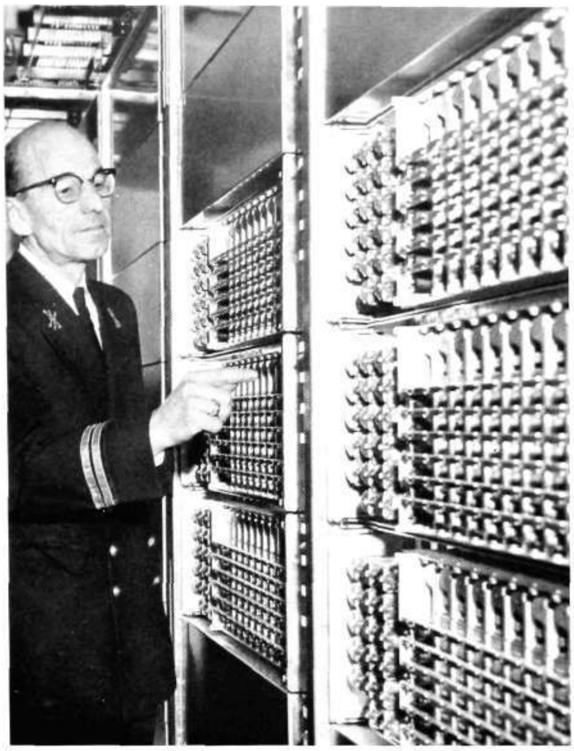
The contract for local manufacture was concluded with the General Organization for Executing the Five Year Industrial Plan. The United Arab Republic, with engineering assistance from L M Ericsson, will build a factory for the production on licence of automatic exchange equipment of crossbar type, telephone instruments, private automatic exchanges, and manual switchboards for local and long distance traffic.

Ericsson will train Egyptian technicians for future work in operating the exchanges and in works management.

Ericsson has delivered telephone equipment to Egypt for more than 50 years. Among other equipment delivered since the war may be mentioned an automatic 500-switch type of exchange installed in Suez in 1951. Even at that time the Egyptian government was aware of the necessity for a highly modern automatic telephone system to keep pace with the rapid industrial expansion of the country. An expert commission was appointed which, during a period of several years, made a study of the various world telephone systems available. The outcome is now seen in the recent contract awarded to L M Ericsson.

(Above) H.E. Moustapha Khalil, Minister of Communications of the U.A.R. and Mr. Sven T. Åberg signing the telephone exchange section of the contract. Seated at far left is the Director General of the U.A.R. Telephone Administration, Mahmoud Mohamed Riad.

(Below) H.E. Aziz Sedki, Minister of Industry, shaking hands with Mr. Åberg after signing the factory section of the contract.



Crossbar Exchange Installed on Large Passenger Steamer

On the new 38,645-ton passenger steamer, T/S Rotterdam, of the Dutch America Line, which recently made her maiden voyage from Rotterdam to New York, almost every passenger on board has an ivory-white L M Ericsson telephone for his or her own use.

The instruments are connected to what is believed to be the world's first ship-borne automatic crossbar telephone exchange. With a capacity of 650 extensions, the exchange was delivered by L M Ericsson and installed by its subsidiary company in Holland. Communications between officers and crew are passed through a separate 80-line automatic switchboard. L M Ericsson also supplied emergency telephones for the ship's lifts and a master clock system with over 100 slave clocks. T/S Rotterdam, built for 1,456 passengers by Rotterdamsche Droogdok Mij. N. V. in Rotterdam, is driven by two steam turbines each developing 17,500 h.p.

(Above) Chief Electrician Vanderwal inspecting a crossbar switch in T/S Rotterdam's automatic switchboard

(Right) The Telephone and Electrical Industries Ltd. factory, Sydney, one of the two locations at which crossbar is to be manufactured.

Crossbar Standard Australian System

Large New L M Ericsson Market

The Australian Post Office has approved the crossbar system offered by L M Ericsson as the new standard system of automatic telephony in Australia. The system is based on the crossbar switch developed by the Swedish Telecommunications Administration. The APO decision must be regarded as an outstanding success for Swedish enterprise and technology, since the Australian market has hitherto been dominated by British telephone companies. The system will be manufactured on licence in Australia under an agreement concluded between L M Ericsson and two Australian manufacturers, Telephone and Electrical Industries Ltd. and Standard Telephones & Cables Pty. Ltd. Production will start as soon as the necessary arrangements have been completed at the two factories. In the meantime deliveries of crossbar equipment will be made from L M Ericsson factories in Sweden.

After several years of thorough study APO has come to the conclusion that this crossbar system best solves the problems associated not only with rapidly expanding city networks, but also with the conversion of rural systems and the introduction of long distance subscriber dialling. APO's evaluation of the suitability of the crossbar system for Australian conditions is reinforced by the long experience of its operation and maintenance gained by the Swedish Telecommunications Administration. The reasons have been partly presented in articles in "The Telecommunication Journal of Australia", which have met with a considerable interest in international telephone circles.

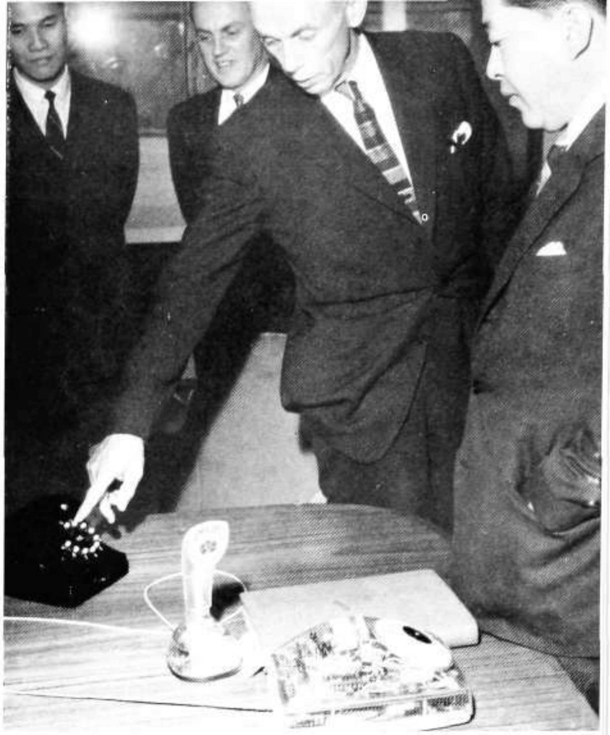
The suitability of the system for Australian conditions has been proved also by the results obtained with two small crossbar exchanges of 600 lines each installed by L M Ericsson on trial in Sydney and Melbourne in 1957. This year APO has placed orders for two more crossbar exchanges to be installed at Petersham (2,800 lines) and Toowoomba (6,300 lines).

The Australian market – comprising, as it does, a whole continent – is a very important one. The present population numbers 10 million and is rapidly growing. The telephone network is being expanded at the rate of 100,000 lines a year.

Expansion of Rangoon Telephone System

An order for expansion of the Rangoon telephone network has been received from the Burmese government, comprising automatic exchange equipment for 4,300 lines and the construction of a new 1,000-line exchange to a total value of some 6 million kronor.

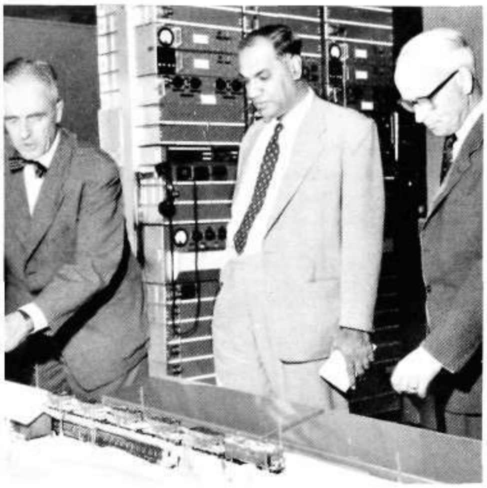
On the completion of these installations Rangoon will have one of the most modern telephone systems in Asia, with a total of 13,600 Ericsson crossbar lines. The conversion of the Rangoon network to automatic operation was entrusted to Ericsson in 1954, initially for 8,300 lines which are now installed.

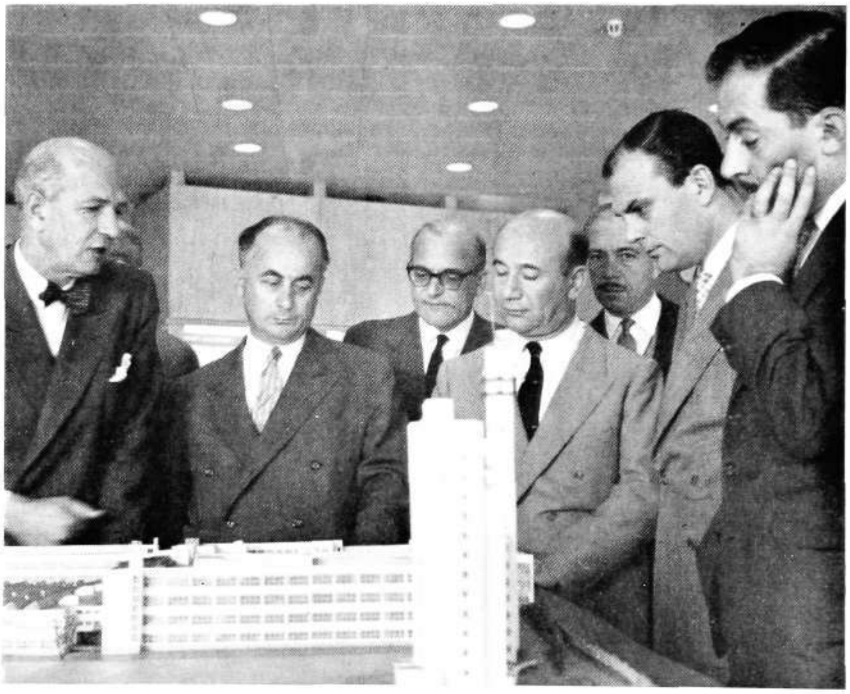


(Above) A recent photograph of the Argentine President, Dr. Arthuro Frondizi, speaking on his Ericofon.

The Thailand Foreign Minister, Thanat Khoman, paid a visit to Midsommarkransen in October Here he is being shown some of Ericsson's telephone instruments by Mr. Sven T. Åberg. In the background are Anand Panyar Achun of the Thailand Foreign Ministry and Erik Tennander, First Secretary of the Swedish Foreign Ministry.

(Below) Director General B. D. Rampala, M.B.E., Ceylon Government Railway, inspecting L M Ericsson's model railway. With him are Messrs. A. Reuterskiöld and Curt Ahlberg of L M Ericsson.





A Turkish trade delegation looking at a model of Ericsson's main factory at Midsommarkransen. (From left) Messrs. E. Lundqvist, LME, H. Erkmen, Turkish Minister of Commerce, Ambassador O. Malmaeus, K. Aygün, Mayor of Istanbul, Ambassador O. Eralp, S. Inan, Commercial Attaché, and A. Erdas of the Turkish Ministry of Commerce (above).

Four picked men from the Royal Härnösand Coast Artillery Corps visited Midsommarkransen in October in the course of a trip to Stockholm, the reward for good service in different fields.

L M Ericsson to Undertake First C.T.C. Installation in Portugal

■ **C.T.C. office at Setil**

▮▮▮▮▮ **C.T.C. installation Setil—Vendas Novas**

Companhia dos Camhinos de Ferro Portugueses (C.P.), the Portuguese Railway Company, has decided to introduce C.T.C. on the single-track line Setil-Vendas Novas (see map), which is important especially for goods traffic. This will be the first C.T.C. installation in Portugal. L M Ericsson is to supply and install the equipment under a contract worth some 3 million kronor.

The Setil-Vendas Novas line is 44 miles in length and has 11 stations. Each station has two tracks. The C.T.C. system will be of special type insofar as the points will not be under remote control. They will normally be positioned for left-track movement at the stations, but facilities will exist for local point operation, for example for shunting purposes. Despite this simplification it is anticipated that the introduction of C.T.C. will substantially increase the capacity of the line and lead to a saving in manpower.

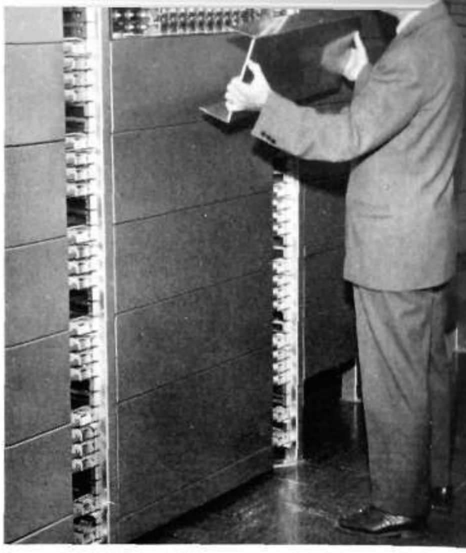
Only two stations receive their current supplies from the mains. The signalling equipment at all other stations will be operated from primary cells. This necessitates a very low current consumption; all signals will therefore normally be extinguished. They light automatically on the arrival of a train on the approach track circuit.

The C.T.C. office will be situated at Setil, and controls will be transmitted with a keyset. The entire plant will comprise about 90 signals and 90 track circuits.

All equipment is to be delivered during 1960, and the installation is to be officially opened on February 1, 1961.

Modern P.A.B.X. for Oslo Newspaper

The Norwegian "Aftenposten" started to use its new telephone switchboard at the end of September. It is a crossbar type P.A.B.X. supplied by L M Ericsson, Stockholm, in cooperation with A/S Elektrisk Bureau, Oslo.



(Above) Mr. Reidar Hansen from Norwegian Telecommunications Administration, Oslo district, inspecting a crossbar switch in the new P.A.B.X.

The plant, comprising 300 extensions within the Aftenposten offices, has greatly improved the newspaper's communications.

The new switchboard makes it easier for the public to contact any member of the editorial staff. The latest news can be heard from an automatic telephone answerer. Through the automatic call-back service an extension user who meets the engaged condition when ringing another extension is connected as soon as the number becomes free.

A recent exhibition in Rome "VI. Rassegna Internazionale Elettronica Nucleare e della Cinematografia" was honoured by the visit of President Giovanni Gronchi. He is here seen with Sr. Luigi Baggiani, managing director of L M Ericsson's Italian subsidiary, F.A.T.M.E., admiring a model of the Ericofon.

UDC 621.395.721.4
621.395.623.7

MITNITZKY, I & AHLSTRÖM, P: *Ericovox, the One-Piece Loudspeaking Telephone.* Ericsson Rev. *36*(1959): 4, pp. 100—108.

Telefonaktiebolaget LM Ericsson's first loudspeaking telephone for operation on public exchange lines was introduced in 1945. The development of semiconductors, in this case represented by transistors and diodes, has opened the way to an entirely new design of loudspeaking telephone, the Ericovox, consisting of a single unit. It can be installed wherever an ordinary telephone is used, being practically independent of room acoustics and length of line. With this telephone conversations can be conducted with both hands free.

UDC 745/749:621.395.623.7

OLSSON, T: *An Idea Takes Shape. How L M Ericsson's New Loudspeaking Telephone Came to Birth.* Ericsson Rev. *36*(1959): 4, pp. 109—117.

The article contains an account of some of the principal steps in the work of designing and giving shape to L M Ericsson's new loudspeaking telephone. The account has inevitably had to be abridged and the chronological sequence to some extent rearranged. In actual fact the designers were so pressed for time that on several occasions they had to work on different lines of development simultaneously.

UDC 621.395.722
621.395.34

REHNBERG, E: *Gothenburg Automatic Transit Exchange ART 205.* Ericsson Rev. *36* (1959): 4, pp. 118 — 126.

The Gothenburg transit exchange was ordered from L M Ericsson on March 26, 1956, for cut-over on April 1, 1959. The exchange was designed on the Administration's crossbar system for transit exchanges A-205. Modifications were introduced to adapt it to existing telephone exchanges in Gothenburg.

UDC 621.395.24

CLEMENTZ, B & MELIN, C: *Private Automatic Exchange for 15 Lines.* Ericsson Rev. *36*(1959): 4, pp. 127—130

In order to be able to offer a complete series of P.A.X. units from 10 extensions and upwards, L M Ericsson has designed a relay switchboard *AMD 20101*. It has a capacity of 15 lines with two link circuits and may be said to replace the popular OL 3511/1 which has now gone out of production.

The Ericsson Group

Associated and co-operating enterprises

• EUROPE •

Denmark

L M Ericsson A/S *København F*, Finsens Vej 78, tel: Fa 6868, tgm: ericsson

Telefon Fabrik Automatic A/S *København K*, Amaliegade 7, tel: C 5188, tgm: automatic

Dansk Signal Industri A/S *København F*, Finsens Vej 78, tel: Fa 6767, tgm: signaler

Finland

O/Y L M Ericsson A/B *Helsinki*, Fabianinkatu 6, tel: A8282, tgm: ericssons

France

Société des Téléphones Ericsson *Colombes (Seine)*, Boulevard de la Finlande, tel: CHA 35-00, tgm: ericsson

Paris 17e, 147 Rue de Courcelles, tel: Carnot 95-30, tgm: eric

Germany

Ericsson Verkaufsgesellschaft m. b. H. *Düsseldorf 1*, Worringer Strasse 109, tel: 84 461, tgm: erictel

Great Britain

Swedish Ericsson Company Ltd. *London, W. C. 1*, 329 High Holborn, tel: Holborn 1092, tgm: teleric

Production Control (Ericsson) Ltd. *London, W. C. 1*, 329 High Holborn, tel: Holborn 1092, tgm: productrol holb

Italy

Setemer, Soc. per Az. *Milano*, Via dei Giardini 7, tel: 662241, tgm: setemer

SIELTE, Soc. per Az. — Società Impianti Elettrici e Telefonici Sistema Ericsson *Roma*, C. P. 4024 Appio, tel: 780221, tgm: sielte

F. A. T. M. E. Soc. per Az. — Fabbrica Apparecchi Telefonici e Materiale Elettrico »Brevetti Ericsson» *Roma*, C. P. 4025 Appio, tel: 780021, tgm: fatme

Netherlands

Ericsson Telefoon-Maatschappij, N.V. *Rijen (N. Br.)*, tel: 01692-555, tgm: erictel

den Haag—Scheveningen, 10, Palacestraat, tel: 55 55 00, tgm: erictel-haag

Norway

A/S Elektrisk Bureau *Oslo NV*, P.B. 5055, tel: Centralbord 46 18 20, tgm: elektriken

A/S Industrikontroll *Oslo*, Teatergaten 12, tel: Centralbord 335085, tgm: indtroll

A/S Norsk Kabelfabrik *Drammen*, P. B. 205, tel: 1285, tgm: kabel

A/S Norsk Signalindustri *Oslo*, P. B. Mj 2214, tel: Centralbord 56 53 54, tgm: signalindustri

Portugal

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

Spain

Cia *Española* Ericsson, S. A. *Madrid-4*, Conde de Xiquena 13, tel: 31 53 03, tgm: ericsson

Sweden

Telefonaktiebolaget L M Ericsson *Stockholm 32*, tel: 19 00 00, tgm: telefonbolaget

AB Alpha *Sundbyberg*, tel: 282600, tgm: aktiealpha-stockholm

AB Ermex *Solna*, tel: 82 01 00, tgm: elock-stockholm

AB Ermi *Bromma 11*, tel: 262600, tgm: ermibolag-stockholm

AB Rifa *Bromma 11*, tel: 26 26 10, tgm: elrifa-stockholm

AB Svenska Elektronrör *Stockholm 20*, tel: 44 03 05, tgm: electronics

L M Ericssons Driftkontrollaktiebolag *Solna*, tel: 27 27 25, tgm: powers-stockholm

L M Ericssons Signalaktiebolag *Stockholm Sv*, tel: 68 07 00, tgm: signalbolaget

L M Ericssons Svenska Försäljningsaktiebolag *Stockholm 1*, Box 877, tel: 22 31 00, tgm: ellem

Mexikanska Telefonaktiebolaget Ericsson *Stockholm 32*, tel: 190000, tgm: mexikan

Sieverts Kabelverk AB *Sundbyberg*, tel 282860, tgm: sievertsfabrik-stockholm

Svenska Radioaktiebolaget *Stockholm 12*, Alströmergatan 14, tel: 22 31 40, tgm: svenskradio

Switzerland

Ericsson Telephone Sales Corp. AB, Stockholm, Zweigniederlassung Zürich *Zürich*, Postfach Zürich 32, tel: 325184, tgm: telericsson

• ASIA •

India

Ericsson Telephone Sales Corporation AB *New Delhi 1*, P.O.B., 669, reg. mail: 1/3 Asaf Ali Road (Delhi Estate Building), tel: 28512, tgm: inderic

Bombay, Manu Mansion, 16, Old Custom House, tel: 254130 tgm: inderic

Calcutta, P. O. B. 2324, tel: 45-4494, tgm: inderic

Indonesia

Ericsson Telephone Sales Corporation AB *Bandung*, Djalan Dago 151, tel: 8294, tgm: javeric

Djakarta, Djalan Gunung Sahari 26, tel: Gambir 50, tgm: javeric

Leban

Telefon

son, Technical Office *Beyrouth*, Rue du Parlement, Immeuble Bisharat, tel: 33555, tgm: ellem

Turkey

Ericsson Türk Ltd. Şirketi *Ankara*, Âdil Han, Zafer Meydani, Yenişehir, tel: 23170, tgm: ellem

Istanbul, Istanbul Bürosu, Liman Han, Kat 5, No. 75, Bahçekapi, tel: 228102, tgm: ellemist

• AFRICA •

Union of South Africa

L M Ericsson Telephone Co. Pty. Ltd. *Johannesburg*, 70, Loveday Street, tel: 33-2742, tgm: ericofon

• AMERICA •

Argentine

Cia Sudamericana de Teléfonos L M Ericsson S. A. *Buenos Aires*, Belgrano 894, tel: 332071, tgm: ericsson

Corp. Sudamericana de Teléfonos y Telégrafos S. A. *Buenos Aires*, Belgrano 894, tel: 332071, tgm: cartefe

Cia Argentina de Teléfonos S. A. *Buenos Aires*, Perú 263, tel: 305011, tgm: cecea

Cia Entrerriana de Teléfonos S. A. *Buenos Aires*, Perú 263, tel: 305011, tgm: cecea

Cia Comercial de Administración S. A. *Buenos Aires*, Perú 263, tel: 305011, tgm: cecea

Industrias Eléctricas de Quilmes S. A. *Quilmes FCNGR*, 12 de Octubre 1090, tel: 203-2775, tgm: indelqui-buenosaires

Brazil

Ericsson do Brasil Comércio e Indústria S. A. *Rio de Janeiro*, C. P. 3601, tel: 43-0990, tgm: ericsson

São Paulo C. P. 5677, tel: 36-6951, tgm: ericsson

Canada

Ericsson Telephone Sales of Canada Ltd. *Montreal 8, Que.*, 130 Bates Road, tel: RE 1-6428, tgm: caneric

Toronto 18, Ont., 34 Advance Road, tel: BE 1-1306

S. A. tel: 82555, tgm: ericsson-santiago-dechile

Colombia

Cia Ericsson Ltda. *Bogotá*, Apartado Aéreo 4052, tel: 11-100, tgm: ericsson

Ecuador

Telefonaktiebolaget LM Ericsson, Technical Office *Quito*, Casilla Postal 2138, tel: 33777, tgm: ericsson

Mexico

Cia Comercial Ericsson S. A. *México D. F.*, Apartado 9958, tel: 46-46-40, tgm: coeric-mexico

Industria de Telecomunicación S.A. de C.V. *México 6, D.F.*, Calle Londres No 47, Colonia Juárez, tel: 250405, tgm: industel

Peru

Cia Ericsson S. A. *Lima*, Apartado 2982, tel: 34941, tgm: ericsson

Soc. Telefónica del Perú, S. A. *Arequipa*, Casilla de Correo 112, tgm: telefonica

El Salvador

Telefonaktiebolaget LM Ericsson, Technical Office, *San Salvador*, Apartado Postal 188, tel: 4989, tgm: ericsson

Uruguay

Cia Ericsson S. A. *Montevideo*, Casilla de Correo 575, tel: 84433, tgm: ericsson

USA

The Ericsson Corporation *New York 17, N. Y.*, 100 Park Avenue, tel: Murray Hill 5-4030, tgm: erictel

North Electric Co. *Galion, Ohio*, P. O. B. 417, tel: Howard 8-2420, tgm: northphone-galionohio

Venezuela

Cia Anónima Ericsson *Caracas*, Apartado 3548, tel: 543121, tgm: ericsson

Teléfonos Ericsson C. A. *Caracas*, Apartado 3548, tel: 543121, tgm: tevela

• AUSTRALIA & OCEANIA •

Australia

L M Ericsson Telephone Co. Pty. Ltd. *Melbourne C 1 (Victoria)*, Kelvin Hall, 55 Collins Place, tel: MF 56 46, tgm: ericmel

Agencies

• EUROPE •

Austria

Inglomark, Industrie-Beliefe-rungs-Gesellschaft Markowitsch & Co. *Wien XV*, Maria Hilferstrasse 133, tel: R 32-0-11, tgm: inglomark

Belgium

Electricité et Mécanique Suédoises *Bruxelles 5*, 56 Rue de Stassart, tel: 11 14 16, tgm: electrosuede

Greece

»ETEP», S. A. Commerciale & Technique *Athens*, 11, Mackenzie King Street, tel: 617041, tgm: aeter-athinai

Ireland

Communication Systems Ltd. *Dublin*, 40, Upper Fitzwilliam Street, tel: 61576/7, tgm: crossbar

Iceland

Johan Rönning H/F *Reykjavik*, P. O. B. 45, tel: 14320, tgm: rönning

Yugo-Slavia

Merkantile Inozemna Zastupstva *Zagreb*, Pošt pretinać 23, tel: 25-222, tgm: merkantile

• ASIA •

Burma

Vulcan Trading Co. Ltd. *Rangoon*, P. O. B. 581, tel: S. 878, tgm: suecia

Ceylon

Vulcan Trading Co. (Private) Ltd. *Colombo 1*, 19, York Street, tel: 36-36, tgm: vultra

China

The Ekman Foreign Agencies Ltd. *Shanghai*, P. O. B. 855, tel: 16242-3, tgm: ekmans

Hong Kong

The Swedish Trading Co. Ltd. *Hongkong*, P.O.B. 108, tel: 20171, tgm: swedetrade

Iran

Irano Swedish Company AB *Teheran*, Khiaban Sevom Esfand 201-203, tel: 36761, tgm: irano-swede

Iraq

Koopman & Co. (Iraq) W. L. L. *Baghdad*, P. O. B. 22, tel: 86860, tgm: havede

Japan

Gadelius & Co. Ltd. *Tokyo*, No. 3-19, Denma-cho, Akasaka, Minato-Ku, tel: 48-5361, tgm: goticus

Jordan

H. L. Larsson & Sons Ltd. Levant *Amman*, P. O. B. 647, tgm: larsonhus

Kuwait

Latiff Supplies Ltd. *Kuwait*, P.O.B. 67, tgm: latisup

Lebanon

Swedish Levant Trading Co. *Beyrouth*, P. O. B. 931, tel: 31624, tgm: skefko

Pakistan

Vulcan Trading Co. (Pakistan) Ltd. *Karachi City*, P. O. B. 4776, tel: 32506, tgm: vulcan

Philippines

Koppel (Philippines) Inc. *Manila P. R.*, P. O. B. 125, tel: 3-19-71, tgm: koppelrail

Saudi Arabia

Mohamed Fazil Abdulla Arab *Jeddah*, P. O. B. 39, tel: 2690, tgm: arab

Singapore and Malaya

The Swedish Trading Co. Ltd. *Singapore*, G. P. O. B. 2791, tgm: metlokcast

Syria

Georgiades, Moussa & Cie *Damas*, Rue Ghassan, Harika, tel: 1-02-89, tgm: georgiades

Thailand

Vichien Radio & Television Co., Ltd. *Bangkok*, 299-301, Prasitsin Building, Surawongse Road, tel: 31 364, tgm: ericsson

Vietnam

Vo Tuyen Dien-Thoai Viet-Nam, Matériel Radio & Téléphonique du Viêtnam *Saïgon*, 17, Cong Truong Lam-Son, tel: 20805, tgm: telerad

• AFRICA •

Belgian Congo

Société Anonyme Internationale de Télégraphie sans Fil (SAIT) *Bruxelles (Belgique)*, 25, Boulevard du Régent, tel: 125070, tgm: wireless (For maritim radio and carrier)

British East Africa

Transcandia Ltd. *Nairobi, Kenya*, P. O. B. 5933, tel. 3312, tgm: *transcanda*

Egypt

The Pharaonic Engineering & Industrial Co. *Cairo*, 33, Orabi Street, tel: 4-36-84, tgm: radiation

Ethiopia

Swedish Ethiopian Company *Addis Ababa*, P. O. B. 264, tel: 1447, tgm: etiocomp

Ghana

The Standard Electric Company *Accra*, P.O.B. 17, tel: 2785, tgm: standard

Morocco

Elcor S. A. *Tangier*, Francisco Vitoria, 4, tel: 2220, tgm: elcor

Mozambique

J. Martins Marques *Lourenço Marques*, P. O. B. 456, tel: 5953, tgm: tinsmarques

Nigeria

Scan African Trading Co. *Yaba-Lagos 32*, P. O. B. 1, tgm: swedafrica

Rhodesia and Nyasaland

Reunert & Lenz, (Rhodesia) Ltd. *Salisbury (Southern Rhodesia)* P.O. B. 2071, tel: 27001, tgm: rockdrill

Sudan

TECOMA Technical Consulting and Machinery Co. Ltd. *Khartoum*, P.O.B. 866, tel: 2224, ext. 35, tgm: sutecoma

• AMERICA •

Bolivia

Johansson & Cía, S. A. *La Paz*, Casilla 678, tel: 2700, tgm: johansson

Costa Rica

Tropical Commission Co. Ltd. *San José*, Apartado 661, tel: 3432, tgm: troco

Cuba

Mc Avoy y Cía *Habana*, Apartado 2379, tel: U-2527, tgm: macavoy

Curaçao N. W. I.

S. E. L. Maduro & Sons, Inc. *Curaçao*, P. O. B. 172, tel: 1200, tgm: madurosons-willemstad

Dominican Republic

García & Gautier, C. por A. *Ciudad Trujillo*, Apartado 771, tel: 3645, tgm: gartier

Guatemala

Nils Pira *Ciudad de Guatemala*, Apartado 36, tel: 3311, tgm: nilspira-guatemala

Haïti

Salon Culturel, Michel Schutt Aîné, *Port-au-Prince*, P.O.B. 903, tgm:

Honduras

Cía de Comisiones Inter-Americana, S. A. *Tegucigalpa D. C.*, P. O. B. 114, tel: 15-63, tgm: inter

Jamaica and Brit. Honduras

Morris E. Parkin *Kingston*, P.O.B. 354, tel: 4077, tgm: morrispark

Nicaragua

J. R. E. Tefel & Co. Ltd. *Managua*, Apartado 24, tel: 387-1169, tgm: tefelto

Panama

Productos Mundiales, S. A. *Panama, R. P.*, P. O. B. 4349, tel: 3-0476, 3-7763, tgm: mundi

Paraguay

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

Puerto Rico

Splendid Inc. *San Juan*, P. O. B. 4568, tel: 3-4095, tgm: splendid

El Salvador

Dada-Dada & Co. *San Salvador*, Apartado 274, tel: 4860, tgm: dada

Surinam

C. Kersten & Co. N. V. *Paramaribo*, P. O. B. 216, tel: 2541, tgm: kersten

USA

State Labs. Inc., *New York 12, N.Y.*, 649 Broadway, tel: Oregon 7-8400, tgm: statelabs. Only for electron tubes

• AUSTRALIA & OCEANIA •

New Zealand

ASEA Electric (N Z) Ltd. *Wellington C.1.*, Huddart Parker Building, Post Office Square, tel: 70-614,