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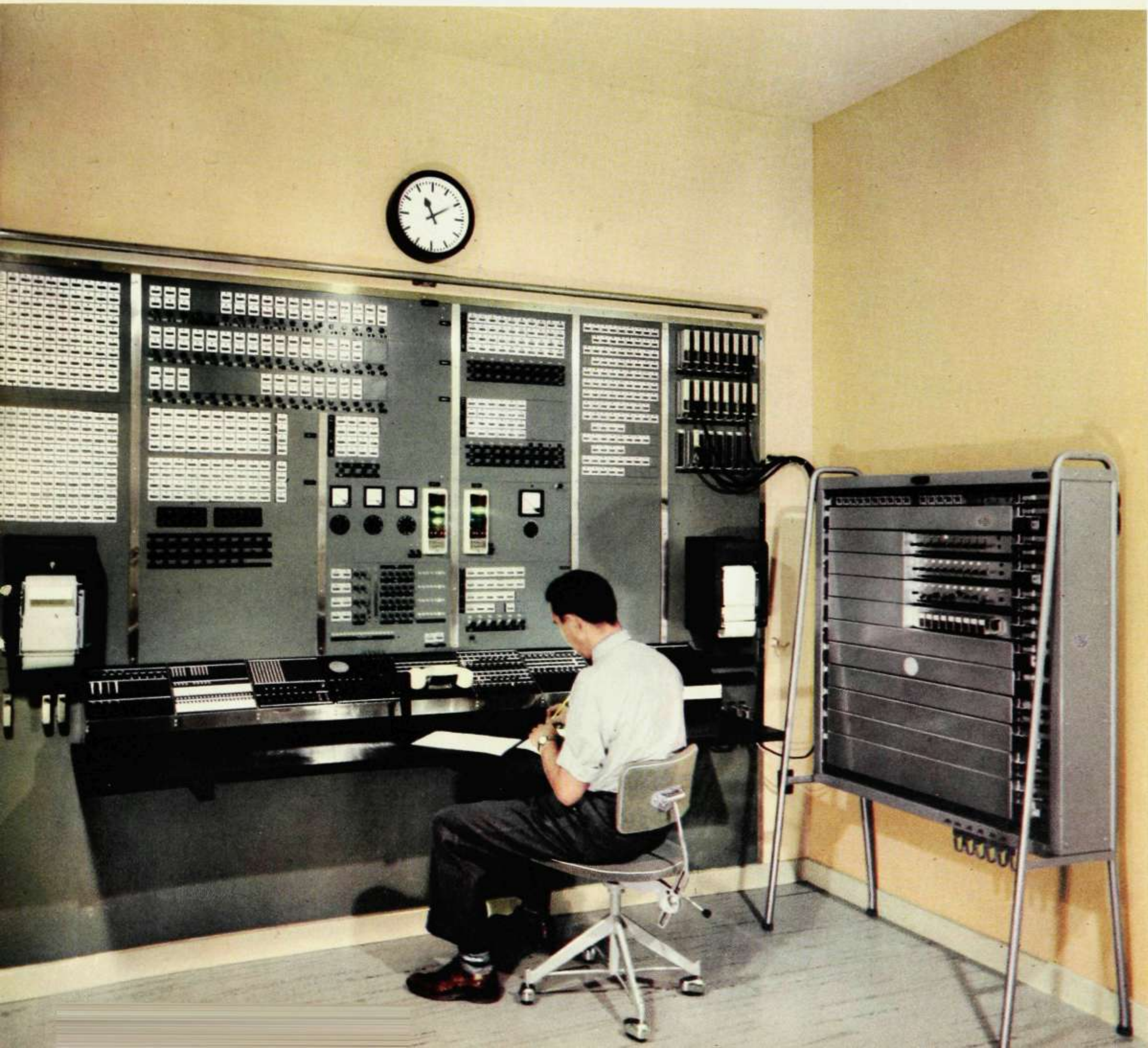

ERICSSON REVIEW

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CONTENTS

On cover: Test Room at Aalborg Autoexchange with L M Ericsson's Traffic Route Tester LTR 1050.

The Traffic Route Tester—a New Tool for Service Observation at Automatic Telephone Exchanges

K G HANSSON, TELEFONAKTIEBOLAGET L M ERICSSON, STOCKHOLM

U.D.C. 621.395.66
621.395.35.001.42

A simple and reliable means of controlling the quality of service in an automatic area, comprising one or more exchanges, is of prime importance to the telephone administration. To meet the needs of its customers in this respect, L M Ericsson has designed a traffic route tester coded LTR 1050.

The rôle of the traffic route tester in maintenance has been touched on in earlier articles in Ericsson Review, No. 4, 1955, "The Assumptions for Economic Maintenance of L M Ericsson's Automatic Telephone Exchanges" and No. 2, 1956, "Qualitative Maintenance of Automatic Telephone Networks". The present article will deal especially with the uses, construction and operation of the traffic route tester.

The traffic route tester *LTR 1050* (fig. 1) is an automatic test equipment which sets up complete test connections within an exchange or between different exchanges. It connects to the exchange equipment in the same way as a telephone instrument, and can be used both on crossbar and 500-switch systems.

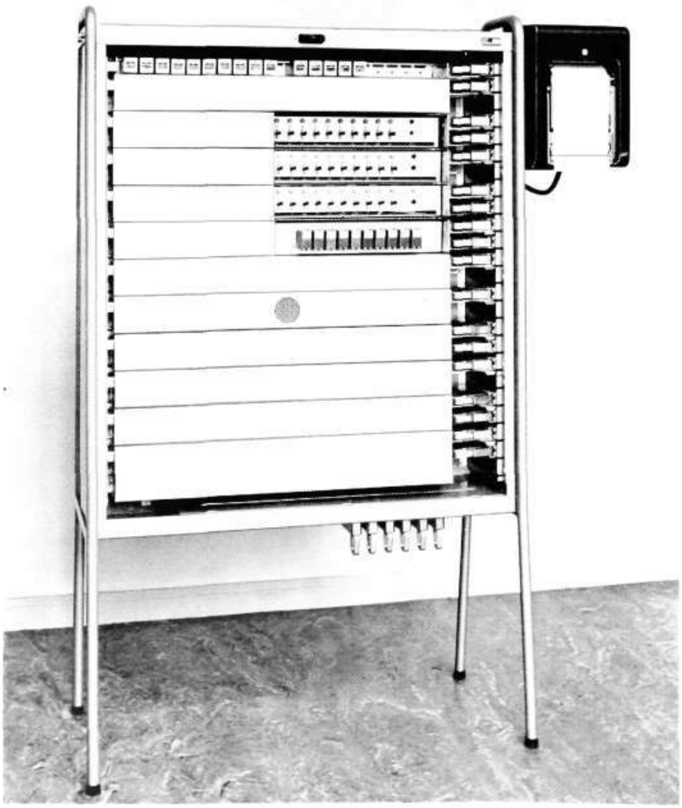


Fig. 1
Traffic route tester LTR 1050
with connected Centralograph (right)

X 8072

A maximum of 20 test circuits can be connected to the traffic route tester. With 10 circuits as A numbers and 10 as B numbers, a complete test program will comprise 100 connections, one connection being established from every A number to every B number.

The traffic route tester acts as a normal subscriber in relation to the exchange. It directs the connection and records the result. The impression gained of the service rendered by the exchange equipment, as recorded by the traffic route tester, will consequently be the same as that received by a subscriber using his telephone. An important difference when using the traffic route tester, however, is that the human factor is eliminated and that failure to obtain connection is immediately recorded on a "Centralograph" and on counters. Subscribers know that they sometimes fail to obtain connection on account of faulty manipulation of the telephone or dialling the wrong number. But if the real cause is an isolated fault in the exchange equipment, the subscriber is seldom aware of the fact and the fault is left unreported.

Applications

The traffic route tester has two essential fields of use:

a. automatic service observation

b. automatic fault indication.

Used for service observation, the traffic route tester sets up test connections between connected A and B numbers. When a fault occurs during the test it is recorded by the Centralograph, after which the tester cuts off that connection and continues to the next. The total number of attempted connections from every A number, and the total number of completed connections, are recorded on special counters. Reading of these counters at the end of the test program, or after a certain number of connections, affords a direct measure of the quality of service within the exchange or exchanges at which the test was carried out. If, for instance, the traffic route tester has made 5000 attempted connections, of which 4995 were completed without fault, this means that 99.9 % of the connections were correct or, in other words, that the fault rate is 0.1 %.

The circuits on which the different faults occurred, and the types of fault, can be traced from the recordings on the Centralograph chart.

A statistical record of the quality of service in the exchange area is thus obtainable by means of the data from the counters and Centralograph. An article entitled "Statistical Methods for Supervision of Telephone Exchanges and Networks" in Ericsson Technics No. 1, 1956, described the mathematical treatment of the statistical material obtained through the use of the traffic route tester.

Used as an automatic fault indicator, the traffic route tester is a very valuable aid to maintenance personnel. If it is found that there are too many faults in any group of exchange equipment or on any particular route, the tests can be concentrated to that section of the exchange. With the tester set for fault indication a faulty connection is locked as soon as encountered; the tester immediately stops, issues an alarm and supplies the necessary information on a lamp panel for guidance in locating the fault. In this case the tester must be restarted manually.

Both for service observation and fault indication, every established test connection is checked, in respect of the following functions:

register connection tone
ringing signal and ringing tone
operation of ringing-trip relay
battery supply
speech level
no circuit interference or crosstalk
no interruption of the connection
correct metering
clearing.

The method of making these checks will be described later in the article.

In addition to service observation and fault indication within the home exchange, the field of use of the traffic route tester can be extended by means of remote-controlled relay selectors for A and B circuits to comprise the following test facilities:

a. Test to other exchange
b. Test from other exchange to home exchange
c. Test within other exchange
d. Test between two other exchanges.

In all cases the traffic route tester is located at the main exchange, so that three control wires are needed for control of the A and B circuit selectors at the other exchange. In each of these four cases the traffic route tester directs the connections, and records the result, from the main exchange. At exchanges where control wires are not available, a code answerer can be used for identification of the correct test number. Examples of different test facilities are shown in fig. 2.

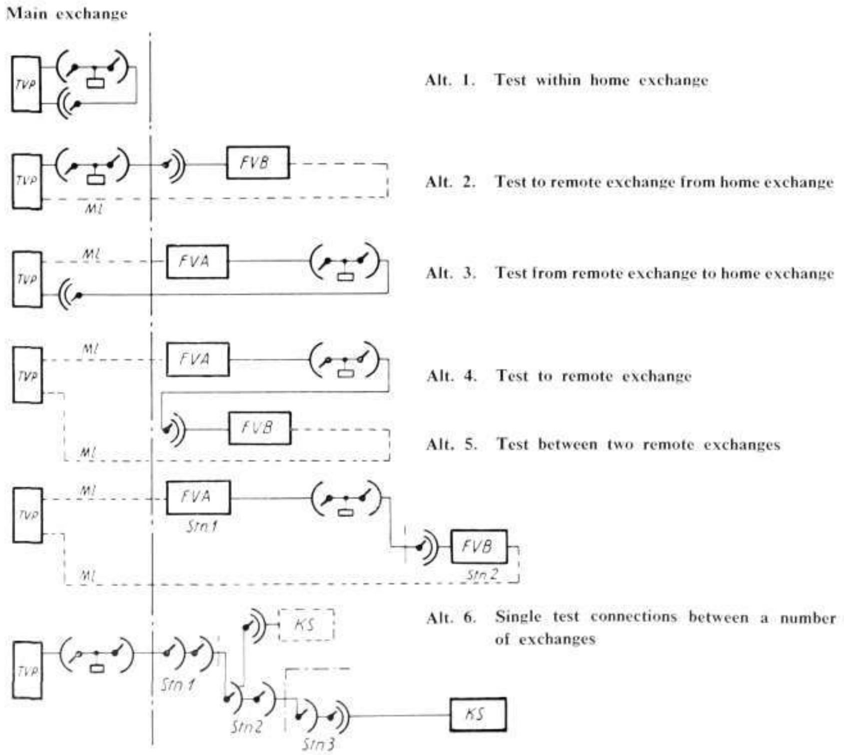


Fig. 2 X 2291

Alternative connections for test traffic

TVP traffic route tester
Ml control wires
FVA } remote-controlled selector for A and
FVB } B circuit
KS code answerer
Stn exchange

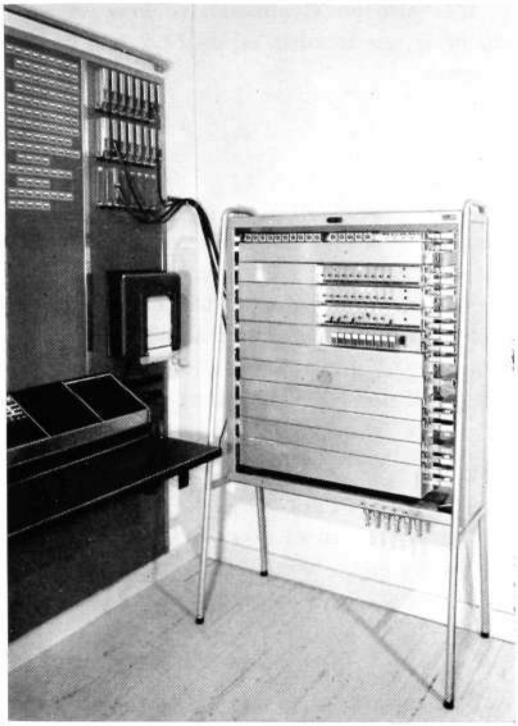


Fig. 3 X 2290

The traffic route tester in a test room

On the left are seen connections to the test number panel and (below) the Centralograph

Mechanical Construction

The traffic route tester is designed as an independent unit, so that it can be placed apart from the exchange equipment, for instance in a test room (fig. 3). The relays and counters in the test equipment are assembled in 12 relay sets type *BCH*. They are suspended in a metal frame made on the same principles as a BCG frame. The frame is supported by a pair of uprights on each side. On the right-hand side of the frame are jacks for connection of the relay sets. At the top of the frame is a common fuse, and at the bottom are nine 80-point jacks for connection of test numbers, Centralograph etc. (fig. 4). Three of the relay sets are partitioned in the middle and have fittings for 10 control keys and lamps. Of the total of 30 keys, 20 are for connection of the required number of test circuits. The remaining 10 are used for starting the test equipment and for setting up the desired program. A fourth relay set is of similar design but is equipped with ten 20-point jacks *PJ1—PJ10*, one for each test number. The test number is selected by means of cross-connections in a 20-point plug, *P*, which is inserted in its corresponding test number jack. The risk of faults which may arise if the number is selected by setting of knobs or similar means is thereby entirely eliminated. The wiring of the test number jacks is also multipled to jacks in the bottom of the frame (fig. 4), *JN1* and *JN2*, so that the test number selection can be connected to a central control point.

Since all relays and other components are mounted on *BCH* bars, the traffic route tester can, if desired, be permanently connected to the remaining exchange equipment. In such case the control and recording equipment can be concentrated at another point in the exchange.

The power wires are protected against overload by the aforementioned common fuse of max. 10 A at the top of the frame and, in addition, by the equipping of every relay set with an individual 3A fuse. The traffic route tester is normally designed to operate on 48 V. If used for an exchange with lower voltage, the supply can be taken direct from the existing mains via a simple rectifier unit such as L M Ericsson's power unit *BMN 211*.

The remoter-controlled relay selectors for selection of A and B test numbers at a remote exchange, and the code answerer, are also assembled on relay sets type *BCH*. They can be suitably mounted on a *BCH* rack at the

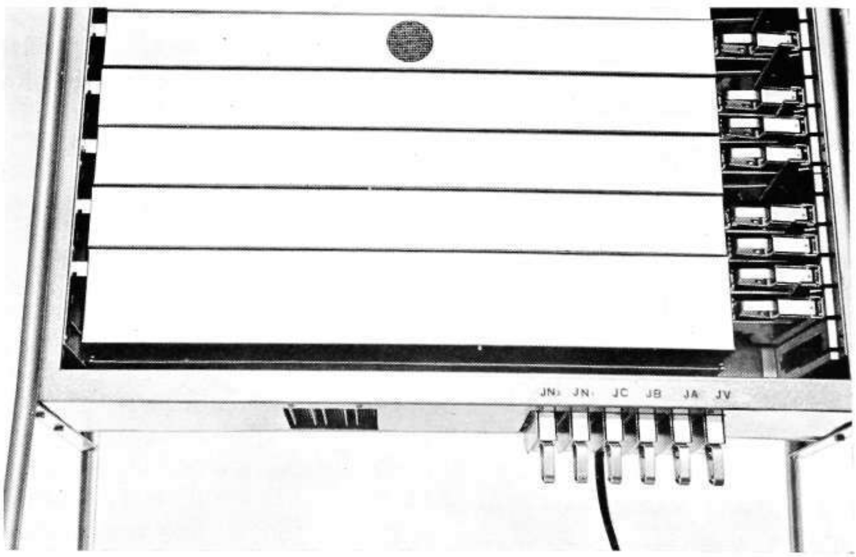


Fig. 4 X 8070

Terminations of traffic route tester

JV 48 V terminal

JA, JB test number panel terminal

JC Centralograph terminal

JN_1, JN_2 terminals for central selection of test numbers

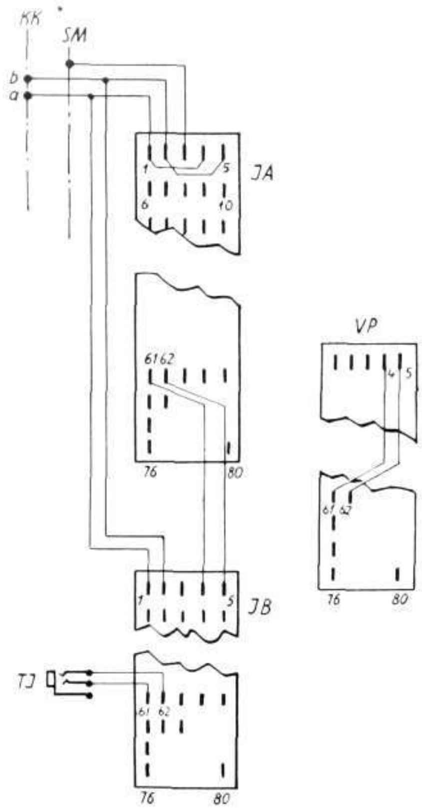


Fig. 5 X 2292

Example of connection of a test circuit to the test number panel

JA } JB }	jacks for A and B test numbers
KK	M.D.F.
SM	subscriber's meter
TJ	service jack in exchange equipment
VP	through-connection plug for JA and JB
a	*a*-wire
b	*b*-wire

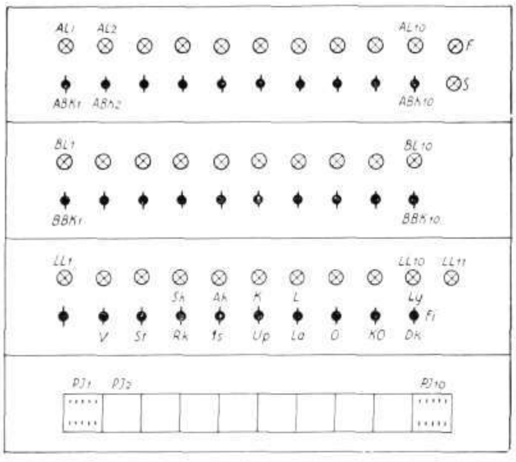


Fig. 6 X 2295

Controls, lamp panel and test number jacks of traffic route tester

exchange in question. The code answerer may also be accommodated in a portable box. The equipment for selection of B test number is identical to the corresponding unit in the traffic route tester.

Connections

The connection and use of the traffic route tester is very simple. No interference with the exchange equipment is necessary. What is required is the provision of circuits for 48 V and the concentration of the desired test numbers at the position where the tester is erected. The choice of test numbers, and the quantity of numbers required, will depend principally on the test program. Normally two test numbers are required per 500 lines at an *AGF* exchange, and one per 200 lines at an *ARF* exchange.

The test circuits can be drawn direct from the M.D.F. and wired to a test number panel in the test room, where they are connected to 80-point jacks. Every A test number must have access to *a*-, *b*- and *r*-wires. The *r*-wire, which comes from the subscriber's meter, is required for checking of the metering.

Two 80-point jacks, *JA* and *JB*, are required for 10 test numbers, *JA* for the A numbers and *JB* for the B numbers. Both *JA* and *JB* contain the same 10 numbers and can thus be used on different occasions as A or B numbers. It is an advantage to use the same numbers for the traffic route tester as are normally employed for service and test numbers in the jack boxes of the exchange equipment panels, where they are connected to the test jacks (*TJ*). The wiring of these numbers to *TJ* via *JA* and *JB* is so arranged that, when the circuits are used by the traffic route tester, they are disconnected in *TJ*. When not used for the traffic route tester, they are connected to *TJ* by the insertion of a through-connection plug in *JA* and *JB*. The connection of a test number to *JA* and *JB*, and the wiring of the through-connection plug, are shown schematically in fig. 5.

Other supervisory circuits of the exchange, such as counting pulses from the master clock, control wires to and from other exchanges etc., are also connected to *JA* and *JB*.

The connection between jacks *JA* and *JB* of the traffic route tester and the *JA* and *JB* jacks of the test number panel is arranged by means of flexible cables with 80-point plugs, *PA* and *PB*, at each end.

When the tester has been connected to the desired test numbers, and plugs *P1—P10* have been properly wired and inserted in jacks *PJ1—PJ10*, the A circuits which are not to be used on the test can be disconnected by means of keys *ABK 1—10*. In the same way the B circuits can be disconnected with keys *BBK 1—10*. If *PA* and *PB* are connected to the same group of 10 test circuits, it should be noted that the same circuit cannot be simultaneously an A and B circuit.

The method of operation of the traffic route tester is that connections are set up from every A test number to every connected B test number in succession. Consequently, before it can be established at the beginning of a test program comprising 20 test numbers that all circuits have been correctly connected, 91 complete connections must be run off. This would take an unnecessarily long time, and it is best first to make a check of the connections of the A and B circuits. This is done by throwing keys *Ak*, *V*, *L*, *Ly*, *1 s* and *St* (fig. 6). Calls are thereby set up from every A test number in succession. As soon as register tone is returned on one test circuit, the next is automatically connected, and so on.

To test the connections of the B circuits, *Ak* and *St* are restored and *St* is depressed once again. From the first A number connections are obtained successively to all B numbers. By watching the lamps and listening to the tones, it can be checked that every B circuit with corresponding number plug is correctly connected.

When all terminations have been tested the traffic route tester can be started on its test program.

Operation

The best idea of the operation of the traffic route tester and of its test facilities can be given by briefly describing its various relay sets. The locations of these relay sets in the tester are shown in fig. 7.

Counters

The tester is equipped with fourteen 5-digit counters of conventional type. The counters can be zeroed. The first ten counters are connected to their respective A test numbers and record the number of attempted calls from each number. Three counters record the number of calls on which register connection is obtained after the first, second and third attempt, and the remaining counter records the number of completed OK connections to B numbers.

Control Relays for Centralograph

The relay set contains relays for driving the Centralograph chart.

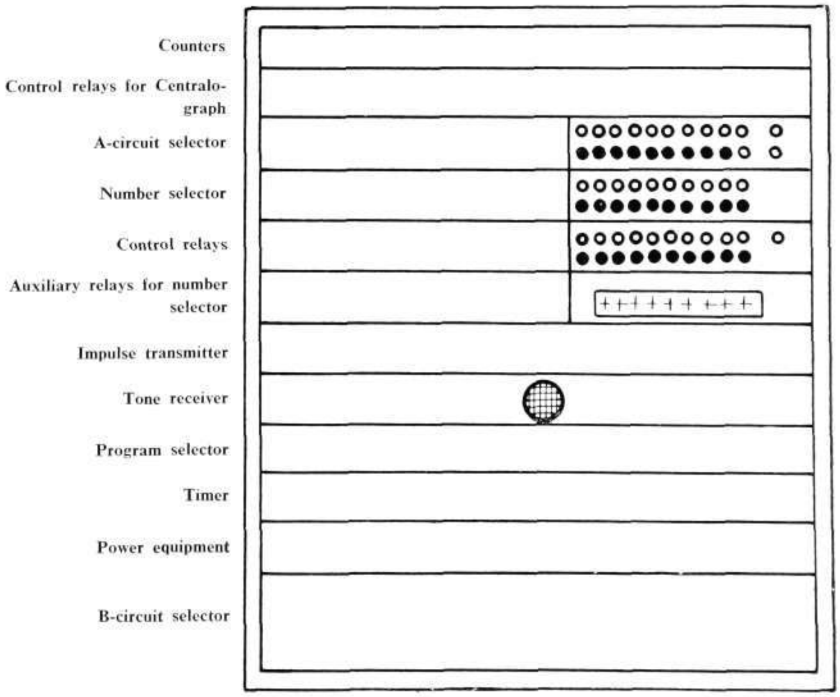


Fig. 7

Location of relay sets in traffic route tester

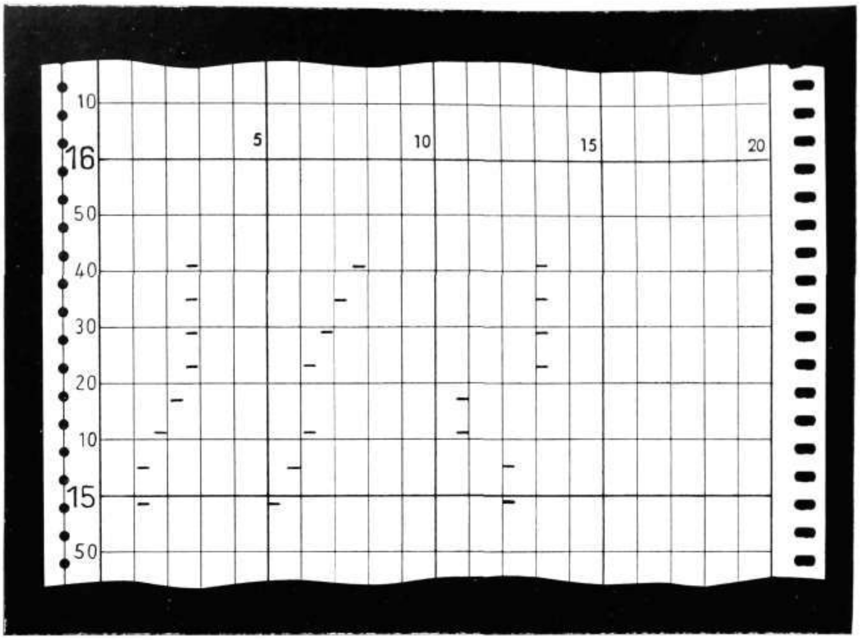


Fig. 8 X 8069

Example of Centralograph recordings

Every horizontal row contains space for fault indications on one connection.

Every column contains space for indications by two hammers. The indications from hammers 15 and 16, for example, will appear in column 8.

The Centralograph indicates the type of fault, and the test circuits connected at the time of the fault, in the following manner.

Hammer No.	
1—10	A-circuit of corresponding number connected at time of fault.
11—20	B-circuit of corresponding number connected at time of fault.
22	Indicates failure of register connection despite three repeated attempts of 2 seconds' duration each. The interval can be increased if so required.
23	Indicates transmission of congestion tone to A circuit within 2 seconds of transmission of last digit in B number.
24	Indicates transmission of congestion tone to A circuit more than 2 seconds after transmission of B number.
25	Indicates ringing signal OK but no speech circuit.
27	Indicates absence of ringing signal on B circuit.
28	Indicates absence of intermittent ringing tone (*SU3*).
29	Indicates that connection not cleared on disconnection from B number.
30	Indicates arrival of more than one meter impulse at test equipment within the metering cycle applicable to that exchange.
31	Indicates absence of meter impulse at test equipment within the metering cycle of the exchange.
32	Indicates that connection was wrongly cut off for at least 2 seconds.
33	Indicates noise of higher level than that for which the tone receiver was set during the test. (Crosstalk, circuit interference.)
39	Indicates absence of intermittent ringing signal (*RGi*).
40	Indicates absence of busy tone on connection to engaged B number.

An example of the record on a Centralograph chart is shown in fig. 8.

A-Circuit Selector

This selector consists of a direct-driven relay chain with the function of connecting the ten A test circuits one at a time. Associated with the relay set are 10 cut-off keys *ABK 1—10* and 12 lamps (fig. 6). The function of the keys is to disconnect an unwanted A test circuit. At the same time the corresponding positions in the relay selector are cancelled. By means of two relays in the control relay set, the relay selector also controls indirectly the remote-controlled A circuit selector.

The 10 lamps *AL 1—10* indicate that the corresponding circuit is ready for testing. Two red lamps indicate fuse alarm and the connection of wrong battery polarity to the test equipment.

Number Selector

The number selector consists of a direct-driven relay chain which, with the assistance of three relays in the relay set for the program selector, controls both the B circuit selector used for the home exchange and the remote-controlled B circuit selector. Associated with the relay set are ten cut-off keys *BBK 1—10* which cause the connection to by-pass the respective B number (fig. 6). The ten lamps *BL 1—10* indicate which test number is connected at any given moment.

Control Relays

The relay set contains 12 relays, 10 keys and 11 lamps.

The keys have the following functions (cf. fig. 6):

Keys

1.		spare.
2.	*V*	down: battery voltage connected to all relay sets.
3.	*St*	down: start of test cycle.
4.	*Rk*	down: check of subscribers' meter signals.
	Sk	up: check of noise level.
5.	*1 s*	down: check of one ringing signal only.
	Ak	up: check of register connection.
6.	*Up*	down: test to engaged B line.
	K	up: test to circuit connected for code answering.
7.	*La*	down: connects tester's alarm equipment to central alarm system.
	L	up: lights lamps on control panel.
8.	*0*	down: "0" transmitted as first digit of all test numbers.
9.	*KO*	permits connection of three sensitivity ranges in tone receiver.
10.	*Dk*	down: tester operates as automatic service observation equipment.
	Fi	normal position: the tester operates as automatic fault indicator. It stops on the first faulty connection encountered and locks it.
	Ly	up: same function as in normal position, but with loudspeaker connected for monitoring.

The ten lamps indicate positions 1—10 of the program selector; positions 11—20 are indicated by the ten lamps working in conjunction with lamp No. 11.

Auxiliary Relays for Number Selector

The relay set contains ten 20-point test number jacks *PJ1—PJ10* and ten relays, each relay being controlled by its corresponding *BBK* key on the number selector.

The test number jacks *PJ* are wired as follows:

Terminal	1	Digit cancellation, by-passing in program selector.
"	2—10	Nine stop circuits, one for each digit.
"	11—20	Translation circuits, one for each digit in the sequence 1—9—0.

Each test number jack permits the transmission of any nine digits in succession. In addition, a tenth digit can generally be transmitted before each such group of nine digits (control key *0*).

The ten relays of the relay set each connect the nine stop circuits so that the numbers of the test number jacks correspond to the same positions of the number selector. Depression of a *BBK* key prevents the transmission of the corresponding series of digits.

Impulse Transmitter

The impulse transmitter consists of a relay chain for digit translation. The impulse loop is drawn via a terminal block on which there are facilities for connecting both line resistance and insulation resistance.

The relay set contains one relay for interruption of the A loop and one for switching the loop between tone receiver and impulse contact.

The impulse relay is designed to give a 67 % break ratio at 10 impulses per second.

For an impulse frequency of 20 impulses per second and 67 % break, a transistor-controlled impulse transmitter is used instead.

Tone Receiver

The tone receiver is entirely transistorized and made up of minisets, each being accommodated in the relay set via 20-point plug and jack for ease of replacement. The tone receiver consists of three main units:

basic amplifier
pre-amplifier
monitoring amplifier.

Five relays and a loudspeaker complete the unit.

For tone reception a relay connected to the basic amplifier operates and indicates to the equipment that a tone of at least minimum level is arriving. The basic amplifier is practically independent of frequency and can be set to the following three grades of sensitivity in respect to the minimum incoming level of the tone:

50 mV	100 mV	250 mV

The sensitivity is selected by means of key *KO* in the control relay set.

For test of noise level the circuit is switched to the pre-amplifier, the following grades of sensitivity corresponding to the basic amplifier being then obtained:

2 mV	8 mV	25 mV

These three values apply to a frequency of 1000 c/s and change psophometrically with higher or lower frequency of the incoming noise.

The monitoring amplifier is connected to the basic amplifier by means of key *Ly*. This connection permits monitoring in the loudspeaker of, for example, a 2 mV disturbance or a 100 mV register connection tone of roughly the same volume.

Program Selector

The program selector consists of a relay chain of 10 relays which perform two cycles and thus provide 20 working positions. The relay set contains the most important relays for the interrelated functions of the A circuit selector, number selector and B circuit selector.

The 20 positions of the program selector are as follows:

Test to free B test circuit

Position	
1	Digit *0* or by-pass.
2—10	Digit transmission.
11	Check of reception of ringing signal by B circuit selector.
12	Check of reception of 2nd ringing signal by B circuit selector, or by-pass (*1 s*).
13	Ringing tone or by-pass (*1 s*).
14	Check of noise or by-pass (*Sk*).
15	Answer from B, check of transmission by means of tone from B to A.
16	Check of metering and that connection has not been unwarrantedly cut off for more than 2 seconds (*Rk*).
17	Disconnection of B circuit; the call should be cleared.
18	Auxiliary position, stepping.
19	Auxiliary position, stepping.
20	Disconnection of A circuit—return to normal.

Test to engaged B test circuit (Up)

1—10	Digit transmission as above.
11—18	Stepping on receipt of busy tones.
19	Stepping.
20	Disconnection of A circuit—return to normal.

Test to code answering number

1—10	Digit transmission as above.
11	Reception of code tone, direct stepping to 20.
20	Disconnection of A circuit—return to normal.

The notations within brackets indicate that the check is performed only if the respective key on the control panel is thrown.

The program selector passes its 20 positions in each test cycle and then sends a stepping impulse to the number selector and B circuit selector at the end of every connection, whether correct or faulty. When the tester is used as fault indicator, the program selector stops on the position where a fault is encountered. Indication of the type of fault is obtained from lamps *LL1—LL11* in the control relay set.

Timer

The timer consists of three relay chains driven by two capacitor-slugged impulse relays. By the arrangement of the wiring on a terminal block, ten different time indications are obtainable between 2 seconds and 3 minutes 58 seconds for different functions of the tester. The timer starts and indicates relative time at 2-second intervals from the moment when register tone is recorded by the program selector. For testing of multimetering the timer is reset by an impulse from the exchange master clock. At position *16* of the program selector a check is thereafter made that the metering of the connected A circuit is correct for the period in question.

Power Distribution

The relay set contains individual 3A fuses for each relay set and a control relay for application of voltage to all relay simultaneously. A rectifier in series with the control relay prevents damage to the equipment as a result of reversed polarity. When used for service observation, the total consumption of the tester is about 0.75 A.

The relay set also contains certain auxiliary relays for identification of tones.

B-Circuit Selector

The relay set contains 16 relays, a transistor type tone generator, 10 lamps and a key for connection of the lamps. For tests to a remote exchange the selector can be placed in a spare position at that exchange.

Calls, requirement of answer indication, and stepping to the next B number are signalled to the B selector. Ringing signals are repeated on calls from the B selector. After answer indication from the B number, an 800-cycle tone is sent from the tone generator via the speaking wires and the test circuit to the tone receiver.

The particular B number under test at any given moment can be observed on the ten lamps.

Remote-controlled A-Circuit Selector and Code Answerer

The A-circuit selector is located at a remote exchange for selection of max. ten A test numbers. It is controlled from the traffic route tester at the main exchange and works in synchronism with the latter's A selector. In reality the selection of A test number has thereby been transferred to the remote exchange. The relay set contains 12 relays, 10 lamps and a key for lighting the lamps in the event of identification of the connected A number being required.

The code answerer is connected at the remote exchange as answering device for the desired B number. It provides a check of the test traffic only on calls from the main exchange to the exchange at which it is connected. It requires no control wires for its operation. The relay set contains seven normal relays, a transistor-controlled tone generator and a transistor-connected time relay.

Summary

In the design of the traffic route tester all possible consideration has been given to its reliable functioning. All circuits and components have been thoroughly tested at laboratories and test rooms, and the tester has been used by telephone administrations for several years with very good results. It has proved an admirable aid both for determination of the quality of service of an automatic telephone system and for fault tracing.

As stated in the introduction to this article, the traffic route tester operates as a completely normal A or B subscriber in relation to the exchange. It sets up correct connections without using marginal tests, and spans the entire exchange equipment as well as junction and rural circuits. It can also be advantageously used for tests on fully automatic long distance lines. Its use is not affected by the type of exchange equipment. It can be used equally well on old or modern systems of L M Ericsson's manufacture. By use of the remote-controlled selectors for A and B test numbers, and of the code answering equipment, a large number of traffic combinations can be tested in a single program.

The information provided by the traffic route tester is unambiguous and easily analysable. To obtain the maximum benefit from the tester, however, the test program must be arranged to suit the existing equipment in the exchange or exchange area, the traffic conditions, circuitry etc. L M Ericsson is always willing to make its experience available in the preparation of test programs.

Brief Presentation of the Theory of Telephone Traffic

A ELLDIN, TELEFONAKTIEBOLAGET L M ERICSSON, STOCKHOLM

U.D.C. 654.15.001.1

The article presents a survey of the problems presented by the theory of telephone traffic and of the means, in the form of mathematical models and measurements, employed to solve them. The subject has been earlier dealt with in an article in the Swedish journal, "Teknisk Tidskrift", Stockholm, No. 5, 1958.

The costs of an automatic telephone plant may be divided into two parts, those relating to the number of connected subscribers and those relating to the telephone traffic. The theory, or technique, of telephone traffic is concerned with the factors affecting the quantities of telephone equipment required to carry the traffic, and is based on statistical methods specially developed for the purpose.

Mathematical Description of Properties of Telephone Traffic

Telephone traffic is initiated by a number of individuals (subscribers). They make calls and hold switching devices fairly independently of one another, but with a certain similarity in their habits. Thus, apart from purely random variations, telephone traffic is found to be subject to both daily and seasonal variations. It also has a tendency to increase with time. It reaches a peak at a particular time of the day, which attains a maximum in a particular month of the year. A certain variation between different weekdays is also distinguishable. During the busiest time of the day the traffic conditions are characterized by a certain stationariness.

This description of the properties of telephone traffic conforms well with the modern theory of time-series analysis, according to which time processes are described by random variations, periodicity, seasonal variations and trends. It was also realized at a very early stage that telephone traffic is best described by a statistical model. The simplest subject for description is the traffic during the busiest part of the day, when the traffic process shows stationary properties. In general terms it may be said that the traffic conditions in the switches, circuits and other traffic-carrying devices are determined by the times at which the calls are initiated and by the duration of the individual calls. In describing the sequences of calls the Danish mathematician *A K Erlang* (1878—1929) made the assumption that

$$y \cdot dt \tag{1}$$

is the probability of a call being made within the interval $(t, t + dt)$, where y is the calling intensity. Assumption (1) premises that the calls are delivered by a large number of subcribers with a finite aggregate calling intensity.

Taking into account that already conversing subscribers cannot call until their conversation is completed, Erlang made the further assumption that

$$(N-p) \cdot \alpha \cdot dt \tag{2}$$

is the probability of a call being made within the interval $(t, t + dt)$ from N subscribers when p of them are engaged. The calling intensity per subscriber (single source) is α when the subscriber is free.

From assumptions (1) and (2) it is apparent that the probabilities of calls are independent of the absolute time t. In the former case (1) this probability will also be independent of the number of sources that are momentarily engaged. From (1) it follows that the distribution of the intervals between successive calls has the frequency function

$$f(t) = y \cdot e^{-yt} \tag{3}$$

The calling intervals have accordingly an exponential distribution. The probability of exactly ν calls during the time T is then described by means of the Poisson distribution

$$P(\nu) = \frac{(yT)^{\nu}}{\nu!} \cdot e^{-yT} \tag{4}$$

where yT is the mathematically expected number of events (calls) during the time T.

Measurements of telephone traffic have shown these assumptions to be in satisfactory accordance with reality when the description is limited to the busiest time of the day (the busy hour). And in determining the quantities of telephone equipment for a given level of traffic, it is the busy hour traffic that is of primary interest.

To describe the duration of telephone calls, Erlang introduced the assumption that the probability of a conversation being completed in the interval $(t, t + dt)$ is

$$\frac{dt}{s} \tag{5}$$

s being the mean duration of conversation. This probability is independent both of other simultaneous conversations and of when the conversation started. The assumption implies that conversation times are exponentially distributed with the frequency function

$$f(t) = \frac{1}{s} \cdot e^{-\frac{t}{s}} \tag{6}$$

Based on the assumptions (1) and (5), and (2) and (5), Erlang obtained a description of telephone traffic, i.e. the distribution of the number of simultaneous conversations. By describing the events as a special type of stochastic process, and by assuming statistical equilibrium, he arrived at a sufficiently realistic description. This method of representation, known as equations of state, is the foundation of the theory of telephone traffic.

To describe the properties of telephone traffic during a longer period than the busy hour, *Palm* (1943) introduced a modification of the Erlang model. He assumed that the traffic intensity was subject to discontinuities during the day. An arbitrary magnitude of state $F(y)$, depending on the intensity y, is said to have the mean value

$$\int_0^{\infty} F(y) \cdot dH(y) \tag{7}$$

where $H(y)$ is the distribution function of the intensity y for the period under consideration. The traffic is said to have "inert variations of intensity", implying that the intensity changes with a certain inertia so that the phenomena of oscillation around each discontinuity may be disregarded. For cases in which the fluctuations have an essential influence, Palm introduced the concept of traffic subject to "rapid variations in intensity".

The validity of Palm's model of inert variations was tested in 1941 by extensive measurements at the Östermalm telephone exchange, Stockholm. Palm's investigations will probably become of growing importance in the future, since they provide the means of making calculations for longer periods than the busy hour.

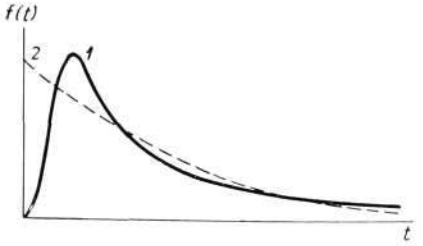


Fig. 1 X 2281

Distribution of conversation times

1 measured distribution
2 exponential distribution

Subscribers' Habits and Reactions

A knowledge of the general habits of subscribers is of prime importance in the calculation of telephone systems. Certain characteristic patterns of behaviour are distinguishable irrespective of the type of system in use. Such patterns include the already mentioned daily and seasonal variations, and certain properties of holding and conversation times. Other habits are partly influenced by the type of telephone system, since the subscribers adapt themselves to some extent to its properties. Instances of this latter point are how subscribers react to delays and congestion and to the called number being engaged.

Measurements of conversation times at different exchanges and on different occasions have yielded the type of distribution shown in fig. 1.

The same type of distribution has been observed for subscribers' dialling times and for the number of calls per subscriber and quarter. There is reason to suppose that this type of distribution occurs also in other situations into which the human factor enters.

(The distribution curve in fig. 1 diverges slightly from the assumption of exponentially distributed holding times. The significance of this was studied by, among others, Palm who also put forward alternative and improved methods of describing this distribution.)

A point of interest in respect to the distribution of conversation times is how the parameters change on conversion from one telephone system to another, as for example from manual to automatic working, on introduction of a new telephone tariff, and during the course of the day. These phenomena, which affect both the investment costs and the income of telephone administrations, have been the subject of study in various connections.

In telephone systems in which a limited number of subscribers form an independent group with their own switching equipment, it is of vital interest to know the distribution of traffic originated by individual subscribers. Subscribers employ their telephones to a very different extent. The design engineer will wish to know how many of the subscribers may be expected to use the telephone during the busy hour. It is known that a small number of subscribers usually answer for the lion's share of the traffic and that a surprisingly large number make no calls at all during the busy hour. These circumstances are important in estimating the requirements of the small groups of subscribers using, for example, line concentrators and multiparty lines.

Lost Call Systems and Delay Systems

To elucidate the reactions of subscribers under conditions of congestion, it is necessary to touch upon the terms "lost call system" and "delay system", which define what happens to a subscriber if he finds all switches in a stage engaged. In a lost call system a new call must be made, whereas a delay system implies that a subscriber waits for a switch to become free so that the connection can be completed.

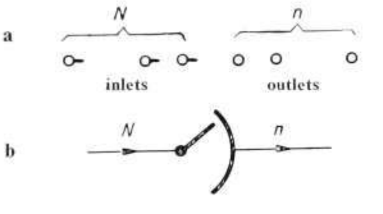
The way in which subscribers react to busy tone and waiting has a certain influence on the traffic conditions. The theory of telephone traffic makes two assumptions which imply certain limits to subscribers' reactions. For a lost call system it can be assumed that a blocked call does not give rise to a renewed call. For a delay system it can be assumed that waiting calls remain waiting until completed, irrespective of the time of waiting. These two assumptions are the most common ones.

But they are not fully realistic, since it may be expected that a blocked subscriber makes a renewed call in a lost call system, and that certain subscribers will not have patience to wait in a delay system. This circumstance has been taken into consideration by the introduction of modified assumptions regarding the way in which subscribers react to congestion and waiting. The higher the level of congestion, the more important are these subscriber reactions in the switch calculation.

The traffic conditions will differ slightly for the two types of system. It is understandable that a greater number of attempted calls per handled erlang will be made in a lost call system than in a delay system. On the other hand, in a delay system, the switching circuits will also be loaded by waiting calls.

Methods of Grouping in Telephony

A telephone system is made up of a number of successive selector stages. The inlet to the subsequent stage is generally given by the chosen outlet in the preceding stage. Consideration of the traffic conditions is usually limited to one selector stage or to one selector unit at a time.



X 2282
X 2283

Fig. 2

Full availability group

a individual symbols

b ordinary switching symbols

A distinction is made between three methods of grouping of selectors in a selector stage:

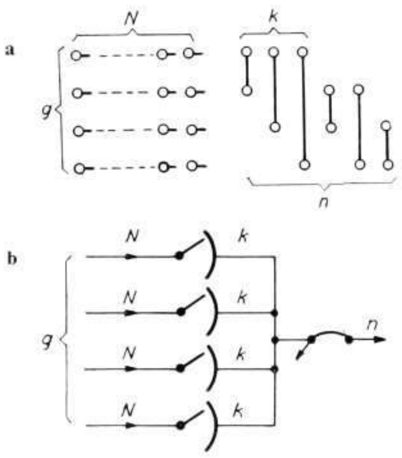
Full availability groups

Gradings (limited availability)

Link systems

A full availability group (fig. 2) is characterized by the fact that all inlets in a selector stage have direct access to each outlet.

In fig. 2 N inlets have access to n outlets. From the traffic point of view it makes no difference whether the choice is from N to n or vice versa.



X 2284
X 2285

Fig. 3

Grading

a individual symbols

b ordinary switching symbols

A grading (fig. 3) is characterized by the fact that the inlets have access solely to certain outlets of the group (limited availability), and that at least some of the outlets are accessible from different groups of inlets. Moreover a grading shall not be divisible into mutually independent parts. The grading in fig. 3 has $g \cdot N$ inlets divided into g groups (inlet groups), each group having access to a combination of k outlets unique to the group. In all, there are $n > k$ outlets. Recourse is had to grading when the traffic on any route requires more circuits than a single selector with "hunting capacity" k can reach. As dictated by engineering requirements, such as design of racks or control units, the inlets are divided into a number of groups, g. With g inlet groups the grading can have at most

$$n \leq g \cdot (k-1) + 1 \tag{8}$$

circuits, if it is to be indivisible.

A link system (fig. 4) is characterized by the fact that the connection between inlets and outlets is effected through links. Connection is established only if a free link is available and has access to a free outlet on the desired route. A link system may also be built up of more than one intermediary stage of links. The link system in fig. 4 has $n \cdot k$ inlets and $m \cdot v$ outlets. The inlets are divided into k columns. Every column A has access to m links and every link has access to v outlets in C, the outlets being in the same row as the link. The outlets on the same route are placed in one or more columns.

Link systems are employed for the purpose of combining the technical advantages of small capacity selectors with the high level of equipment utilization characteristic of high hunting capacity. Thus the main crossbar switching systems of today are almost without exception designed on the link grouping principle. Link systems are often combined with grading by grading of the outlets from different link system units.

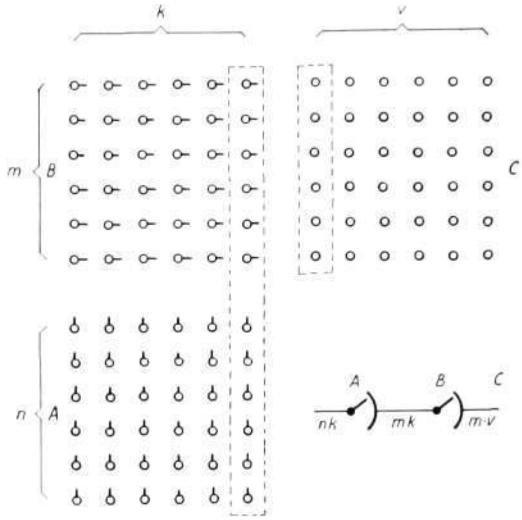


Fig. 4
Link system

X 2286

The three types of grouping occur both as lost call systems and as delay systems.

Methods of Calculation

Based on the description of busy hour telephone traffic given in formulae (1), (2) and (5), and on Erlang's method of equations of state under conditions of statistical equilibrium, methods of calculation have been developed for the groupings and methods of traffic handling that occur in practice. As regards the full availability group, exact solutions have been found for various alternative assumptions. Exact solutions of gradings and link systems are only possible for very simple cases. For practical design purposes the methods of calculation are based on approximations derived from the knowledge of the properties of the full availability group.

In studying the traffic conditions of any switching arrangement, the following factors must be taken into consideration:

1. The grouping
2. The traffic sources, i.e. the number of inlets and their calling intensity
3. The method of hunting for a free outlet
4. The distribution of holding times
5. The method of handling calls that cannot be immediately completed, i.e. lost call system or delay system. Also, what happens when calls are discarded; when all callers wait; and when all callers do not wait. And how the queue is dispatched in a delay system.

Full Availability Groups

Depending on the complexity of the particular case, a greater or smaller measure of consideration can be given to the conditions occurring in practice. The full availability group has been studied in respect to most of the alternative assumptions for factors 2—5, and is today about as well charted as the normal distribution in mathematical statistics. The only distribution that will be considered here is one given by Erlang, which may be said to be the basic method for the full availability group.

N single sources with calling intensity α have, when free, full access to n switches in a lost call system. The mean holding time is s. On the assumption of statistical equilibrium—that is that the process has continued for an infinitely long time, so that the conditions are no longer affected by the initial state—and of constant intensities, the probability $[p]$ of exactly p switches being engaged will be

$$[p] = \frac{\binom{N}{p} \cdot (\alpha s)^p}{\sum_{\nu=0}^{n} \binom{N}{\nu} \cdot (\alpha s)^\nu} \tag{9}$$

If $n < N$ this distribution, known as Erlang's Bernoulli distribution, is a truncated binomial distribution. It presupposes that discarded calls do not give rise to renewed attempts. The probability that all switches in the group are engaged (the time congestion) obtains when $p = n$.

By varying N in eq. (9) two limit values of the traffic distribution are obtained.

The condition when $N \leq n$ leads to a binomial distribution, usually referred to in this paper as the Bernoulli distribution,

$$[p] = \binom{N}{p} \cdot \left(\frac{\alpha s}{1 + \alpha s}\right)^p \cdot \left(1 - \frac{\alpha s}{1 + \alpha s}\right)^{N-p} \tag{9a}$$

where $\left(\frac{\alpha s}{1 + \alpha s}\right)$ is the traffic handled per single source. This distribution is of great importance in the practical design of, in particular, link systems.

If $N \to \infty$ and $\alpha \to 0$, whereas $N \alpha s = A$, an Erlang distribution is obtained:

$$[p] = \frac{\frac{A^p}{p!}}{\sum_{\nu=0}^{n} \frac{A}{\nu}} \tag{9 b}$$

For $p = n$, the expression is Erlang's First Loss Formula, also called Erlang's B Formula,

$$E_n(A) = [n]$$

B being his notation for the congestion.

For $n \to \infty$ we have

$$[p] = \frac{A^p}{p!} \cdot e^{-A} \tag{9 c}$$

i.e. the Poisson distribution with the mean value A simultaneous occupations.

Modification of the assumptions results in modification of the distributions in (9), (9a) and (9b). Interesting solutions are also obtainable for the full availability group when arranged as delay system. The theory of telephone traffic has been used for similar purposes outside telephony. Examples are the problems of idle time in conjunction with discharging and loading of ships in harbour, arrivals and departures of aircraft, self-service shops, road signals, lifts, servicing of machines etc. (Refer, for example, *Jensen* 1957.) Further developments outside the realm of telephony are to be expected.

Gradings

The treatment of equations of state for gradings is very complicated on account of the necessity of the grouping being represented in detail in the equations. The conditions are here affected by the following factors among others:

Number of sources in every sub-group of inlets.
Traffic offered from every sub-group.
Number of outlets accessible from every sub-group (the availability).
The interconnections, i.e. the manner of commoning the outlets for the various inlet groups.
Total number of outlets.
Method of hunting.
Lost call system or delay system.
Subscribers' reactions to congestion and delay.

These factors render exact solutions by means of equations of state possible only for certain special types of grading. The future prospects of these methods have, however, been improved since the advent of rapid electronic computers with high memory capacity. The majority of gradings encountered in practice are calculated by approximate methods of varying precision.

Link Systems

In connecting from inlet to outlet in a link system the accessibility is dependent on whether a free link can be combined with a free outlet. If the links of a B-column are considered in conjunction with the outlets of a C-column and called the interworking link and outlet of a pair, the distribution of the number of engaged pairs will be analogous to the distribution of the number of engaged switches in a full availability group. Four cases of switch occupation can render the pair unusable for connection between inlet and outlet in the link system. For the link system shown in fig. 4 these cases are as follows (see fig. 5).

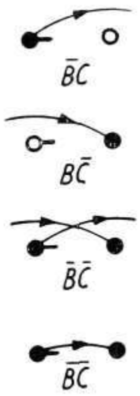


Fig. 5 X 2287

Four types of engaged pairs in a link system

1. ($\bar{B}C$) The B-link is engaged by connection to another outlet, but the C-outlet is free.
2. ($B\bar{C}$) The B-link is free, but the C-outlet is engaged by connection from another AB-column in the link system.
3. ($\bar{B}\bar{C}$) The B-link is engaged by connection to another outlet and the C-outlet by connection to a link in another AB-column.
4. ($\overline{BC}$) The B-link is connected to the outlet, i.e. both are engaged by an "internal" occupation.

The congestion in a link system is defined by the following general expression

$$E = \sum_{p=0}^{m} G(p) \cdot H(m-p|p) \qquad (12)$$

where $G(p)$ is the probability of p B-links being engaged in the B-column under consideration, and $H(m—p|p)$ the probability of the m-p outlets corresponding to free links being engaged. This probability is expressed in (12) as a probability conditional on p, in order to indicate that the two parts of the link system, B and C, are not independent of one another. Their interdependence is fairly complicated since the occurrence of the p occupations in the B-stage is naturally dependent on what other occupations exist in the outlets. Likewise the probability H for the m-p blocked outlets in the outlet column under consideration is dependent on the condition of the remaining B-columns. The interdependence between the links and outlets, however, becomes of less practical importance, the greater the number of B- and C-columns in the link system.

By considering G and H in (12) as independent probabilities, and using the distributions of the full availability group for G and H, fully satisfactory expressions of congestion are obtained for practical purposes *(Jacobæus, 1950)*. Investigations, moreover, have shown that the interdependence between links and outlets operates in a favourable direction, which means that the above-mentioned approximation for G and H gives congestion values with a reasonable margin of safety.

As regards link systems and gradings, the use of practical methods of calculation has been possible only for lost call systems. The difficulties inherent in delay systems are due to the necessity of introducing into the calculations the number of waiting calls in every inlet group in the grading and in every inlet column in the link system respectively. In addition, clear rules for the queuing discipline must be defined. For practical purposes the calculation is done as for lost call systems.

Traffic Measurements, Traffic Machines

Measurements of the traffic and congestion in a telephone exchange are usually made once to twice a year. The purpose of these measurements is to check the accessibility through the system and to serve as basis for planning of future extensions.

Like other modern mathematical statistics, the theory of telephone traffic takes reality as its yardstick. This means that every theoretical model that shows unsatisfactory conformity with reality should be modified. It also means that the theoretical methods must always be tested by measurement of actual telephone traffic.

When the problems become too complicated to handle by theoretical means, empirical methods are sometimes adopted. The attempt is made to estimate the importance of different factors by systematic measurements. The measurements may be performed either on actual telephone traffic or on artificial traffic. Apart from the difficulty of arranging the desired traffic conditions, it is often difficult to distinguish between the effects of different factors in the measurement of actual telephone traffic. The results are therefore often very diffuse and hard to interpret. In such cases artificial traffic measurements will be preferable. There are today a few traffic machines for this purpose in various parts of the world, of which the Swedish Traffic Machine, owned and operated jointly by the Royal Swedish Board of Telecommunications and Telefonaktiebolaget L M Ericsson, may be mentioned. In traffic machines a random traffic is simulated and made to operate on the grouping under study. Since the processes can be performed much more rapidly than is possible with actual telephone traffic, results can be obtained in a few hours which would otherwise take years to collect. These machines, which may be considered as analogue computers, are primarily intended for measurements of gradings.

Artificial traffic can also be generated by the drawing of random numbers, the drawn number indicating that a call is initiated or that a connection has terminated. Manually performed traffic trials generally take a long time, but have nevertheless been carried out. *Holm* (1919) was probably the first person to perform manual traffic trials. The generation of pseudo-random numbers in a digital computer, with the computer keeping count of the conditions in the group under study, leads to extremely precise measurements more quickly than is possible with a traffic machine. A method developed by *Neovius* (1955) for the Swedish *BESK* digital computer gives the same quantity of measurements as the Swedish Traffic Machine in one-fiftieth to one-fifth of the time. Traffic measurements made with the help of digital computers also have the advantage that any desired grouping can be programmed, whereas a traffic machine usually requires to be modified mechanically in order to handle a new grouping. The use of digital computers for the study of theoretically complicated cases is thus feasible.

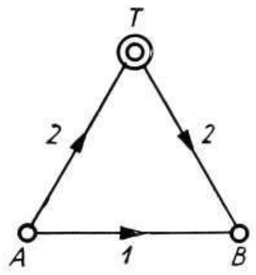
Despite the great opportunities offered by traffic machines and computers for the elucidation of complicated problems, work on theoretical problems must continue in order to explain the functional relations. Measurements of actual traffic must also be made as a check that one is in touch with reality. However admirable the mathematical model, it will be of little value without an adequate counterpart in reality.

Economic Aspects, Design Standards

In order to guarantee subscribers almost complete access throughout the telephone system, the various selector stages are designed, under present standards, for a very small probability of congestion during the busy hour at the busiest season of the year. There is always reason to enquire whether existing standards of congestion are economically warranted. The question should be considered in the light of how income and expenditure are affected by design standards. The loss of income as a result of congestion must be capable of estimation by reliable methods. This means taking into account that a subscriber, on encountering congestion, sometimes makes a new attempt to call at a less busy time of the day. The consequences of technical faults must also be considered. A further subject for speculation is how different types of telephone tariffs affect telephone traffic, and so telephone income. On the expenditure side, both running costs and amortization costs must be considered. The technical design of the telephone system and the technical requirements imposed on it must naturally be taken into account. As a rule, too little is yet known of the factors affecting the economy of telephone operation to give general rules for tackling the problem. Conscious and coordinated research will, however, undoubtedly lead to the elaboration of such rules in a not too distant future.

Certain progress has already been made in this direction. Mention may be made of the principle of marginal utility applied to telephone conditions, known in telephony as Moe's principle after the Danish telephone engineer *K Moe* (1893—1949). For a given total congestion between the calling and called subscribers, the rates of congestion in different selector stages and groups of switches can be chosen in accordance with Moe's principle so that the total cost of the system is kept at a minimum.

A similar means of arriving at the economic optimum is the use of alternative routing in the design of telephone networks. On the origination of a call from one exchange to another, the attempt is first made to seize a direct circuit and, if unsuccessful, the connection is passed via a tandem exchange (fig. 6). The number of direct circuits designed for a high level of congestion, and the number of tandem circuits designed for low congestion, are so balanced as to keep the total cost at a minimum. Alternative routing arrangements are often used when the cost of the junction plant represents a major proportion of the total cost of the system. Very considerable savings may be made by correct design of the circuit arrangements.



X 2288

Fig. 6

Alternative routing

1 direct route AB
2 alternative route ATB

Conclusion

In the present advanced state of development of the theory of telephone traffic one may enquire to what extent telephone engineers of today and of to-morrow need be acquainted with its workings. Telephone traffic is one of the most pregnant, practical examples of statistical phenomena. Consequently, the technician should be well acquainted with statistical ways of thought in order to be able to judge the significance of the traffic phenomena he encounters at a telephone exchange. In order to be able to form a judgement on design questions, moreover, he should have a certain knowledge of the distinctions and methods of calculation employed in traffic theory. Just as it is demanded of him today that he should have a certain insight into automatic techniques, the theory of electricity, filter techniques and acoustics, he should also be acquainted with telephone traffic theory.

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Central Dictation through Private Automatic Telephone Systems

E LARSON & O SUNDÉN, TELEFONAKTIEBOLAGET L M ERICSSON, STOCKHOLM

U.D.C. 681.847.1
621.395.24

Machine dictation, i.e. the recording of text in a recording machine, can now be done telephonically through a private automatic telephone system. The normal telephone instrument is used, and the entire control of the recording machine is exercised through the agency of the dial. A special relay equipment developed by L M Ericsson for this purpose is added to the automatic switchboard, and the recording machines are usually located in a central transcribing department. This article presents certain aspects of machine dictation and briefly describes the relay equipment involved.

Machine Dictating Systems

Three main systems can be used for machine dictation.

1. Individual recording machines — decentralized recording

Every "dictator" or executive has his own recorder and the records are sent to a secretary for transcription.

Advantages

The recorder is always free for dictation, is simple to manipulate and is under the executive's complete control.

Disadvantages

The system is expensive if many machines are required. One way of overcoming this difficulty is that persons who regularly dictate should have their own recorder, while others loan machines from a central pool.

Applications

The system is used mostly when transcription is decentralized. It therefore lies outside the scope of this article.

2. Special dictating telephones — centralized recording

Every user of the system has a special telephone instrument from which he can dictate to a central recording department containing the necessary number of recorders.

Advantages

Less recorders will be required than in the previous case.

All transport of records, tapes, rolls etc. is eliminated.

Disadvantages

Each person must have a special dictating telephone. The system requires a considerable quantity of cabling, with consequent addition to the installation

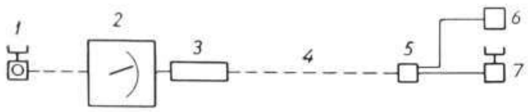


Fig. 1 X 2294

Block schematic for connection of recorder to automatic telephone switchboard

1 extension telephone
2 automatic telephone switchboard
3 relay equipment (DMR)
4 cable between switchroom and central transcribing dept
5 connecting box for termination of recorder
6 recorder
7 secretary's telephone in central transcribing dept

cost. Persons who do regular dictation can be provided with a set of their own, while others may possibly have to use "dictating kiosks" for general use.

Applications

The system is well adapted to offices in which there is a high volume of dictation per "dictator".

3. Dictation to central recording equipment through ordinary telephone system

In this system all extensions of the private automatic exchange can dictate to the central transcribing department at any time.

Advantages

No special measures are required to enable a person to dictate.

No separate cabling.

During dictation the normal telephone instrument is engaged, so that there is no need to worry about being disturbed by internal telephone calls.

The system is generally cheaper than the two previous systems.

Disadvantages

The automatic switchboard has to carry the dictating traffic and must therefore be of rather larger capacity than usual.

In P.A.B.X. systems it may be a disadvantage that the executive's telephone is engaged, so that he does not receive calls from the public telephone system while he is dictating.

Applications

The system can be specially recommended for offices where the number of "dictators" is large in relation to the total quantity of dictation.

The following account will be concerned with system 3.

Equipment and Operation of a Central Dictating System

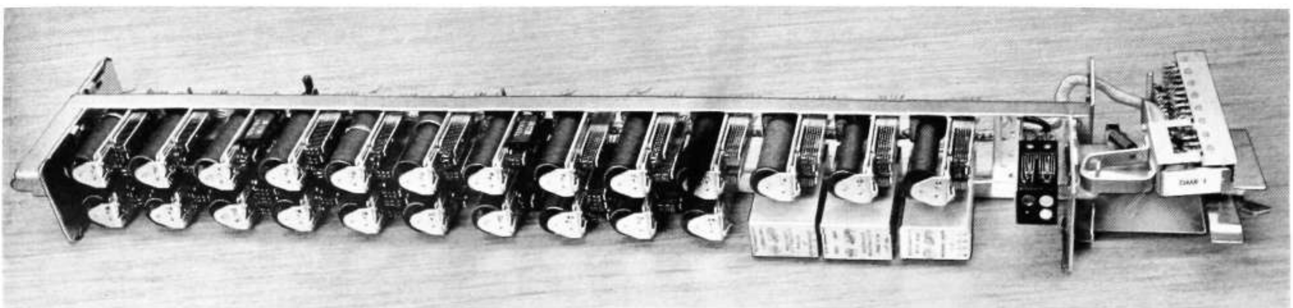
Equipment

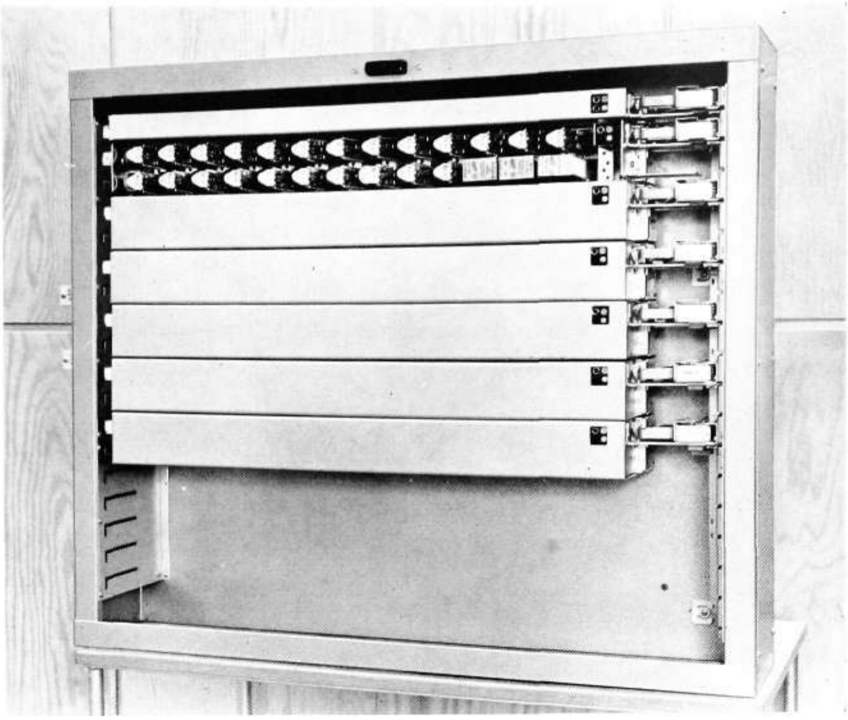
The general layout of the system is shown in the block schematic in fig. 1. Every dictating machine is connected to the telephone switchboard via a relay set *DMR* (fig. 2).

The relay set can be placed either in a separate rack beside the switchboard, or in the switchboard itself if space is available.

Fig. 2 X 7732

Relay set DMR (BCH 12), cover removed





X 8071

Fig. 3
Rack BDH 10
for max. 8 relay sets DMR

A rack type *BDH 10* for max. 8 relay sets *DMR* is shown in fig. 3. This rack is made for wall mounting.

Between the *DMR* relay rack in the switchroom and the central transcribing department there is a multi-wire cable which terminates in a connecting box for termination of the dictating machines.

The relay sets are available in different designs for various types of L M Ericsson automatic switchboards.

The connection to the dictating machine, however, is standardized and conforms fully with the American Bell system standards which are already being adopted by the majority of manufacturers of dictating machines.

Operation

The relay set *DMR* is connected to an extension number. If several relay sets are installed, they are connected to a group number in the telephone switchboard.

The dictating machine is controlled from the dial of the extension telephone, for which purpose the following digits are used:

1 start and stop of dictating machine
2 correction indexing
3 backspacing
4 end-of-letter indexing
5 telephone call to secretary

The dial impulses are transmitted to relay set *DMR*, the relays of which control the dictating machine.

To start dictating, the executive dials the number of the dictating machine and, after connection to the machine, hears continuous buzzer tone. If the machine is engaged or not ready for dictation, the caller receives busy tone.

The dictating machine is started by dialling digit *1*, whereupon the buzzer tone ceases and dictation can begin. The machine is likewise stopped by dialling digit *1*, whereupon continuous buzzer tone is returned. In this way the machine can be alternately started and stopped any number of times during dictation. It is also possible to connect a dictating machine equipped for voice-controlled starting and stopping. In the latter case the machine starts automatically as soon as dictation begins, and stops at every pause in dictation. The need of dial-controlled starting and stopping is hereby eliminated.

Correction indexing during dictation is indicated to the machine by dialling digit *2*.

Backspacing is indicated by dialling digit *3*, which switches the machine to playback and the executive hears the latter part of his recorded text. Playback is interrupted by dialling digit *1*, which returns continuous buzzer tone. To continue dictation he dials digit *1*. As long as the machine is switched to backspacing, a faint intermittent buzzer tone is heard, indicating to the executive that the machine is not connected for recording. The length of the playback period is limited by a timing device to avoid unnecessary blank spaces on the record. After a certain time (max. 40 seconds) continuous buzzer tone is heard unless digit *1* is dialled.

End-of-letter indexing is indicated to the dictating machine by dialling digit *4*, whereupon continuous buzzer tone is received. If digit *1* is again dialled, the buzzer tone ceases and the dictating machine starts again. End-of-letter indexing by dialling digit *4* is unnecessary if the dictation comprises a single letter, and likewise after the last letter in a series of dictations, since end-of-letter indexing is automatically indicated to the machine when the handset is replaced at the extension telephone.

A secretary's telephone in the central transcribing department can be called by dialling *5*. An intermittent ringing tone is returned to the caller, and the dictating machine stops. The ringing tone is cut off when the call is answered. When the secretary replaces her handset, continuous buzzer tone is emitted once again, after which the dictating machine can be started, as earlier, by dialling *1*.

For the large majority of firms and other organizations considering the introduction of machine dictating in place of the older method of dictating to a stenographer, the present system should provide the solution that comes closest to the ideal. The change-over from personal dictation to machine dictation in itself brings a saving in personnel, since only *one* person is engaged during actual dictation. Centralized transcribing permits better employment of secretaries than if each secretary works for a few executives, so that added savings are made on this score. Of all existing central dictating systems the one described here should prove the most practicable, since anybody, whether he dictates often or not, can dictate while sitting at his desk without any special measures being necessary. Reorganization or movements within the office can be arranged without affecting the dictating system.

New Capacitors for Power Factor Improvement

K HÄGGLUND, SIEVERTS KABELVERK, SUNDBYBERG

U.D.C. 621.319.4
621.761.2

Sieverts Kabelverk has manufactured capacitors since 1925. Designs and constructional materials have since then passed through many stages of development which have led to more efficient, more reliable and cheaper capacitors. These capacitors are now being installed to an increasing extent as a means towards rational utilization of electricity supply systems.

The present article deals with the design and methods of manufacture of the new capacitors that have been produced by Sieverts Kabelverk since 1955.

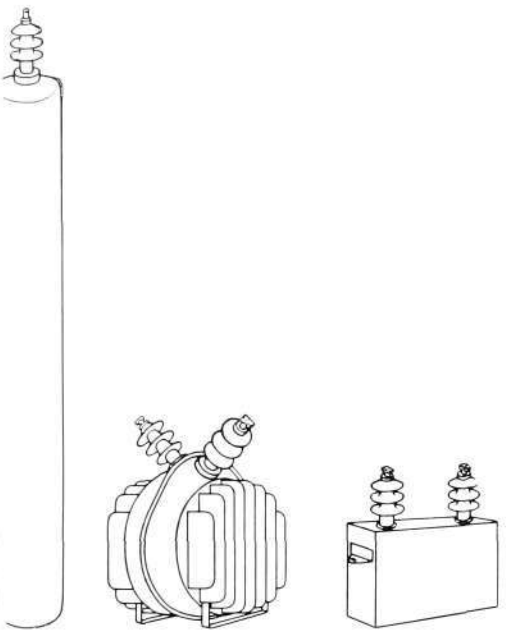


Fig. 1
Stages of capacitor development

General Features

The main characteristics of the new series of capacitor types *CR* and *CRK* are their appreciably higher output per unit of volume and weight than in the earlier designs (fig. 1). This was achieved by means of the following interrelated factors:

a) compact construction,
b) high vacuum drying,
c) low losses of capacitor paper,
d) high dielectric constant of impregnant.

Construction

The active parts of a capacitor are composed of two aluminium foils separated by several layers of impregnated paper (fig. 2). The paper varies in thickness between 8 μ and 20 μ (1 $\mu = 0.001$ mm or 0.00003937 in.), and the number of layers between 3 and 6, depending upon the voltage for which the insulation is designed. The capacitor elements are wound into rolls and, after removal from the winding machine, flattened out, compressed into packs, enclosed in an insulating cover and inserted into the container (fig. 3). The container is designed to take up the changes in volume of the impregnant caused by changes in temperature. After the lid with soldered bushings has been welded to the container, the capacitor is ready for drying and impregnation.

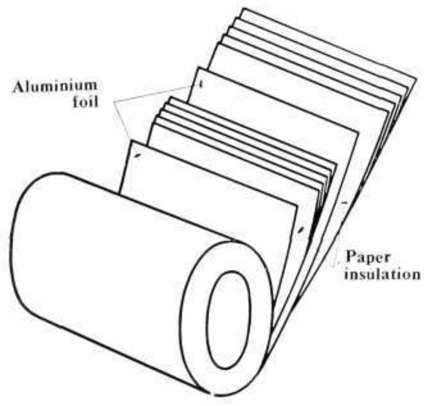


Fig. 2
Capacitor element

Drying and Impregnation

The drying and impregnating plant shown in fig. 6 consists of two horizontally mounted autoclaves for the capacitors, a degassing equipment for the impregnant, a storage tank for the degassed impregnant, and an extensive series of vacuum pumps. The latter consist of rotating pumps, oil jet pumps and diffusion pumps, and the final pressure both for drying the capacitors and for degassing and storage of the impregnant is lower than 10^{-3} mm Hg. Consequently, after impregnation, the insulation in the capacitors is entirely free from moisture and gas and has electrical properties of the highest standard obtainable at this time.

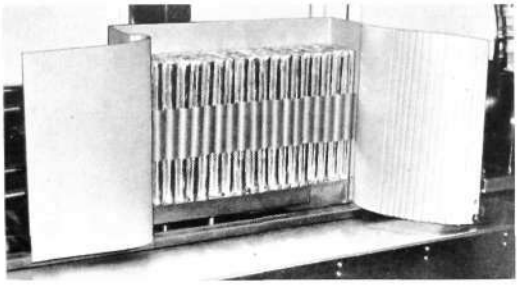


Fig. 3 X 2258

Pack of capacitor elements

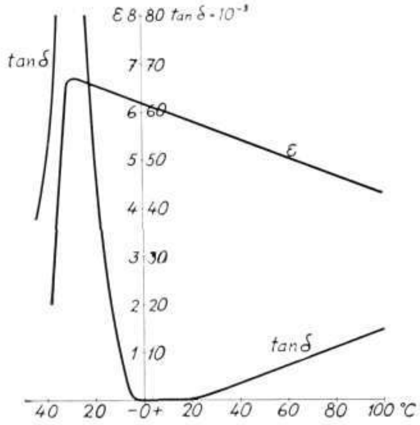


Fig. 4 X 2296

Temperature dependence of Siklonyl

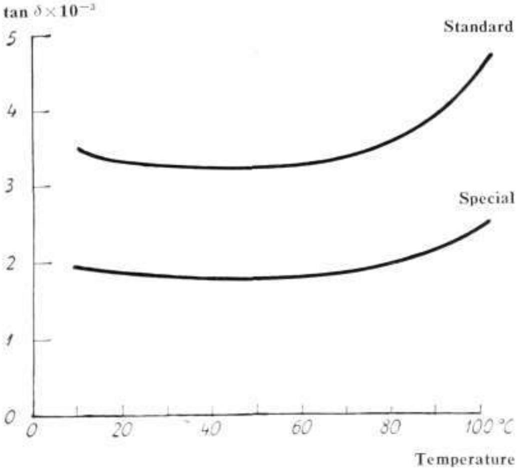


Fig. 5 X 2257

Loss factor of capacitors with standard and special type papers respectively, and impregnated with chlordiphenyl

Impregnant

The impregnant is Siklonyl, a chlorinated diphenyl. Siklonyl possesses the following advantages as compared with the previously used mineral oil:

a) It is chemically stable and will not polymerize, as mineral oils sometimes do (wax formation).

b) It has a high dielectric constant and gives a higher capacitance per unit of volume than mineral oil.

c) It has a high electrical strength and, since its dielectric constant is close to that of the cellulose fibres in the paper, there is no extra stress on the impregnant.

d) It is non-inflammable.

Siklonyl is a polar fluid, as evidenced by its temperature characteristics. This is shown for trichlordiphenyl in fig. 4. When the temperature drops, the fluid becomes increasingly viscous. The rotation of the dipoles is restricted, resulting in a greater requirement of dipolar work and greater losses (tan δ). When the fluid finally congeals, the dipolar rotation ceases and the losses decrease, although not to the same low level as before. The dielectric constant is also affected and falls rapidly during the solidification. These phenomena have no bearing on the functioning of the capacitor. If a capacitor that has cooled down to below the solidification point of Siklonyl is energized, the losses will be so appreciable that it rapidly warms up. The losses thereby decrease and the temperature reaches equilibrium.

Capacitor Losses

Fig. 5 shows the losses in capacitors made of paper of standard quality and special quality respectively, and impregnated with chlordiphenyl. It will be seen that the losses in special paper capacitors are about 50 % lower than in standard paper capacitors. The lowering of the loss angle from 0.35 % to below 0.20 % gives the capacitors a low operating temperature and therefore long life. In addition, the cost to the capacitor user, due to losses, will decrease. The capitalized cost of capacitor losses may be taken as being about 400 dollars per kW. If the loss factor drops from 0.35 % to 0.20 %, the loss cost diminishes by 60 cents per kVAr, which is roughly 15 % of the capacitor price per kVAr.

Testing of Capacitors

All capacitors are normally subjected to loss measurement, capacitance and voltage tests, phase to phase and phase to earth.

A one minute D.C. test is done with the following test voltage across the terminals:

$$U_p = 4.3\ U_m - 0.5$$

where U_m is the rated voltage indicated, like U_p, in kV.

The test voltage between phase and earth (container) is dependent on the system voltage and class of insulation as set out in table 1.

X 8063

Fig. 6
Impregnating plant

Table 1

System voltage kV	Normal insulation class	Test voltage d.c. 1 min. kV
0.5	K_1 3	5
3	K_s 40	40
6	K_s 55	55
10	K_s 75	75

The above routine test is in accordance with the Swedish Electrotechnical Standards SEN 2705, but can also be performed to comply with the standards of other countries or with international standards.

Types and Data

Power Capacitors Type CRK for 230—550 V

Types and power ratings as in table 2.

Table 2
Capacitor Units

Type	kVAr output at		
	250 V	400 V	525 V
CRK- 5	3.3	5.5	5.5
CRK- 8	5.0	8.3	8.3
CRK-10	8.5	14	14
CRK-20	12	20	20
CRK-40	24	40	40

The capacitors are made in two designs, one delta-connected, the other with all six phase terminals accessible and designated *CRK* and *CRK-YD* respectively. The latter design is suited for individual compensation of an induction motor with normal star-delta starting switch.

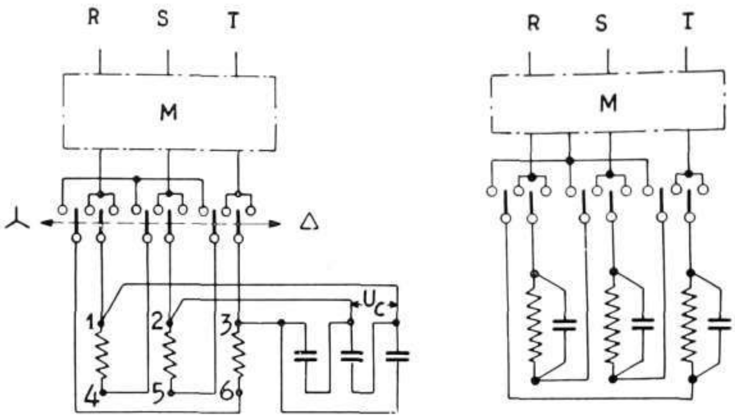


Fig. 7 X 2275 X 2276

Wrong (left) and right methods of connection with star-delta switch

If the capacitor is delta-connected, and connected to a motor with star-delta starting switch as in fig. 7 (left), high overvoltages may arise due to self-excitation during switching from star to delta. The reason for this will be seen from fig. 8, which shows the no-load current of a motor as function of the voltage when the motor is star-connected and delta-connected respectively.

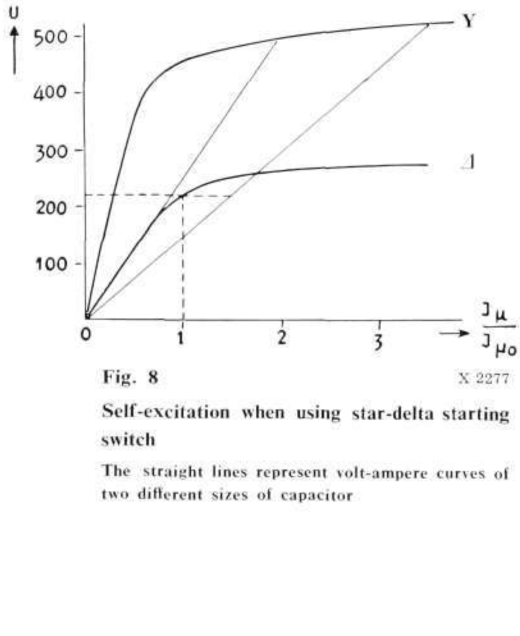


Fig. 8 X 2277

Self-excitation when using star-delta starting switch

The straight lines represent volt-ampere curves of two different sizes of capacitor

Fig. 8 also includes the volt-ampere curves of two different sizes of capacitor. One of the capacitors will barely compensate the no-load current of the motor, whereas the other capacitor is larger.

If contact with the line is broken during switching from star to delta, before the neutral point connection is broken, the motor will rotate independent of the line and steal the excitation power from the capacitor. The motor thus operates as a generator and the voltage across the motor rapidly rises to the level corresponding to the point of intersection between the no-load curve of the star-connected motor and the volt-ampere characteristic of the capacitor. The voltage attains its peak value, two to three times that of the rated voltage, within the course of a few cycles. Another disadvantage of this connection derives from the property of the capacitor to retain its charge during a long period.

Hence phase differences may arise when switching between star and delta, resulting in violent discharges which damage the breaker contact.

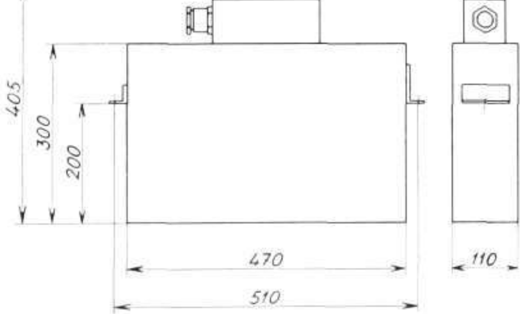


Fig. 9 X 2254

Dimensions in mm of low voltage capacitor unit CRK-20

If the capacitor is connected to terminals 4, 5 and 6 in fig. 7 (left), series resonance may occur if the neutral point connection is broken before disconnection from the line. This acts as a short-circuit and gives rise to currents and voltages of very high value. The difficulties are eliminated if the capacitor is connected in single phase as in fig. 7 (right).

For compensation of a large number of small motors and other inductive loads the capacitors are assembled into banks. These banks are built up of the delta-connected standard units and can be supplied with standard racking for outputs up to 200 kVAr. The standard banks are designated *CRK-FL*, their remaining data being listed in table 3. The banks can be supplied complete with breaker equipment and for automatic switching on and off. The

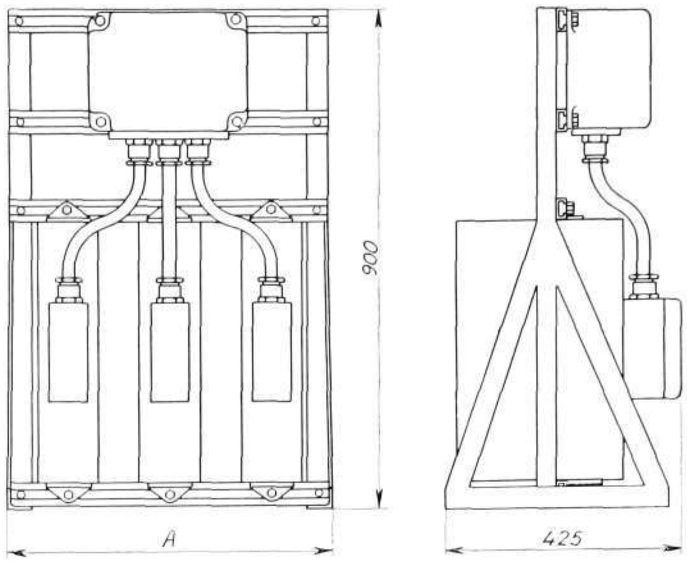


Fig. 10 X 8061
Standard bank type CRK-FL
Dimensions in mm

dimensions and design of a *CRK* unit are shown in fig. 9, and a standard battery of type *CRK-FL* in fig. 10. Fig. 11 shows an installed bank for 160 kVAr, equipped with a VAr-relay for automatic operation.

Table 3
Capacitor banks

Type	kVAr output at			Width A (fig. 10) mm
	250 V	400 V	525 V	
CRK 220 FL	24	40	40	400
CRK 320 FL	36	60	60	590
CRK 420 FL	48	80	80	780
CRK 520 FL	60	100	100	970
CRK 240 FL	48	80	80	420
CRK 340 FL	72	120	120	610
CRK 440 FL	96	160	160	800
CRK 540 FL	120	200	200	990

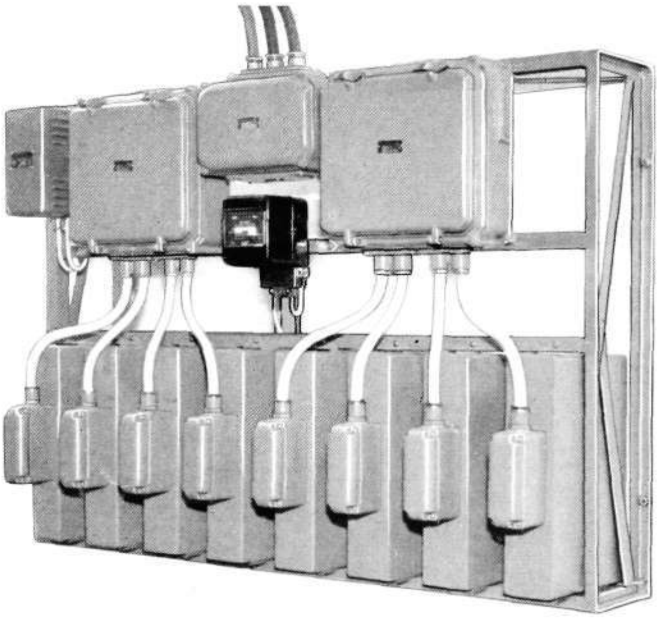


Fig. 11 X 8064
Capacitor installation

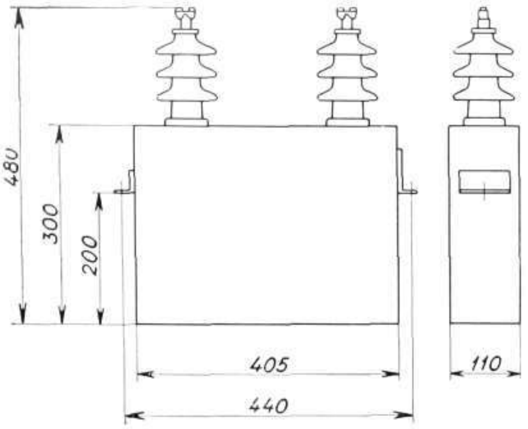


Fig. 12 X 2255

Dimensions in mm of high voltage power capacitor unit, 20 kVAr

High Voltage Power Capacitors Type CR

These capacitors are normally made for voltage ratings between 1 and 2 kV and rated outputs of 20 kVAr and 50 kVAr. By series-parallel connection of these units, capacitor banks can be built up for any desired voltage and output. The design of a unit *CR 20* is shown in fig. 12, and a capacitor bank for 18 MVAr at 10 kV in fig. 13.

Protective Equipment

Like other machines and equipment, capacitors and capacitor banks must have reliable protective devices that will rapidly limit the effects of faults. Sieverts Kabelverk, therefore, supply complete banks with the necessary protective equipment consisting of breakers, discharge devices, relays etc.

High voltage banks, which are usually star-connected, are normally given some form of unbalance protection. The bank may, for example, be divided into two parallel halves. Wired to the neutral points of the two halves is a current transformer. In case of failure in one of the halves, a current will flow through the transformer and energize a relay circuit in connection with the capacitor breaker or release a signal device.

Capacitors and banks for voltages below 600 V are, as already mentioned, normally delta-connected and protected by a breaker which, in the event of fault, disconnects all three phases of the unit or bank. External fuses alone for a delta-connected capacitor do not provide sufficient protection.

In addition to the external protectors the capacitors may be equipped with internal fuses which disconnect a part of the faulty unit.

Both high voltage and low voltage capacitors are normally equipped with built-in discharge resistors which rapidly discharge the capacitors.

The discharge time is 1 min. for high voltage capacitors and 30 secs. for low voltage capacitors, as specified by Swedish standards.

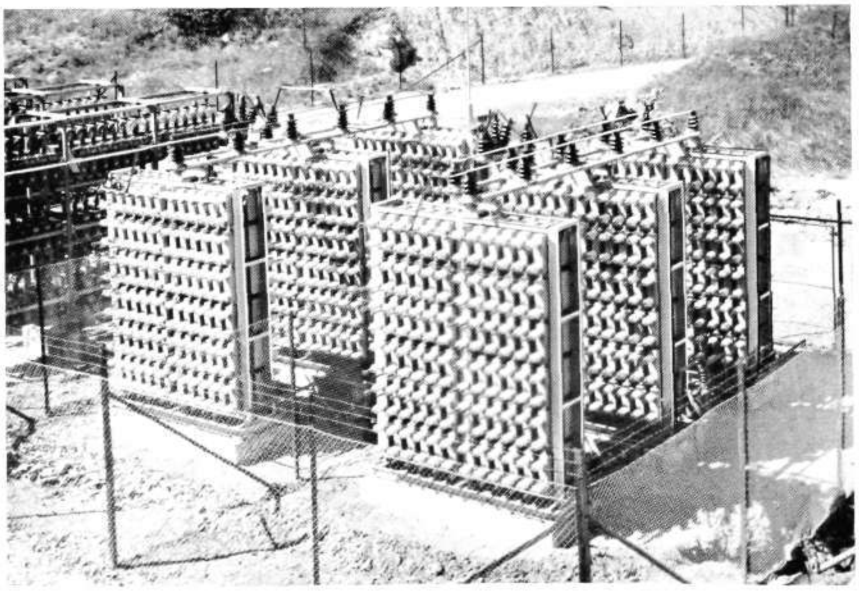


Fig. 13 X 8065

Capacitor bank, 18 MVAr

L M Ericsson Exchanges Cut into Service 1957

Exchanges with 500-line selectors

Town	Exchange		Number of lines
Argentine			
Paraná		(extension)	1500
Rosario de Tala		(extension)	100
San Juan		(extension)	2000
Bolivia			
Calacoto			200
La Paz		(extension)	5000
Sucre		(extension)	500
Brazil			
Aracajú			1500
Araçatuba			1000
Belém	Umarizal		500
Brusque			500
Campina Grande		(extension)	1000
Campo Grande			1500
Campo Mourão			300
Itararé		(extension)	100
Joaçaba			300
Jundiaí			3000
Mandaguarí			200
Nova Esperança			200
Piracicaba			2000
Sacramento			300
S. Luiz do Maranhão		(extension)	1000
Uberlandia		(extension)	1500
Colombia			
Barranquilla	Estadio	(extension)	3500
»	Sur	(extension)	500
Bogotá DE	Centro	(extension)	2000
»	Las Cruces	(extension)	2000
»	Muzu	(extension)	1000
»	San Fernando		3000
Medellín	America	(extension)	3000
»	Bosque	(extension)	1000
»	Centro	(extension)	4000
»	Poblado	(extension)	1000
Finland			
Ekenäs/Tammisaari		(extension)	500
Jyväskylä		(extension)	1000
Nokia		(extension)	300
Tuira			500
Turku/Åbo		(extension)	1500
Iceland			
Hafnarfjördur		(extension)	40
Reykjavik	Reykjavik II		3000
»	Grensås		3000
Italy			
North Italy			
Iesolo		(extension)	200
Monselice			500
Oderzo			500
Stra			300
Verona		(extension)	4000

Town	Exchange		Number of lines
South Italy			
Agrigento			2500
Bari		(extension)	3000
Caltanissetta		(extension)	1000
Castellamare del Golfo			400
Catania		(extension)	2000
Crotone		(extension)	100
Formia			600
Giarre Riposto		(extension)	80
Napoli	Vomero	(extension)	4000
Nocera Inferiore		(extension)	200
Potenza		(extension)	1000
Rossano		(extension)	100
Termini Imerese			800
Vibo Valentia		(extension)	20
Lebanon			
Beirut		(extension)	3500
Tripoli			6000
Mexico			
México DF	Peravillo	(extension)	500
»	Roma	(extension)	2500
»	Sabino	(extension)	3500
»	San Angel	(extension)	500
»	Saro	(extension)	1500
»	Valle	(extension)	2000
»	Zócalo	(extension)	1500
Netherlands			
Rotterdam	Centrum III		9500
»	Zuid II	(extension)	3500
Norway			
Grimstad			1200
Kristiansand S		(extension)	500
Kristiansund N		(extension)	800
Panama			
Panama City	Panama III	(extension)	500
Peru			
Arequipa		(extension)	500
Sweden			
Borås		(extension)	2500
Gävle		(extension)	1000
Gothenburg	Kålltorp	(extension)	2000
»	Mölndal	(extension)	1000
Hälsingborg		(extension)	2500
Jakobsberg		(extension)	500
Katrineholm		(extension)	1000
Kiruna		(extension)	1000
Kristianstad		(extension)	500
Köping		(extension)	500
Linköping		(extension)	3000
Skellefteå		(extension)	500
Stockholm	Aspudden	(extension)	1500
»	Huddinge	(extension)	1000
»	Hässelby	(extension)	1000
»	Lidingö-Villastad	(extension)	1000
»	Mälarhöjden	(extension)	1000
»	Råsunda	(extension)	1000
»	Spånga	(extension)	1000
»	Sundbyberg	(extension)	1000

Town	Exchange		Number of lines
Stockholm	Tureberg	(extension)	1000
»	Ängby	(extension)	500
»	Örby	(extension)	4000
Södertälje		(extension)	1500
Tumba		(extension)	500
Uddevalla		(extension)	1000
Ulricehamn		(extension)	500
Uppsala		(extension)	1000
Värnamo		(extension)	500
Västerås		(extension)	1500
Åmål		(extension)	500
Ängelholm		(extension)	500
Östersund		(extension)	1500
Turkey			
Ankara	Keçiören	(extension)	500
Edirne			500
Isparta			500
Venezuela			
Barcelona		(extension)	1400
Barquisimeto			3000
Porlamar		(extension)	600
Puerto la Cruz		(extension)	2400
Rubio		(extension)	250
San Cristóbal		(extension)	2500
Trujillo		(extension)	300
Valera		(extension)	1400
		Total	166690

Public exchanges with crossbar switches

Town	Exchange		Number of lines
Australia			
Melbourne	Templestowe		600
Sydney	Sefton		600
Denmark			
Aalborg			16000
Aarhus	Syd	(extension)	1000
Copenhagen	Ballerup		3000
»	Brøndbyøster	(extension)	1000
»	Herlev	(extension)	1000
»	Kastrup	(extension)	1000
»	Nærum		2000
»	Ryvang		1000
»	Taastrup		2000
Finland			
Helsinki/Helsingfors	Haaga/Haga	(extension)	1000
»	Herttoniemi/Hertonäs	(extension)	2000
»	Keskusta/Centrum	(extension)	2000
»	Malmi/Malm		1000
»	Meilahti/Mejlans		2000
»	Pakila/Baggböle	(extension)	1000
»	Sörnäinen/Sörnäs	(extension)	2000
Porvoo/Borgå			2500
Indonesia			
Solo			4000

Town	Exchange		Number of lines
Ireland			
Limerick			2000
Netherlands			
Rotterdam	Centrum III		9700
»	Schiedam		5500
»	Zuid I		10000
»	Zuid II	(extension)	3500
Rhodesia and Nyasaland			
Gatooma			1000
Sweden			
Karlskrona			12000
Landskrona			7000
Lysekil			1900
Motala		(extension)	1000
Sunne		(extension)	100
Ystad		(extension)	400
Yugo-Slavia			
Niš			1000
Travnik			300
Zenica			400
*U.S.A.**			
Mansfield, Ohio			8000
Moultrie, Georgia			2500
Perry, Georgia			1000
Rolla, Missouri			2600
Winter Park, Florida			5500
		Total	122100

* 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		
Finland	34	2460
Italy	2	300
Netherlands	10	3600
Sweden	11	4400
Total	57	10760
Rural exchanges with 100-line selectors, system XY		
Norway	22	3790
Private automatic telephone exchanges PAX and PABX (delivered from Stockholm)		
Exchanges with 500-line selectors and crossbar switches	58	17220
All-relay exchanges	382	3373
Exchanges with 100-line selectors, system AHD	149	13160
Exchanges with 30- and 25-line selectors, system OL	437	13447
Total	1026	47200

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

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

Holland's Largest and most Modern Department Stores Served by L M Ericsson Equipment

A P.A.B.X. type ARD 141 has been installed in Holland's largest and most modern department stores, Bijenkorf, at Rotterdam.

This L M Ericsson switchboard is of crossbar type. It is equipped for 300 internal lines and 20 exchange lines, of which 15 have so far been taken into use. External traffic is handled by two operators. The switchboard incorporates night watchman control equipment, the watchmen's rounds being recorded on a Centralograph.

In addition to the P.A.B.X. equipment, five conference telephone systems type DYA have been installed, with loudspeaking master stations and up to nine extensions per master station.

The impressive Bijenkorf building at Rotterdam is seen in the photo above.

(Right) The new exchange building at Leesburg, Florida. The microwave tower is seen in the background.

New Booklet on L M Ericsson Crossbar Switching Systems

A new booklet in the series of L M Ericsson crossbar switching systems has recently been issued. It deals with the four standard types of automatic rural systems: terminal exchanges ARK 312 (for 20—60 subscribers), ARK 314 (60—180 subscribers), ARK 315 (100—1600 subscribers), and ARK 335 serving 100—1600 local subscribers and also handling transit traffic.

The booklet starts by presenting the fundamental theories of crossbar switching, and goes on to describe in detail each separate type of exchange. Many of the illustrations are in several colours to make the principles easier to understand. Apart from the mechanical and electrical design of the exchanges, the 54-page booklet discusses the principles of rural automatization in general and goes into questions of numbering schemes, signalling and charging methods.

More than 180 of these ARK exchanges are now operating in different parts of the world, and new exchanges are being continuously put in service.

Crossbar Exchange Opened in World's Hottest Region

The first L M Ericsson crossbar exchange to be installed in Pakistan was opened on January 25. The exchange is located in the town of Sukkur and comprises 1000 lines and 7 manual trunk positions. Sukkur is on the river Indus some 300 miles north of Karachi, and lies on the outskirts of a desert region. Not far from there is Jakobabad, reputed to be the hottest place in the world.

Crossbar Exchange at Leesburg, Florida

A new crossbar exchange was opened at Leesburg, Florida, in mid-January. It was supplied by L M Ericsson's associates, North Electric Company. The exchange has 3000 lines and a toll board with 30 positions.

During the week following the cutover the Florida Telephone Corporation arranged a demonstration of the exchange to the public, and it was visited by some 3700 persons.

Dial Operation of Rotterdam Zone Moves Ahead

In October 1957 a further area of the Rotterdam zone, equipped by L M Ericsson, was opened to automatic traffic. This was the Spijkenisse area consisting of group centre and, at present, five terminal exchanges catering for a total of 2500 lines. L M Ericsson has a further two areas under installation, namely Ond Beijerland and Sliedrecht. These consist of two group centres and altogether twelve terminal exchanges. Orders for terminal exchanges in other parts of the zone have also been received. On the left is seen a photograph from the opening of the Spijkenisse exchange.

Venezuela:

LM Ericsson Voted Best Telephone Company

The Swedish telephone company, L M Ericsson, was recently voted the "best telephone company" in a poll taken in Caracas, Venezuela. The poll was arranged by the largest Venezuelan newspaper El Universal. Between 30000 and 40000 people, representing a good half of El Universal's readers, voted.

The poll, which took the form of a market investigation, was at the same time a competition for El Universal's readers. Its aim was to discover which firms and products in each branch possessed the greatest confidence of the Venezuelan public.

To the question "Which is the best company selling telephone equipment?" nearly 11000 readers, or 35 per cent of participators, gave their votes to Telefonaktiebolaget L M Ericsson.

The victor in each branch received a cash prize and the benefit of publicity in El Universal. Furthermore the Venezuelan Radio granted 90 minutes' programme time to the winning companies.

Mr Kjell Nordby is seen in the photo (right) studying the diploma presented to the company.

It may be noted that most of the world's telephone companies are represented in Venezuela.

L M Ericsson Acquires Flying Salesman

Since last autumn L M Ericsson has had a salesman visiting remote customers in the north of Sweden in his own aircraft. He is Henry Österlund, stationed at the Sundsvall branch office. In his small Piper Cub he has covered nearly 4000 miles of those northerly tracts.

His main job is the sale of Radiola products, L M Ericsson's radio and TV sets. But Österlund uses his plane for advertising purposes as well. There's no doubt of the sensation he causes when he lands on a meadow outside the Norrland towns.

From the Visitors' Book

Cycle dealer Torsten Wigström of Visby still uses his 1892 L M Ericsson telephone as a local extension. It works just as well today as when it burst on the world with revolutionary force 66 years ago.

A delegation from the Italian P.T.T. visited the L M Ericsson Midsommarkransen factory in December. *The group above consists of (from left)* Major Betardinelli, Dr Degano, Mr Mazzarella, General Vercelloni and Capt. Pallari.

Before Christmas a study group from the Ministère de l'Economie Nationale of Casablanca paid a visit to L M Ericsson. In the photograph below are seen (from left) M. Jean Février, commercial attaché at the French Embassy in Stockholm, and Dr Alberto Bensahel and Dr Ruben Levy of Casablanca.

A group of Burmese Army Officers from the Rangoon Signal Corps were at Midsommarkransen in December last. Seen from left are Col. Thein Han, Burmese military attaché in London, Capt. Maung Tun, Col. Shein, Commander of the Signal Corps, and Capt. Than Tin watching a relay adjuster at his work.

L M Ericsson Honours 1957 Gold Medallists

Every year L M Ericsson makes presentations of gold medals to old retainers of the company. The ceremony usually takes place just before Christmas, and in recent years Restaurant Gillet in Stockholm has been the scene of this gathering.

Last year's presentation — the fourteenth — followed earlier traditions. No less than 37 persons received medals, among whom the feminine element was particularly well represented.

The gathering was attended by Admiral Erik Anderberg, Professor Ragnar Woxén, Mr Marc Wallenberg Jr and Mr Sven Salmonson of the board of L M Ericsson, and by members of the management with the president, Sven Ture Åberg, at their head.

The speech of the evening came from Professor Ragnar Woxén, who also presented the medals. In his speech he recalled the far-sightedness of Lars Magnus Ericsson in the employment of female workers. "It is surely no mere chance that this year's gold medallists include so many women who have served the company sufficiently long to earn this award", he said. "L M Ericsson was the first company in the Swedish engineering industry to employ female labour. And the company has reaped much joy from its decision."

The speech of thanks was delivered by foreman Nils Andersson, the youngest in age but, with his 41 years of service, the oldest servant of the company among the gold medallists.

Professor Ragnar Woxén with three women gold medallists. (From left) Mrs Ingeborg Törnkvist, Mrs Hanna Andersson, and Mrs Inga Andersson. (Above.)

The Aula of the Copenhagen Institute of Technology during one of the meetings on Electronics, televised to islands of Fyn and Jutland. (Right.)

L M Ericsson Supplies Private Telephone Equipment to Largest Spanish Steelworks

Spain's largest steelworks, Empresa Nacional Siderúrgica S.A., at Aviles in the province of Ovideo, installed last year an L M Ericsson 1000-line private telephone switchboard, an AGD-PAX, of 500-switch type.

Swedish Electronics Experts address Danish Telecommunications Engineers

In coordination with the Swedish Telecommunications Administration, the Copenhagen Institute of Technology is arranging for a series of 30 addresses on electronics to students in their last year. Experts from the Swedish Telecommunications Administration and from L M Ericsson have been called upon to give lectures.

The interest in these lectures, to which members of the Danish Engineering Association were also invited, was very great among the Danish telephone engineers. In order to reach a larger circle, the lectures are being televised to the islands of Fyn and Jutland. Sixty-five telephone engineers at Aarhus were able to follow the lectures in this way.

U.D.C. 621.395.66
621.395.35.001.42

HANSSON, K G: *The Traffic Route Tester—a New Tool for Service Observation at Automatic Telephone Exchanges.* Ericsson Rev. *35*(1958): No. 1, pp. 2—12.

In order to be able to offer telephone administrations a simple and reliable means of qualitative service control in automatic telephone areas, L M Ericsson has designed a traffic route tester LTR 1050. The article describes its uses, construction and manner of operation.

U.D.C. 654.15.001.1

ELLDIN, A: *Brief Presentation of the Theory of Telephone Traffic.* Ericsson Rev. *35*(1958): No. 1, pp. 13—22.

The article presents a survey of the problems presented by the theory of telephone traffic and of the means, in the form of mathematical models and measurements, employed to solve them. The subject has been earlier dealt with in an article in the Swedish journal, "Teknisk Tidskrift" No. 5, 1958.

U.D.C. 681.847.1
621.395.24

LARSON, E & SUNDÉN, O: *Central Dictation through Private Automatic Telephone Systems.* Ericsson Rev. *35*(1958): No. 1, pp. 23—26.

Machine dictation, that is dictation to a dictating machine, can now be performed telephonically through a P.A.X. The entire control of the dictating machine is exercised through a normal telephone dial, the machines being located in a central transcribing dept. The telephone switchboard is equipped with a special relay set developed by L M Ericsson. Some aspects of machine dictation are presented, and the relay equipment is described.

U.D.C. 621.319.4
621.761.2

HÄGGLUND, K: *New Capacitors for Power Factor Improvement.* Ericsson Rev. *35*(1958): No. 1, pp. 27—32.

The article deals with the design and methods of manufacture of the new capacitors that have been produced by Sieverts Kabelverk since 1955.

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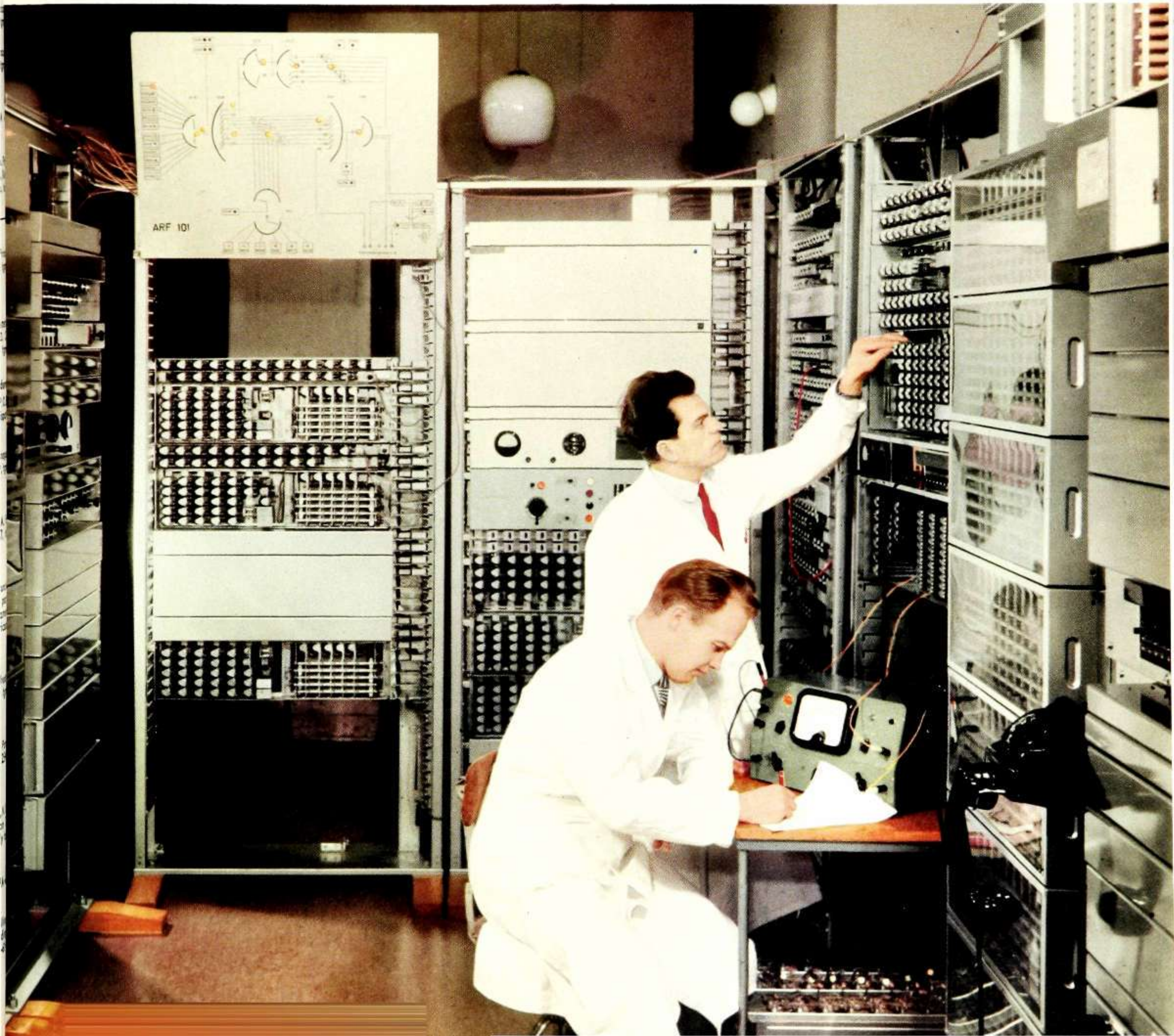

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L M Ericsson's 960-Circuit System for Coaxial Cables

II. HF Line Equipment

Power Supply, Supervision and Maintenance, Mechanical Design

A BÜLOW, F JONSON & T KJELLERYD, TELEFONAKTIEBOLAGET LM ERICSSON, STOCKHOLM

U.D.C. 621.395.44
621.395.521
621.311.6

In this number of Ericsson Review, the chapter on the h.f. line equipment of the coaxial system ZAX 960/2 is completed. Previous articles on this system appear in Ericsson Review Nos. 2, 3 and 4, 1957.

The present article describes equipment for the transmission of power to the unattended repeater stations and for transforming the power to the voltages required for operating the repeater equipment.

The problems of maintenance and the supervisory equipment are dealt with together in one section, and finally details are given of the division of the different equipment into bays and panels with reference to photographs.

Power Supply

The h. f. line equipment which is to be supplied with power from a terminal station consists of the line equipment of the terminal station and equipment in the repeater stations along the route. The solution of supplying the repeater stations with power via the coaxial cable has been chosen for two reasons: reliability in operation and economy. It is more reliable to provide a number of repeater stations with power from a common source in the terminal station, where it can be centrally monitored, than to generate the power in each repeater station or to use the local public a.c. mains supply.

The coaxial line is often routed through regions where it would be very expensive to extend power supply lines to the repeater stations. The coaxial tube has a sufficiently high breakdown voltage between the inner and outer conductors and a sufficiently low conductor resistance for it to be a reasonably good transmission line for the amount of power involved.

Alternating current at mains frequency is injected into the cable and is used for supplying the repeater stations, since alternating current provides the simplest method of obtaining the different voltages which are required for the line equipment in the stations.

In L M Ericsson's h.f. line equipment, power is fed to the repeater stations along the line via the inner conductors of the two coaxial tubes which are used for the transmission of telephony, and in the repeater stations power is taken out via transformers connected across these conductors. The power supply path is separated from the transmission path by power separating filters in the equipment. The high-pass sections in these filters have been so designed that the filters can be used for a future 12 Mc/s system.

The low pass section is designed to withstand a feeding voltage of up to 2000 V with a very high margin of safety.

Power Supply at Repeater Stations

The main power consuming equipment in a repeater station is the line amplifiers, one for each direction of transmission. In addition there is level regulating equipment, supervisory equipment and monitoring equipment, with possible amplifiers in the speaker circuit which is used for communication between the station and the supervising station and with the other repeater stations along the route. The following voltages are required for this equipment to operate.

Heater voltage for tubes in the amplifiers (U_f) 6.3 V a.c. ± 2 %
Anode voltage (U_a) 180 V d.c. ± 5 V
Relay voltage (U_r) 24 V d.c.
for relays, lamps and monitoring equipment
Magnetic Amplifier voltage (U_{td}) 18 V a.c.
for magnetic amplifiers in the automatic level regulating equipment.

Current requirements:
Heater current (If) 4.2 A, with optional speaker circuit amplifier 4.35 A
Anode current (I_a) 260 mA, with optional speaker circuit amplifier 270 mA
Relay current (I_r) 140—300 mA
Magnetic Amplifier current (I_{td}) 50—100 mA

The station equipment consumes 140 VA which is fed from the coaxial cable. As mentioned previously in this series of articles, the μ-section of the amplifier is duplicated for reasons of reliability. Each amplifier therefore consists of two parts which are each supplied with anode voltage from its own mains supply unit in such a way that the μ-section *1* for direction *A—B* and the μ-section *1* for direction *B—A* are supplied from one mains supply unit. The other two μ-sections are both supplied with power from the other mains supply unit. The heater voltage, however, is obtained from a common transformer, as this is considered to be an operationally reliable component in which it is extremely rare for a fault to occur.

The two mains supply units for the amplifier parts *1* and *2* generate anode voltages U_{a1} and U_{a2} respectively. These voltage outputs are connected together across rectifiers to a common output, see fig. 1. The voltage U_a, which is the anode voltage for the pilot receivers, is taken from this output.

The anode supply units are so designed that if the voltage from one supply unit fails, the other can provide full anode power to its own amplifier halves as well as to the pilot receivers. The reduction in voltage is only about 5 Volts.

The rectifiers for U_r are also duplicated and connected together in the manner mentioned above.

The alternating voltage 18 V (U_{td}) for the magnetic amplifiers in the level regulating equipment comes from a separate winding on the heater transformer.

If a speaker circuit amplifier is provided at the station, the heater current is taken from the common heater transformer and the anode current from the common voltage output U_a.

The mains supply units are placed in a special bay, the power supply bay. The reason for this arrangement is firstly because it is advantageous to have

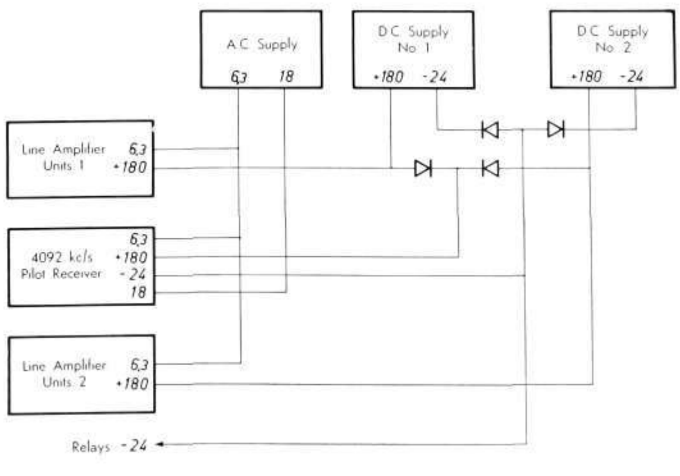


Fig. 1 X 8090

Circuit diagram of the Power Supply Bay of the coaxial cable system ZAX 960/2

all power panels at one place and secondly because it is suitable for reasons of safety. With this arrangement it is not necessary to introduce the mains voltage into the amplifier bay, but only the less dangerous working voltages for tubes and other equipment. A power supply bay provides all the requisite power for a two-directional amplifier equipment.

The rectifiers for U_{a1} and U_{r1} with a common transformer are placed on one panel. On this panel there are also smoothing filters for these voltages. The filter for the anode voltage is of a double section type, and a single section filter is used for the relay voltage. The filter capacitors for U_a consist of electrolytic capacitors connected in parallel with an oil-filled capacitor. The latter together with the chokes can provide the requisite smoothing of the anode voltage in the event of failure of one of the electrolytic capacitors. These are provided with a discharge circuit consisting of a resistor and a neon lamp with which it is possible to estimate the capacitance of the electrolytic capacitor by depressing a push-button on the panel. This estimation is done by measuring the time during which the neon lamp glows. The rectifier elements and electrolytic capacitors are provided with plug-in contacts to simplify the replacement of these components if this becomes necessary.

There is a similar panel for the voltages U_{a2} and U_{r2} to the other half sections of the amplifier.

The common heater transformer is mounted on a separate panel.

In addition to a test panel with a meter and switches for measurement of all voltages in the bay, there is a control panel containing circuit-breakers and fuses for the power supply unit and an alarm panel with relays and alarm lamps for indication of faults in the supply units.

The bay can also be provided with a trickle charging unit for a small 24 volt accumulator which is used for alarm indication and microphone supply in the event of complete failure of power supply to the station. The equipment can also contain a regulator and a contactor for the local stand-by mains.

Transmission of Power

The normal distance between repeater stations on the h.f. line is decided by the high frequency transmission characteristics of the cable and by the performance of the repeaters, and is about 9.5—10 km. The number of repeater stations which can be supplied with power from a main repeater station depends on the power consumption of the stations, the resistance of the inner conductors of the coaxial tubes and the highest permissible voltage sent out. This voltage is determined by the breakdown voltage of the cable and the ionisation voltage; in the event of corona formation, traffic can no longer be transmitted within the frequency range of the system.

The coaxial tube of normal type 2.55/9.47 mm has a breakdown voltage between inner and outer conductors which is higher than 2000 V r.m.s. The resistance of the inner conductor is 3.42 ohms/km at + 20°C, and the lowest voltage for corona formation is 2.1 kV r.m.s. for a jointed cable section.

The resistance of the inner conductors of a pair of tubes is about 70 ohms per cable section including the resistance of the filters. The power consumption in accordance with the above is 140 watts/station.

Proceeding from these facts, it is possible to work out the number of auxiliary repeater stations which can be supplied with power from a power feeding station with a given output voltage, or to calculate the required output voltage so as to be able to feed a certain number of repeater stations.

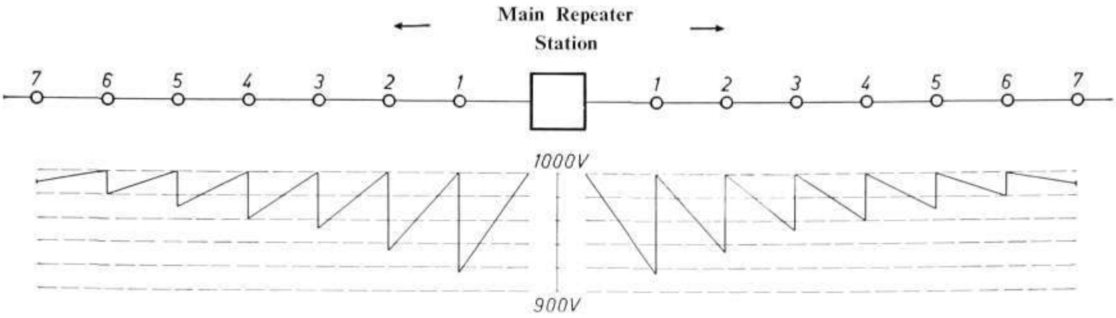


Fig. 2 X 8077

Voltage diagram for the feeding of power from a main repeater station

The method of calculation is described in an article in Ericsson Technics No. 2, 1957. The table below has been worked out using this article as a guide.

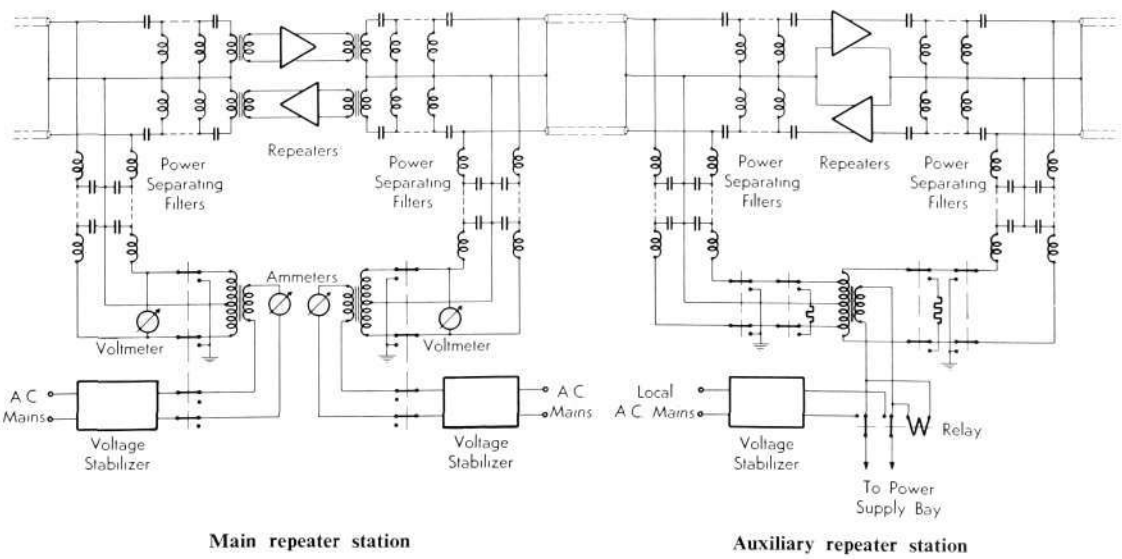
Power per station W	Voltage sent out (volts)								
	1000	1100	1200	1400	1500	1600	1800	2000	2500
50	15	16	18	>20	>20	>20	>20	>20	>20
60	13	14	16	18	20	>20	>20	>20	>20
70	12	13	14	16	17	19	20	>20	>20
80	11	12	14	16	17	17	19	>20	>20
90	9	10	11	13	14	15	17	19	>20
100	9	10	11	12	13	14	16	18	>20
110	8	9	10	11	12	13	15	16	20
120	7	8	9	11	11	12	14	15	19
130	7	8	8	10	11	11	13	14	18
140	7	7	8	9	10	11	12	13	17
150	6	7	7	9	9	10	11	13	16
160	6	6	7	8	9	10	11	12	15
170	5	6	7	8	8	9	10	11	14
180	5	6	6	7	8	9	10	11	14
190	5	5	6	7	8	8	9	10	13
200	5	5	6	7	7	8	9	10	12

The table shows the number of stations which can be supplied with power from a feeding point at given voltages and station powers. The voltage is transformed up at each station to its original value. The value of the current fed out is limited to 1.3 A for practical reasons.

Fig. 3 X 8091

Block schematic of power supply

Power is fed from the main repeater stations through the inner conductors of a pair of coaxial tubes via a transformer having a centre tap on the winding on the cable side which is connected to the outer conductors of the tubes.



The auxiliary repeater stations are provided with transformers which are connected in parallel across the inner conductors of a pair of coaxial tubes, see fig. 3. The voltage is transformed down to 220 V in these for feeding the mains supply units of the station. This transformer also has the centre tap on the cable side connected to the outer conductors.

The transformers are designed for feeding voltages of 1000 V and 1500 V. With these voltages, 7 and 10 stations respectively can be fed from each terminal station. This corresponds to 15 and 21 repeater sections, or 150 and 210 km respectively. With greater distances between terminal stations, one or more main repeater (power feeding) stations are introduced into the h.f. line. These can be attended or unattended (the first is more usual) and should be situated at places which have access to electrical power. If the distance between two main repeater stations is greater than 210 km, the transformers can be exchanged for other transformers giving an output voltage of 2000 V. With this feeding voltage, up to 13 auxiliary repeater stations can be supplied with power from a main repeater station.

Main Repeater Stations

The transformer in a main repeater station is placed together with the smoothing filters in a separate well protected bay, the high voltage bay. In addition, this contains instruments for supervision of outgoing voltage and current to the coaxial cable, and also circuit breakers and fuses.

To protect the transformer from overload due to a short circuit in the coaxial cable or in the main repeater stations, an overload current relay is connected in the primary circuit. If a short circuit occurs in or between the last stations in a long feeding section, the usual fuses do not blow due to the resistance of the inner conductors of the tubes. The value of current for the relay to operate can be set so that it is suitable for a different number of stations and the relay operates if a short circuit occurs in, or before, the last auxiliary station. The operation of the relay can be delayed 2 to 10 seconds so that switchings or other operations in the auxiliary repeater stations shall not operate the relay by current impulses which thus can be caused in the feeding line. In addition, the relay can break the circuit instantaneously to take care of short circuits on the feeding line near the main repeater station.

A minimum current relay may also be placed in the high voltage bay in certain cases. This interrupts the power fed out in the event of an interruption in the cable or stations along the section which is fed with power.

The coaxial cable is brought in to the station through cable boxes, where the coaxial tubes are separated from the other conductors in the cable. The boxes are placed in a special cable terminating bay which is situated beside the high voltage bay.

In the cable terminating bay, arrangements for protection from excessive voltages can be provided in certain cases.

There are h.f. lines where the outer conductors of the tubes are not earthed. With such h.f. lines, the outer conductors are often used as a common return conductor for alarm and remote supervision. To protect the supervisory equipment from excessive voltages which may arise if faults occur in the power feeding system, an earth leakage relay is connected between earth (the cable sheath) and the outer conductors of the coaxial tubes which are connected together. With a voltage of 60 to 80 V between the outer conductors and earth, this relay operates and earths the outer conductors. In this way danger to personnel coming into contact with the associated circuits is averted.

In order to protect further such equipment which is associated with the outer conductors of the tubes against excessive voltages, an over-voltage protection device using neon tubes is connected between these conductors and earth.

In these bays, the cable terminating bay and the high voltage bay, there are a.c. voltages of up to 2000 V. These bays must therefore be especially well protected from unintentional contact with internal parts. This has been obtained by means of mechanical interlocks which are connected with the main circuit breaker of the bay. In principle, these operate so that the doors of the bay cannot be opened until the circuit breaker has been moved to the open position. The circuit breaker cannot be moved to the closed position again before the doors have been closed and locked.

Auxiliary Repeater Stations

The equipment in the auxiliary repeater stations is arranged in the same manner as in the main repeater stations. There is a cable terminating bay, a high voltage bay for each pair of tubes in the coaxial cable and a power supply bay for each two-directional amplifier equipment.

In addition to the transformer and the power separating filters, the high voltage bay also contains two circuit breakers with earthing contacts, one on each side of the transformer. With these circuit breakers, it is possible to isolate and earth the cable before and after the station when repair work is being carried out. Opening of the circuit breaker before the transformer breaks the feed voltage in the main repeater station. The action of opening the circuit breaker also short-circuits and earths the inner conductors in the tubes. The outgoing current is thereby increased so much that the over-voltage relay in the main repeater station operates and stops the feeding of power to the repeater stations. When necessary this circuit breaker can therefore be used as an emergency circuit breaker.

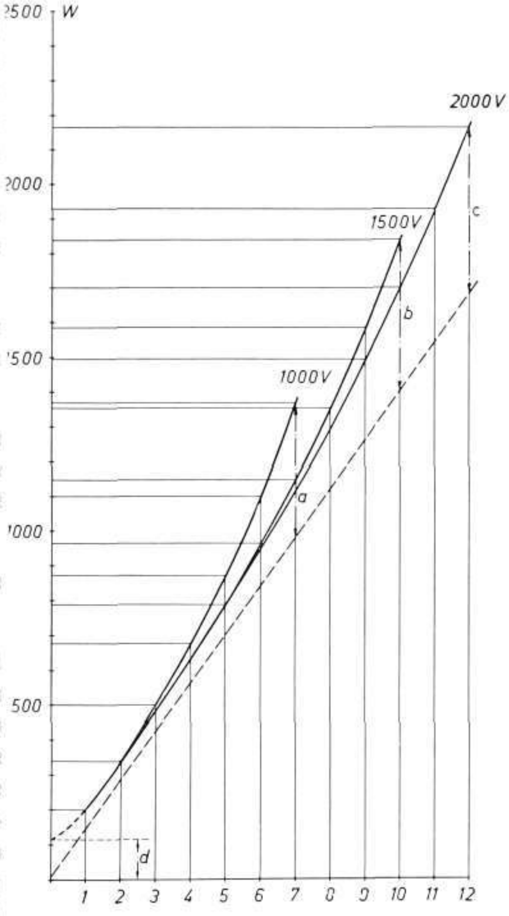


Fig. 4

Power requirements for auxiliary repeater stations

Coaxial tube 2.55/9.47 mm; repeater spacing 9.6 km; 140 W/station

If the coaxial cable goes through districts having easy access to electricity supplies, it can be advantageous to bring in a supply from the public network to the repeater stations. Besides electric lighting and heating for the stations, a standby power supply is obtained which can be used in the event of a fault occurring on the cable feed. In such cases, the power supply bay in the repeater stations is provided with a contactor, which connects the local a.c. mains to the power supply unit on failure of the supply of current from the high voltage bay. The local a.c. mains at different places along an h.f. line can have rather large voltage variations. In general, the power supply bay must therefore be provided with a constant voltage stabilizer which maintains the a.c. voltage constant to within one or two per cent.

In the design of the station power equipment for stand-by a.c. mains, it is possible to disconnect one or more stations from a feeding section and provide them with power from the local network during the time required for repairs, measurements or other maintenance work. To enable such disconnexion to take place without affecting the other repeater stations supplied, a changeover switch in the high voltage bay is used. This removes the station from the power supply via the coaxial cable and simultaneously connects a load across the cable which is equal to the load normally taken by the power supply equipment of the station.

With h.f. lines where the stations do not have access to the local power supply, a 220 V alternating voltage can be obtained from a socket in the power supply bay. Its power output is limited to 50 W at one station at a time on one feeding section, and is intended for the connexion of mains operated measuring equipment carried with the maintenance personnel.

Power Supply Requirements

The alternating power which is necessary to supply h.f. line sections having a different number of repeater stations is seen from the curves at the left. The power fed out is shown as being real. The cable and the station load form in themselves an inductive load. This can, however, be easily compensated for by connecting a capacitor of about 1 μF across the power feeding pair in the repeater stations along the feeding sections. In this way a load phase angle of very nearly zero is obtained.

The total transformer and line losses for different numbers of auxiliary repeater stations is also seen from the curves in fig. 4. Sections *a*, *b* and *c* in the curves shown are examples of this and show the power loss when transmitting power to 7, 10 and 12 stations at a feeding voltage of 1000 V, 1500 V and 2000 V respectively. The power loss with a different number of stations from that given can be obtained by taking the difference between a point on the voltage curve at the required number of stations and the dotted line $n \times 140$ W. The point *d* at zero stations shows the power loss in the feeding transformer at the main repeater station.

Supervision and Maintenance

In an h.f. line which operates with almost 1000 trunk telephone circuits and where the transmission medium itself, the coaxial cable, under normal conditions is exceedingly reliable, the repeater equipment should also be so constructed that the time of interruption is kept down to an absolute minimum. In the system *ZAX 960/2*, as pointed out in the previous sections, reliability of operation has been built into the system itself as far as is possible, among other things by duplication of vital units. With the amount of equipment which goes into a complete h.f. line, on which the majority of repeater stations are unattended, it is also necessary to ease the work of maintenance personnel by means of effective supervisory equipment.

All supervision should in the first instance aim at *preventing* the interruption of traffic. Incipient faults taking a long time to appear should be capable of being detected by easy methods during routine measurements. In the event of a fault which means a serious reduction of reliability, e.g. failure of one of the two duplicated units, the personnel should have their attention drawn to this by means of a "non-urgent alarm", while other types of faults which can be predicted, and which directly interrupt the traffic should be indicated by alarms which enable the personnel to take the right measures immediately at the right place. This means that rather detailed reporting must occur automatically from the unattended stations to a pre-determined attended station.

The choice of the supervising station should be made jointly with the customer, and to a certain extent the scope of the alarm information can also be the subject for discussion. A number of the interstitial pairs which are placed between the coaxial tubes in the cable are used for alarm transmission. Normally one of the terminals is responsible for supervision of the whole h.f. line, but from a construction point of view there is nothing to prevent the supervision being subdivided into the different types of attended stations, e.g. so that each power feeding station takes care of the supervision of the unattended stations within its feeding section.

As will be described in more detail later, the unattended stations in the system ZAX 960/2 can also be equipped so that to a certain extent they can be controlled from the supervising station. However, a greater number of supervisory wires are needed than those required for the sole transmission of the alarm.

Moreover, with the help of gas control, the coaxial cable itself can be placed under continuous supervision. Gas control equipment is installed in general at all the attended repeater stations. The system which is recommended by L M Ericsson operates with four supervisory wires and can supervise up to twelve repeater sections in each direction.

Equipment for Local Supervision

Included in the normal routine maintenance of a coaxial h.f. line is the making of periodic visits to the unattended repeater stations to ensure their correct functioning. It is an absolute requirement that the requisite observations can be made without causing any interference to traffic.

As already described, the power supply equipment has built-in meters for the measurement of the working voltages, and on the meter in the current distribution panel of the repeater bay (of normal design for L M Ericsson's transmission equipment), it is possible with the help of a rotary switch to measure the individual anode currents for all the tubes in the bay. The automatic level regulating equipment can be checked with the help of a built-in supervisory panel containing meters and switches for measurement of the rectified pilot current, reference current and the regulating current to the thermistors of the regulating network.

The following four types of alarm are indicated in a separate alarm panel via common relays:

a) Incorrect pilot level, direction *A—B*
b) Ditto, direction *B—A*
c) Power alarm, urgent
d) Non-urgent alarm

These relays each have contacts for completing an alarm circuit to the supervising station, and also to light a general warning lamp and individual lamps showing the alarm in its own station. All individual lamps for showing an alarm or other indication are connected to the relay voltage via a spring-return push-button with make contacts. This is done so that power will not be used for alarm purposes in other stations except when it is needed.

The pilot alarm equipment is in general adjusted to give an alarm when the outgoing pilot level deviates from the nominal value by more than plus or minus 0.5 db. The pilot current which is amplified and rectified in the pilot receiver is compared with a reference current derived from a voltage stabilizer tube type 85A2, the difference current is then amplified in a magnetic amplifier (transductor) and then passes through the heater winding of the thermistor in the variable feedback network of the line amplifier. This current, the control current, also passes through a polarized relay for pilot alarm. The placing of the alarm relay in a circuit having the pilot current variation already amplified has made it possible to use a robust relay without having to operate with a high output current from the pilot receiver itself.

The tubes in the line amplifiers are individually supervised by relays in the leads to the anodes. The relays are mounted in two separate panels which each supervise two amplifier sections. The same subdivision is carried out here as is done with the anode power supply unit, i.e. one panel supervises μ-section *1* of both the *A—B* amplifier and the *B—A* amplifier, and the other panel supervises the corresponding μ-sections *2*. This method of connexion also enables one of the anode alarm panels to be removed at a time, e.g. for checking without causing interference to traffic.

With regard to the line amplifier, maintenance considerations have influenced the electrical as well as the mechanical construction. In the section on the h.f. signal path (Ericsson Review No. 3, 1957), it has already been stated that a low intermodulation noise should be aimed at for the single amplifier, as the intermodulation products can add in an unfavourable way along a long h.f. line. With tubes having normal characteristics, the distortion in a single amplifier is very low, and for the h.f. line the intermodulation noise is therefore much lower than the basic noise. However, the change of tube characteristics cannot be prevented. A noticeable increase of the intermodulation noise is often caused by worsened characteristics of single tubes in the h.f. line. It can, however, be difficult to localize a tube having high distortion as it does not always make itself apparent by abnormal anode current. The "cut and try" method is often the only one possible for finding the fault quickly.

The construction of the amplifier with two μ-sections operating in parallel enables one of these to be disabled without causing interference to traffic. The disabling, which is carried out by putting a high negative potential on the grids of the tubes, can always be made locally using a switch situated on the supervisory panel. If a sufficient number of supervisory pairs in the coaxial cable is available, this may be done by remote control with the aid of relays. To provide protection for traffic in progress, the possibility of disabling a certain μ-section is prevented if any tube in the other μ-section in the same amplifier has already given an alarm.

Intermodulation tests can be carried out in several different ways. To check that the intermodulation has not increased to an abnormal value, one or more combinations of three telephone channels can be used. These are so chosen that the intermodulation signal falls in one of these channels when sending with e.g. an 800 c/s test tone in each of the other two channels. This method is, however, limited to measurements over a complete h.f. line as the terminal equipment must be accessible for sending and receiving.

Intermodulation measurements on the line should be carried out using the inter-supergroup pilots standardized by the CCITT. Intermodulation of the type f_1—f_2 can be measured e.g. by sending the inter-supergroup pilots 3784 and/or 3536 kc/s. These, together with the 4092 kc/s level regulation pilot give 308 and 556 kc/s respectively, which are also inter-supergroup pilot frequencies. Using a suitable instrument e.g. an inter-supergroup pilot measuring set with extra filters and amplifiers, it is possible with this method to follow the intermodulation along the line. Alternatively, if the expense of portable inter-supergroup pilot generators having high output impedance is permitted, it is possible to measure the intermodulation per amplifier and, due to the method of disabling, even per single μ-section while it is in traffic.

Exchange of a tube in an amplifier can take place without the amplifier being taken out of service. The μ-section containing the tube is disabled, and as work is then carried out on a completely dead part of the amplifier, there is no risk of such short-term disturbances, "clicks", which would otherwise occur on changing a tube in a three-stage amplifier having a low input level.

The preservation of a good signal-to-noise ratio requires that not too great deviations are permitted from the output level curve decided for the system. On installation it is usual to put in fixed equalizing networks so that the deviation does not exceed 2.5 db at any station. For the finally equalized curve for the whole h.f. line, the deviations must not exceed 1 db. Long-term variations in the transmission curve of the h.f. line are compensated for with the help of the cosine equalizer as already described in Ericsson Review No. 4, 1957. For very long h.f. lines, noise considerations may make it advisable to install a cosine equalizer not only at the terminal stations but also at an attended station in the middle of the route so as to hold the curve within tighter tolerances along the whole route. For h.f. lines of average length where one cosine equalizer for each direction can take up the variations, it may be better to place this in the middle of the route than at a terminal station, for the same reason. Irrespective of the location of the cosine equalizer it is suitable to carry out a check once a year, station by station, with the help of the portable inter-supergroup pilot measuring set, the power for operating this being taken direct from the power bay. An operational tolerance of ± 4 db on the transmission curve should be held.

For exchange of line amplifiers while traffic is in progress a special changeover switching device has been developed. The coaxial jacks on the amplifier input and output are duplicated and the corresponding jacks are to be found in the bay, see fig. 7. The upper pair of jacks is used for the normal connexion of the amplifier to the bay cabling while the lower pair is intended for connexion to the changeover switch. The power supply (on the right of the bay) is also duplicated so that the amplifier which is to be put into service can be warmed up and regulated to give the right gain. Switchover takes place as a continuous process simultaneously on both the input and output sides, and it is completed in less than 0.5 millisecs.

As the amplifier is designed using d.c. feedback which aims at compensating a reduction in the emission of the tubes by changing the control grid bias, the normal measurement of anode current does not give any clear indication of the actual figure of merit of a tube before it is already falling off in performance. To enable a continuous check of tubes and a change to be made in good time in an amplifier which is in operation, a so-called grid bias volt-meter has been developed. This has a cable for connexion to the duplicated socket in the bay and a switch for selection of each amplifier tube in turn so that the actual grid bias on each tube can be measured.

Remote Supervision

This can be made more or less comprehensive depending on the number of the interstitial pairs which can be made available.

Normally all the four types of alarm which are described in connexion with the local supervision are sent to the supervisory station, but there is nothing to prevent the combination e.g. of the level alarms for both directions of transmission. The transmission of the alarm could very well be carried out by using *one* wire for each type of alarm with a common return conductor. At the supervising station it is not of much assistance to know only *that* a fault has occurred; it must know, too, *where* it has occurred. This localization of the fault is carried out with the help of a resistance bridge which is calibrated in repeater stations. It can happen that several simultaneous alarms are received. It is true that it has been arranged that the urgent power alarm removes the non-urgent alarm from the same station, but the total failure of one station e.g. due to a fault in the power supply equipment, giving a pilot alarm in both its own and subsequent stations cannot be avoided. As the common return conductor on a part of the section then becomes connected in parallel with one or more alarm wires, a lower resistance will be measured on the bridge than that corresponding to the distance to the faulty station. An incorrect indication of the position will be obtained as long as the return conductor does not fulfil the requirement of having a negligible loss compared with the resistance of each alarm wire. The only conductor which fulfils this requirement is that formed by the outer conductor of the coaxial tube. It is therefore used in many installations as the alarm return conductor. However, it is necessary that this is galvanically separated from earth. It has been shown in practice that the potential differences between the various earthing points are normally so large and variable that the definite measurement of a remote faulty station is impossible even if a high feeding voltage to the fault localization bridge is used. In the cases where the coaxial outer conductors are not metallically separated from earth, a separate pair must be used for each alarm, i.e. a total of 8 wires, if four types of alarm are desired.

If, having regard to the transmission of alarms or for other reasons (better protection against damage by electrical discharges has sometimes been put forward in this connexion) it has been decided not to earth the outer conductors, the bays should for safety reasons be earthed at all stations where personnel can come into contact with them. H.F. transformers for earth separation are therefore placed in the attended stations, and in all the unattended stations where power and amplifier bays are mounted on insulating slabs, the door closing mechanisms are combined with contact equipment which automatically earths the bay when personnel are present at the station.

As has already been stated, the h.f. line for the system ZAX 960/2 may be provided with equipment for remotely controlling the disabling of the line amplifiers. The station required is connected in with the help of a selector equipment. Impulsing is carried out over the phantom circuit in the quad which is used for the speaker circuit (which will be described next). A total of three wires is used for the selection of system, direction (*A—B* amplifiers or *B—A* amplifiers respectively) and amplifier section (μ-section). With a further wire, the selector equipment can be used for so-called selective alarm finding. As distinct from fault location using a bridge which can only give the nearest station with a certain type of fault, the selective alarm finding can enable a fault analysis to be carried out station by station by disconnecting the alarm wires to all stations except that connected with the help of the selector equipment.

The remote control equipment which is assembled on a separate bay can, with the same number of wires, i.e. 4, serve two parallel h.f. lines by selection of the polarity on the system selector wire. The equipment can control up to a maximum of 22 repeater stations, the supplementary equipment in each attended station, however, normally being considered as a separate station. For longer h.f. lines, the supervision is subdivided into several sections with impulsing barriers at the points of division.

Speaker Circuit

A part of the supervisory equipment is a speaker circuit, with the help of which communication can be made between stations. If two coaxial systems are operated in the same cable, it is in general sufficient to have one speaker circuit.

The speaker circuit is designed as a four-wire circuit over either an unloaded or a loaded quad (in general using wires of 0.9 mm diameter). When operating over an unloaded quad, an amplifier is required at every other station, but the distance between amplifiers can be appreciably larger when operating over a loaded quad. Often it is sufficient with amplifiers at the attended stations.

In order to avoid an interruption on the speaker circuit due to a possible tube failure, the amplifiers are designed so that on tube failure they are by-passed and give an alarm. This is of special importance if there are amplifiers at unattended stations.

At terminal stations, the speaker circuit is in general connected to the respective trunk test board via four-wire terminations with signal repeaters, and it can then be extended on a four-wire basis to other four-wire circuits.

All repeater bays, and also supervisory bays where these exist are provided with a monitoring panel which by means of a switch can be connected in parallel with the speaker circuit. The monitoring panel has a high input and output impedance, and the increase of loss is therefore negligible if a monitoring panel is connected across a speaker circuit between two stations with a conversation going on between them.

The phantom is taken out on both pairs in the quad, and this is used for signalling purposes and in certain cases also for impulsing, as has already been given in the section on remote control.

The terminals can signal directly to each other, and from them it is also possible to signal to the repeater stations along the line. However, from the repeater stations it is only possible to signal separately to the terminal stations. All signalling is done using direct current.

The Mechanical Design

The different types of bays for the h.f. line equipment for the system ZAX 960/2 are given in the table below. The number of these bays required for the different stations when used for one or two systems respectively are given.

Bay type	Number of Bays					
	Terminal repeater station		Attended main repeater station		Unattended auxiliary repeater station	
	System I	System II	System I	System II	System I	System II
Line Amplifier Bay	1	1	1	1	1	1
Power Supply Bay	1		1		1	1
High Voltage Bay	1		1	1	1	1
Cable Termin. Bay	1		1		1	
Supervisory Bay	(1)		(1)*	—	—	
	Bay height 2590 mm (8′ 6″)				Bay height 2190 mm (7′ 2″)	

* This bay is only required when long lines are used, or when the supervision sections correspond with the power feeding sections.

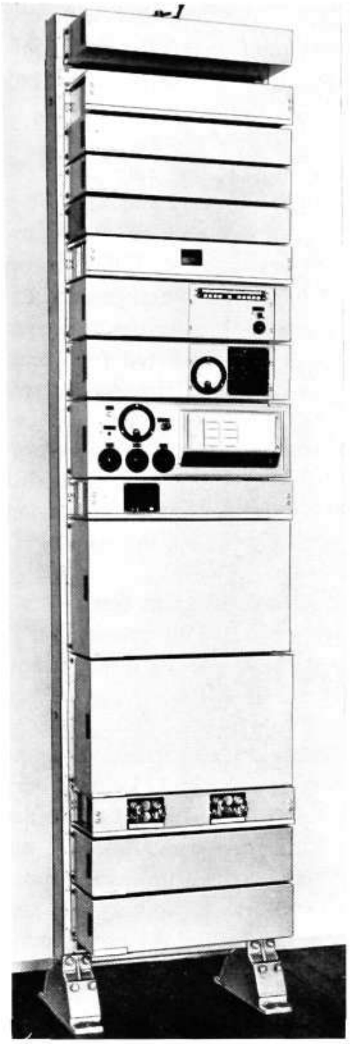


Fig. 5 X 2306

Line Amplifier Bay for an auxiliary repeater station

The amplifier bay, power bay and supervisory bay are of normal design for L M Ericsson's transmission equipment, i.e. they consist of a bay frame with panels mounted on one side or two sides. The bay width is 514 mm (20 1/4″), the depth of a double sided bay is approximately 460 mm (18″) and of a single sided bay is about 280 mm (11″). Having regard to the buildings, low bays with panels mounted on one side have been used for the unattended stations. These can be mounted against a wall, and thereby provide the optimum usage of the space in the station.

The cable terminating bay and the high voltage bay on the other hand are, for reasons given in the description of the power equipment, designed in the form of cabinets having special arrangements for protection. The width and depth are the same as for a double sided bay and the height is also here 2590 mm or 2190 mm.

Line Amplifier Bay

The line amplifier bay for an unattended station is shown in fig. 5.

The two lowest panels, one for each direction of transmission are intended for line building-out and equalizer networks. Of the line building-out networks which are provided in standardized electrical lengths, the probable variants are selected already in the design stage using the information on repeater spacing and cable temperature. However, especially owing to the uncertainty of determination of the earth temperature, the building-out network may have to be altered one position in either direction and the networks must therefore be easy to mount. This applies to an even greater extent to the equalizer network which must often be built on the site.

For the mounting of the different types of networks which are needed in the h.f. line, a special box has been constructed which is shown in fig. 6. This consists of an outer die-cast light metal box, the main function of which is to protect the networks against damp. It has sealed insulating bushes and a lid with rubber packing. The air which is enclosed when the box is closed is dried with silica gel which is kept in a special container. The real container for the networks is mounted inside the box on pillars of insulating material, and the box is therefore like a growth on the coaxial cable.

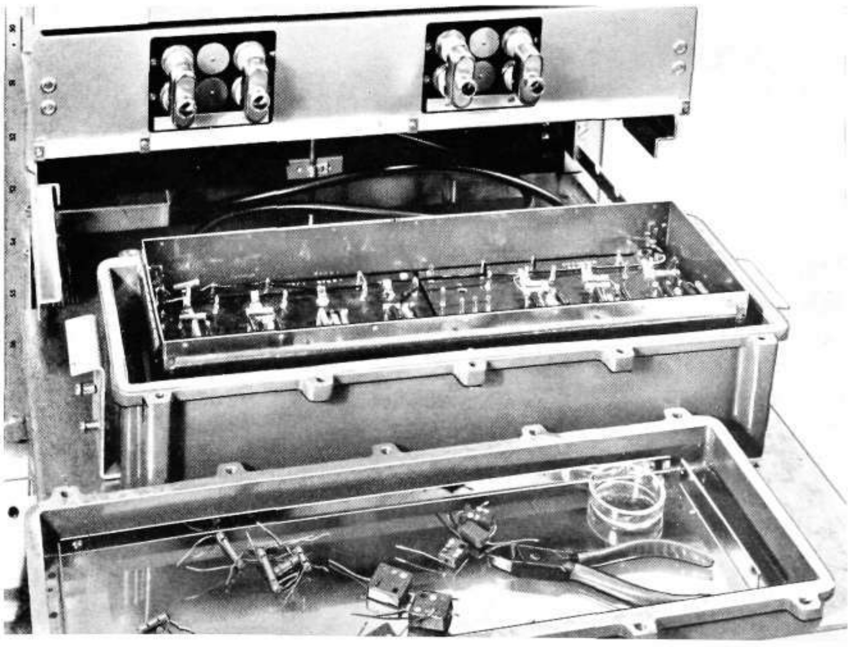


Fig. 6 X 8085

Box for line building-out networks and equalizing networks

The stub cables of the network box which are terminated with coaxial plugs are of such a length that when carrying out final adjustments of the network, the whole container can be placed on a shelf outside the bay as shown in the figure.

The next panel contains the gain equalizers of both line amplifiers. These networks of which there are separate variants for the 46.0 and 48.6 db connexion of the amplifiers are mounted in sealed boxes and connected to the bay cable by means of U-links. Both line amplifiers which follow complete the real high frequency equipment in the bay. They have been placed at such a height that they are easily accessible for measurement purposes and possibly exchange. Fig. 7 shows how a stand-by amplifier is connected for exchange with the help of the previously mentioned fast operating changeover switch.

In addition, the bay contains a central current distribution panel of normal design placed at the height standardized for bays used in L M Ericsson's carrier frequency equipment. It contains, besides a meter and measuring switches, individual fuses for the different power consuming panels in the bay.

Above the current distribution panel there are the different types of alarm and supervisory arrangements which have been described previously. The next panel contains level alarm relays, a meter and switch for observations on the level regulation and switches for disabling the amplifier.

If the bay is arranged for remote control of the amplifiers, disabling is carried out by means of relays in the adjacent alarm panel. Remote control is carried out by means of the impulse receiver which is placed immediately above. The right hand part of the alarm panel is formed into an alarm indication field with individual indication lamps for different types of alarm and operation and a larger general warning lamp. The magnetic amplifier units for the automatic level regulation are situated in the panel immediately above the alarm panel.

The amplifiers for the speaker circuit and the monitoring unit with the jack field are placed immediately below the current distribution panel.

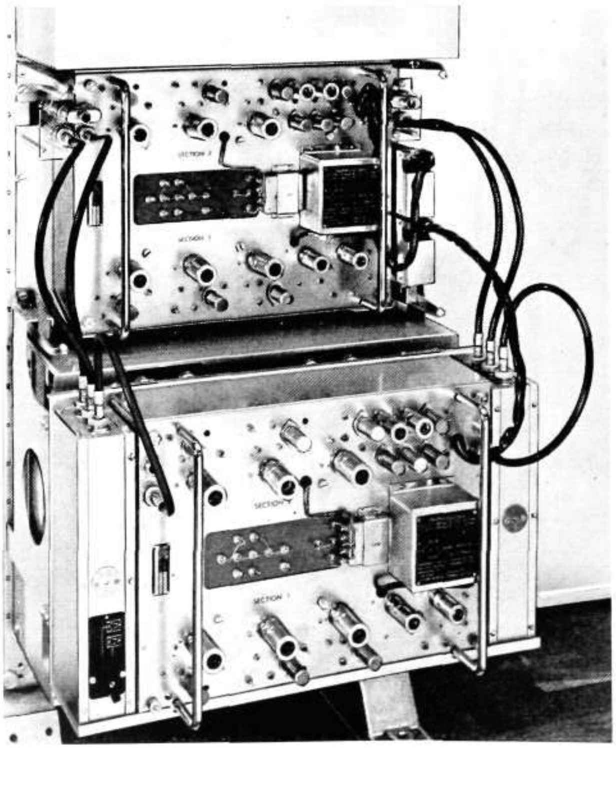
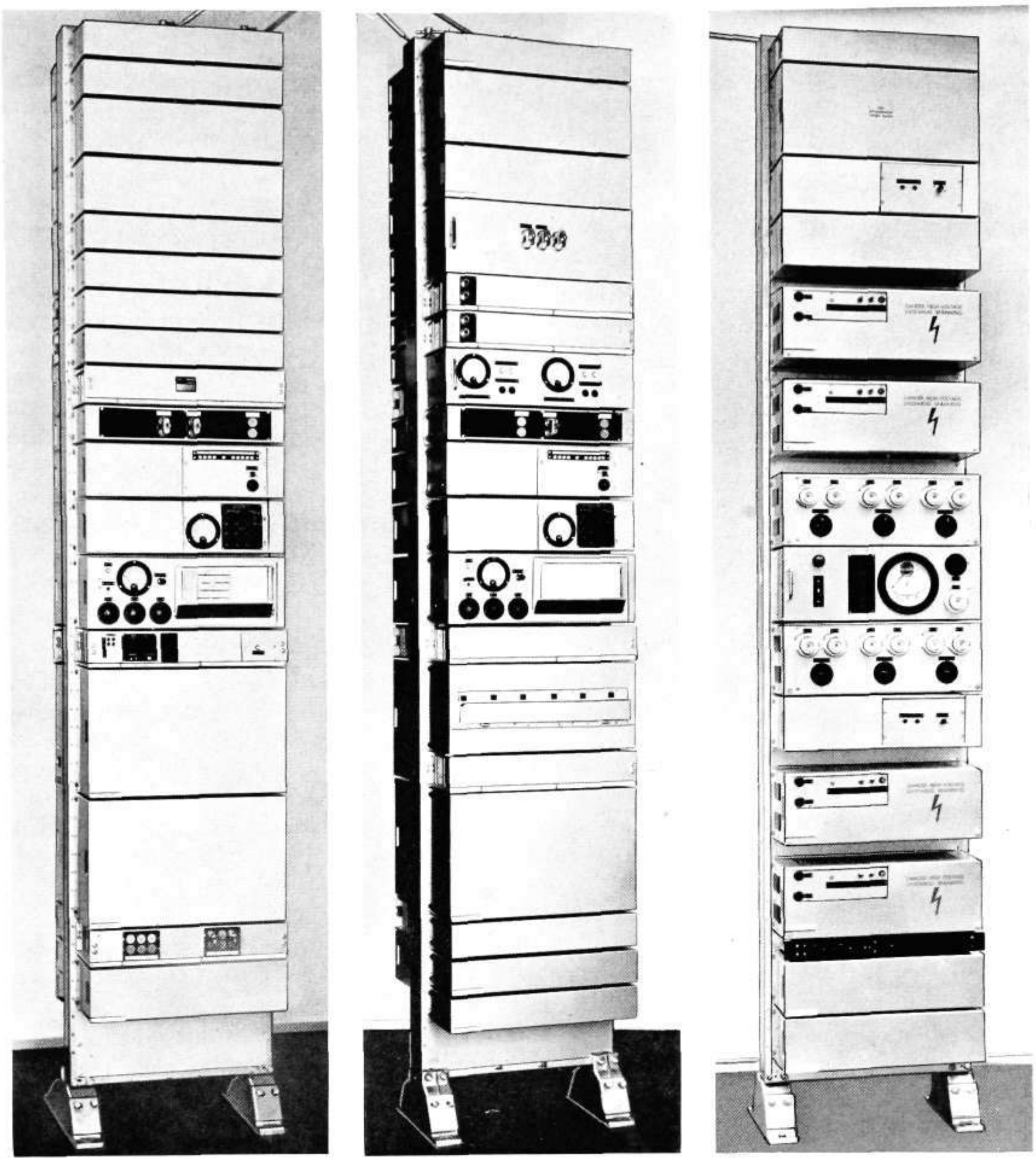


Fig. 7 X 8086

Switching device for exchange of a line amplifier while in service



X 2307
X 2308
X 2318

Fig. 8

Line Amplifier Bay for a terminal repeater station. Left, front view. Middle, rear view. Right, Power Supply Bay for a terminal repeater station and a main repeater station.

The cables for the bay power supply are terminated in screw terminals in the terminal strips (uppermost) which also contain soldering tags for the supervisory wires. The high frequency connexions of the bay, on the other hand, are made by direct jointing (using special, so-called tube joints) of the coaxial cables going from the bay to the station cables.

Below the terminal strips is seen a panel for the transformers for the speaker circuit and the two anode alarm panels.

The repeater equipment as it is installed in the unattended repeater station bays is seen to be almost identical as regards the basic equipment on the front of the amplifier bay of the attended repeater station and the terminal station. The usual line building-out and equalizer networks are not mounted on the sending side, as the level characteristic is flat when coming in direct from the terminal equipment. Instead, the amplifier in the sending direction is preceded by a so-called pre-emphasis network, which together with the line amplifier gain which increases with frequency gives a sloping output level curve with about 10 db higher level at the highest frequency than at the lowest frequency.

Fig. 9 X 2319

Power Supply Bay for an auxiliary repeater station

On the receiving side the sloping output level characteristic must be changed to a flat level characteristic and this takes place in a so-called de-emphasis network. Both these networks are built into the same type of boxes which are used for the line building-out and equalizing networks and these are to be seen in the upper part of the picture, fig. 8 (left).

At the rear of the terminal repeater bay fig. 8 (middle) is seen at the top the stabilizing, injection and supervisory panels for the 4092 kc/s and 2792 kc/s line pilots.

The lower part of the bay is taken up by the cosine equalizer (described in detail in Ericsson Review No. 4, 1957), followed by a flat amplifier for compensation of the basic loss of the cosine network and, where provided, of the automatic regulation equipment (controlled by the 2792 kc/s pilot), which also has a place in the panels at the rear. The flat amplifier is constructed in accordance with the same general principles as the line amplifier, but it has a much simpler feedback network. Power supply equipment, alarm and disabling equipment is practically identical with that on the front of the bay.

The Power Supply Bay

The power supply bay for an unattended repeater station is shown in fig. 9. The voltage stabilizing unit for the stand-by local a.c. mains, where used, is placed at the bottom. Then comes the power equipment consisting of the heater transformer, the two anode supply units, an alarm panel, a switch panel with fuses and switches for the different supply units and finally a test panel in which is also placed the switching equipment between the cable supply and local a.c. mains. The socket for the 220 V a.c. supply is placed on a small panel immediately above the heater transformer.

A trickle charging equipment for the microphone and alarm voltage can be mounted above the power equipment as shown in the figure.

A bay with two power supply units shown in fig. 8 (right) is used for stations with supplementary equipment i.e. main repeater stations which are equipped with cosine equalizers, and terminal repeater stations. The test panel and terminal strips at the top of the bay are the only common items for the two units. An exactly identical equipment may be mounted on the rear of the bay in a station which is equipped for two systems. In stations with remote control equipment, a mains supply unit for the control voltages is installed at the bottom of one side of the bay.

High Voltage and Cable Terminating Bays

These bays which have already been described in detail in connexion with the power supply equipment are shown for the terminal repeater station in fig. 10 and for an unattended station in fig. 11. The circuit breakers are shown in the open position in fig. 10 and the door in front of the power separating filters is removed.

The high voltage bay and the cable terminating bay which are placed beside each other have common interlocks on the door locks. Interlocking of the doors is carried out from the main circuit breakers in the high voltage bay by means of a shaft which can be rotated and which is common to both bay interlocks. In the cases where the high voltage bay contains equipment for two systems, both circuit breakers in this bay must be opened before the door to the cable terminating bay can be opened. The conductors in the cable terminating bay which carry power to the high voltage bay are provided with

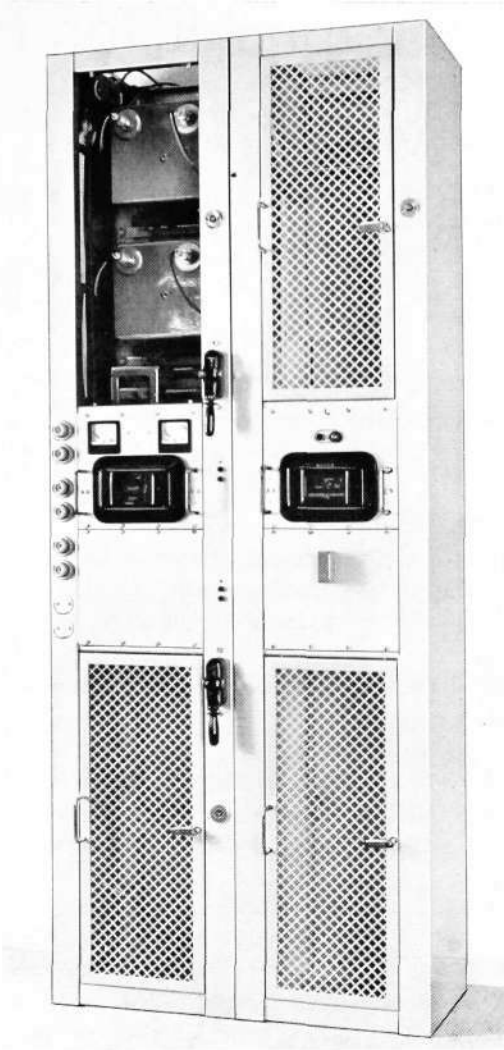


Fig. 10

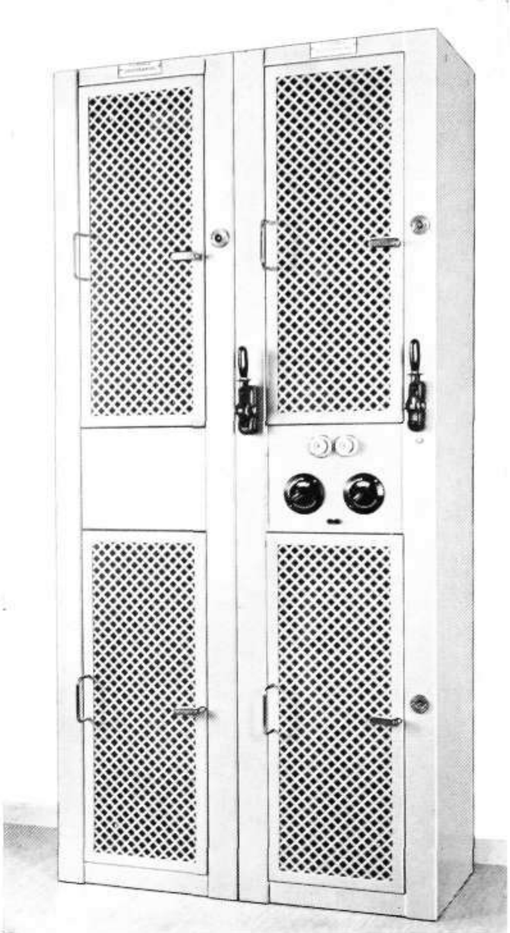


Fig. 11

Fig. 10 X 2309

High Voltage Bay (left) and Cable Terminating Bay for a terminal repeater station

Fig. 11 X 2310

Cable Terminating Bay (left) and High Voltage Bay for an unattended repeater station

plugs which are terminated in coaxial jacks in the cable boxes. It is therefore possible to make interconnexions between the jacks of the tubes. It is to prevent accidents when carrying out such interconnexions that the doors of the cable terminating bay are interlocked by closing the main circuit breaker. The high voltage equipment for system 1 is, however, independent of system 2, and their doors can be opened after the respective main circuit breaker has been opened.

The connexions of the a.c. mains to the high voltage bay are made in sealed connexion boxes of heavy current type. The a.c. mains input to the main circuit breaker is also completely sealed. The bay is therefore completely protected from interference with live parts.

Centralized Impulse Equipment for Final Test Applications

H EGGEHORN, TELEFONAKTIEBOLAGET L M ERICSSON, STOCKHOLM

U.D.C. 621.395.633

In the course of the years L M Ericsson has developed and constructed various apparatus and systems as adjuncts in the testing and control of equipment for automatic telephone switchboards. The present article describes a centralized impulse equipment for irregular impulse trains.

The establishment of a connection between two subscribers calls for close coordination between the various items of equipment in the automatic switchboard in receiving and transmitting information in the form of electrical impulses for control of the switching processes.

Switchboard equipment is usually made up of units or sets of devices for plug and jack connection.

When they come off the assembly line, these units are isolated from their true environment; and for their final test before leaving the factory this environment must often be created by artificial means.

L M Ericsson makes use of methods and equipment which have been specially developed for final testing, such as test jigs, test robots etc., with which all the functions of the relay set or rack equipment can be controlled.

The factory test room equipment described in this article was designed to cover the need of code signals or impulses with varying impulse frequencies and impulse ratios within any one impulse train.

Retrospect

In older types of impulse machine the impulses were often produced by the opening and closing of contacts through the agency of one or more rotating cams. The cams were formed out of a shaft which was driven by a constant speed motor. By regulating the speed of the motor, and by mechanical regulation also of the cams, it was possible to obtain a given impulse frequency and ratio from a single continuously running machine. The disadvantages of this method appeared when the need arose for hundreds of different impulse trains of arbitrary shape (fig. 1) and for means of introducing rapid changes in the impulse programme during production.

In order to eliminate the drawbacks of the older impulse machines, while at the same time satisfying the new requirements as to the characteristics of impulse trains, it was decided to depart from the mechanical procedure. The attempt was made to produce the desired trains of impulses by electronic and electromagnetic means; and an impulse equipment was designed on these principles.

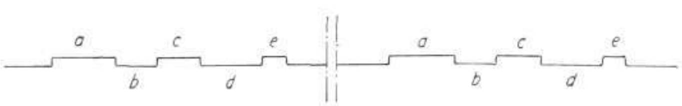


Fig. 1

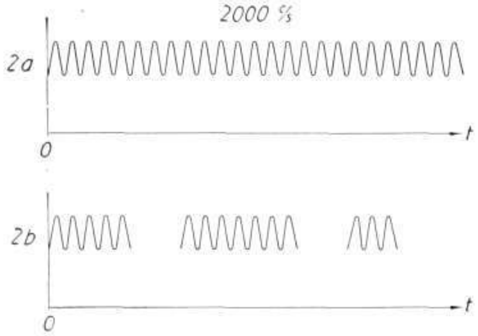
Example of irregular inpulse train

X 8078

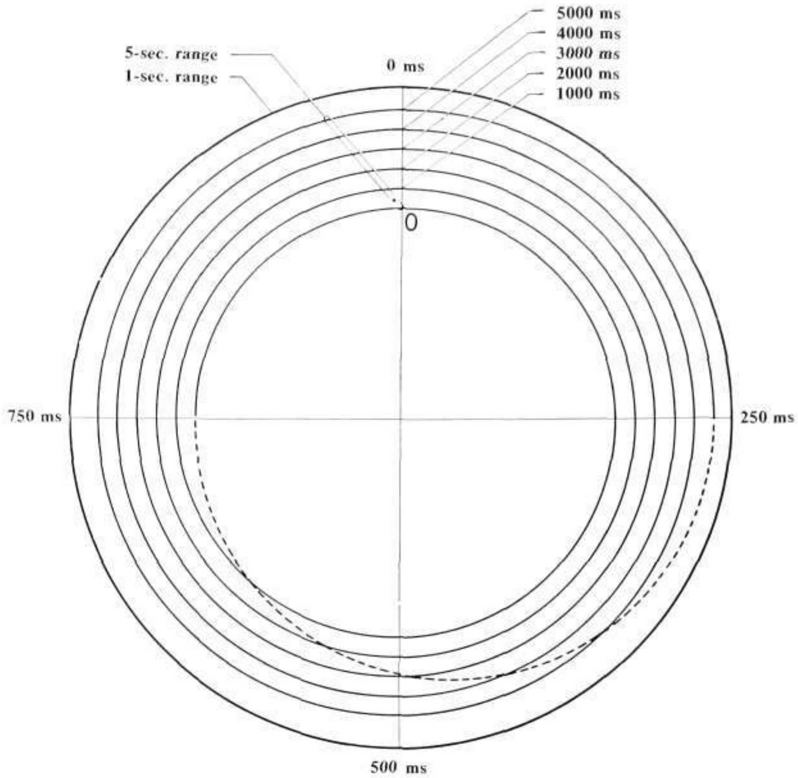
Fig. 2

X 8080
X 2317

The magnetization is effected with a 2000-cycle alternating current (2a). The relevant portions of the magnetization path are thereafter erased (2b).



2a magnetization of path *t*
2b erasing of relevant portions of path *t*



Moreover, since the same types of impulse trains were required at several test positions, the impulse equipments were assembled on a central distribution board.

In view of the sometimes quite large distance between the distribution board and the test rooms, the impulses from the board are distributed in the form of voice frequency signals, so reducing the effect of disturbances and line losses.

General Principles

The new method of generating arbitrary trains of impulses is arranged on the following principles.

In the recording apparatus, the "signal converter", is a circular disc coated with a magnetic foil. The foil, against which a record head rests, is magnetized in a circular or spiral path during the rotation of the disc (fig. 2).

The resulting characteristic of the v.f. impulses is transferred to and stored on an equivalent magnetic foil in a v.f. impulse transmitter; thereafter, when the magnetic foil is played back, the v.f. impulses are distributed to the various test positions (fig. 6).

The distribution network consists of ordinary telephone cable *EDBA 2 × 0.6* (*one* channel from each v.f. transmitter). An additional signal wire is required for the transmission of the synchronizing impulse from the v.f. impulse transmitter to the v.f. impulse receiver.

The v.f. impulse receiver at the test position converts the a.c. signals into d.c. signals of corresponding characteristic.

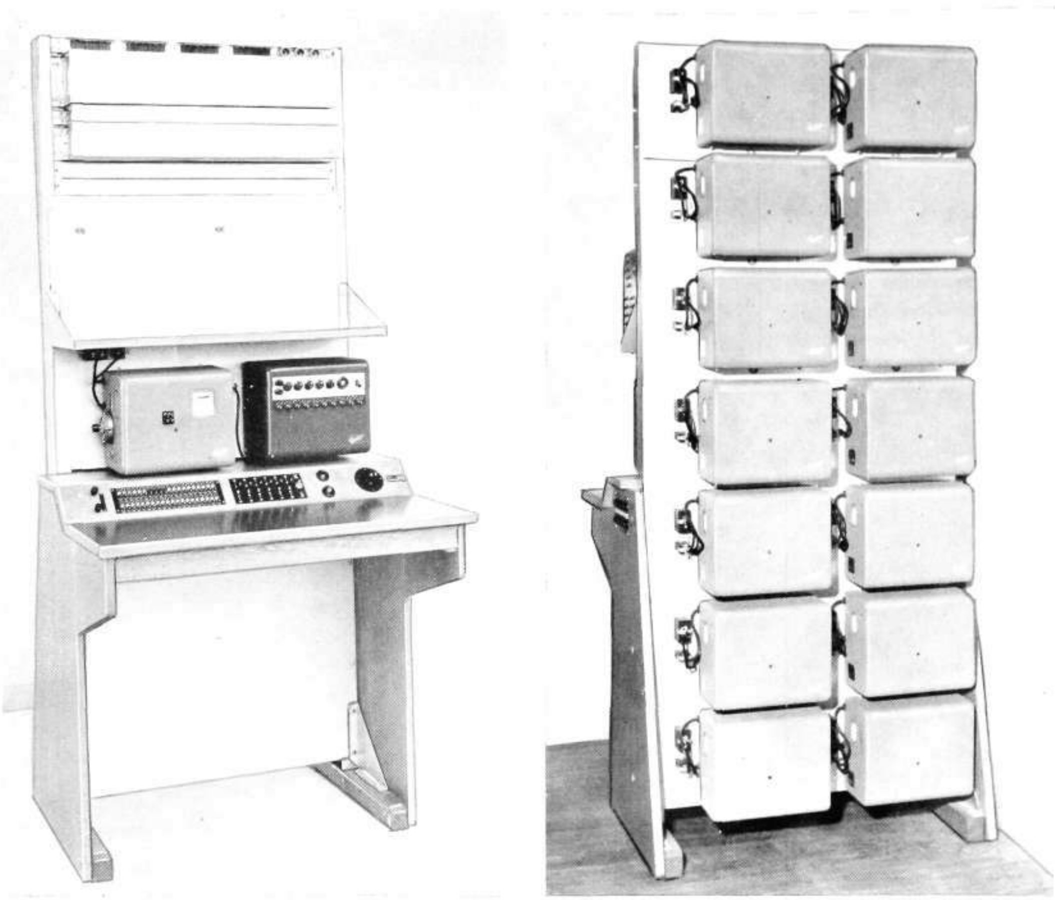


Fig. 3 X 2297 X 2298

Central equipment LTM 182780

(right) rear view

The permanently wired units consist of connecting relays, jacks for connection to mains, jacks for 14 v.f. impulse transmitters, jacks for connection of supplementary rack for 16 v.f. impulse transmitters, and a control panel with lamps, buttons and keys for supervision and distribution of outgoing signals.

Working on these principles, an equipment has been designed which can repeat signals from the impulse source to the various test positions practically without any distortion.

The various units in this equipment are described below.

Centralized Impulse Equipment

The equipment consists of the following main parts:

1. Central equipment	*LTM 182780*
2. Signal converter	*LTM 182798*
3. V.f. impulse transmitter	*LTM 182776*
4. Distribution cables	
5. V.f. impulse receiver	*LTM 182777*
6. Supplementary rack	*LTM 183980*

The central equipment contains the following detachable units:

A signal converter	*LTM 182798*
A v.f. impulse receiver	*LTM 182777*
A signalling unit	*BCG 813X63*
A control relay set	*BCG 803241*

Technical Data

For the elimination of delay when impulses or impulse trains of shorter duration than 1 second are required at brief intervals, only one revolution of the magnetic disc (= 1 sec.) is employed. For longer impulses or impulse trains five revolutions (= 5 secs.) are recorded. One revolution is used, in addition, for restoring the playback head.

The delay for the two ranges will thus be 1 and 6 seconds respectively. The accuracy is ± 1 ms for any chosen impulse or impulse train down to 10 ms make or break impulse.

Apart from the operations performed by the central equipment in conjunction with the recording of impulses, several supervisory operations can be performed from the control panel.

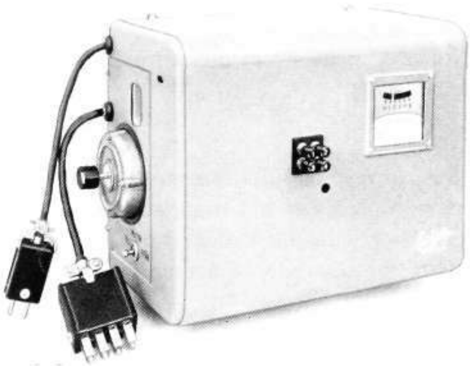
For instance, checks can be made of which transmitters are operating, or of the characteristics of the respective impulse trains, without in any way disturbing the transmission. Lamp indicators show whether the signal voltage level is correct on the various channels and on the signal converter.

Likewise it is possible to check how often an impulse train is repeated from any transmitter or how many receivers are connected in parallel on any one channel.

Impulse trains can also be transmitted automatically via a separate mechanical impulsing unit.

The central equipment operates off a 50-cycle 110 V, 127 V or 220 V supply. A special design will also operate off 60 cycles. A 24 V battery is required for operation of the central equipment relays.

Signal Converter and V.F. Impulse Transmitter



These devices are made from the same basic unit and are assembled on the same kind of frame. The basic unit consists of a modified telephone answerer type *KTB 1001* of L M Ericsson make.

By employing the three units of the recording machine (the base plate, the motor with magnetic recording disc and record and playback heads, and the amplifier and mains terminals), and by the addition of certain equipment, it has been possible to produce an impulsing machine of the desired design, which generates and repeats any desired impulses or trains of impulses.

Signal converter

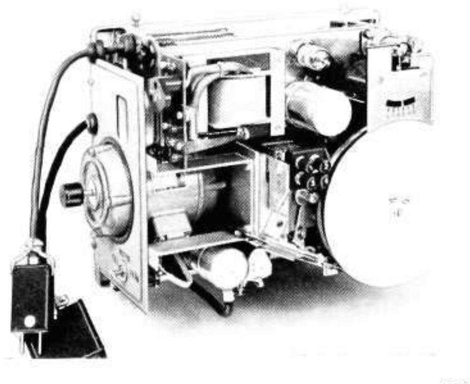


Fig. 4

Signal converter LTM 182798

(below) with cover removed

X 2299
X 2300

The new types of impulses or impulse trains required for each particular purpose at the test positions are produced in the signal converter. The procedure is briefly as follows.

The motor of the signal converter is started. A 2000-cycle current is automatically applied to the sound disc from the signal unit in the central equipment, via the record head. A signal is received from the control panel as soon as the recording is completed, and the motor circuit is broken. As seen in fig. 4, the sound disc has a graduated scale with 500 equal divisions. Every graduation represents 2 ms. In this way the position of the record head can be exactly determined.

The sound disc is turned to 0 with the knob on the end of the motor spindle.

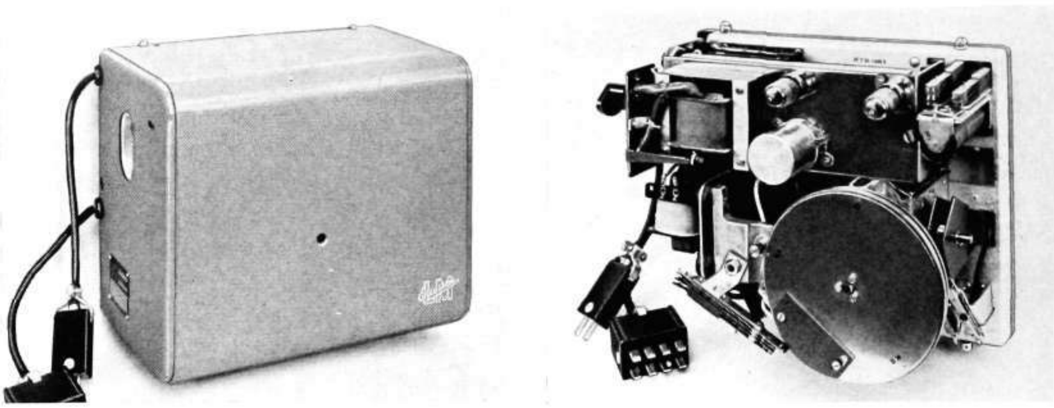


Fig. 5 X 2301 X 2302

V.f. *impulse transmitter* LTM 182776

(right) with cover removed

The sections of the disc which are to represent a break impulse are then erased electromagnetically.

There is a choice of two maximum lengths of impulse train, 910 ms or 5000 ms. The disc normally rotates at 1 r.p.s., but if the 5-sec. range is desired a pointer above the scale is engaged; this shows the position of the record head counted in seconds from the starting position.

When the desired impulse characteristic has been obtained, the motor is started again. The control panel has indicating lamps showing which impulse transmitters are free and which are engaged. A free transmitter is chosen for transmission of the "recorded" impulse train.

V.f. impulse transmitter

The v.f. impulse transmitter (fig. 5) constitutes a magnetic memory for the impulse characteristic recorded on the magnetic foil.

When a new impulse train is to be introduced, a free impulse transmitter is selected. While the new impulse train is being recorded, the old train is automatically erased. The impulse trains which are stored in the various impulse transmitters are marked on the control panel by the insertion of a numbered plug.

The time of utilization of recorded v.f. impulses is proportional to the need of impulses at the respective test positions. In some cases a certain impulse train is required only for a few hours, in others for several weeks or months.

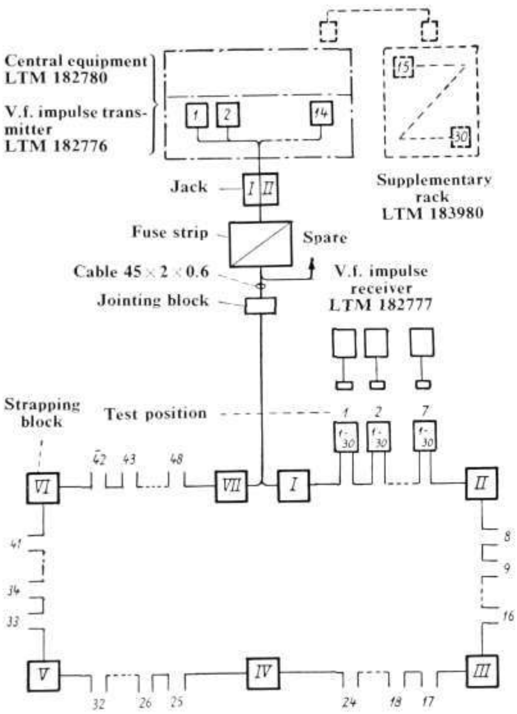


Fig. 6 X 2316

Example of distribution circuits for v.f. impulses with 48 test positions, split into 6 sections, for any desired choice of impulses from 14 impulse transmitters. The wiring is shown for a final capacity of 30 impulse transmitters.

Distribution System

To prevent crosstalk or extraneous disturbances, two-core twisted lead-sheathed cable (2 × 0.6) is used for each distribution channel. The lead sheath is earthed. The synchronizing impulse from the v.f. impulse transmitters is transmitted on single-core conductors. Large installations should be split into sections with a strapping block for each section (figs. 6 and 7).

The strapping block serves as an intermediate distribution frame and simplifies fault tracing in the event of cable damage.

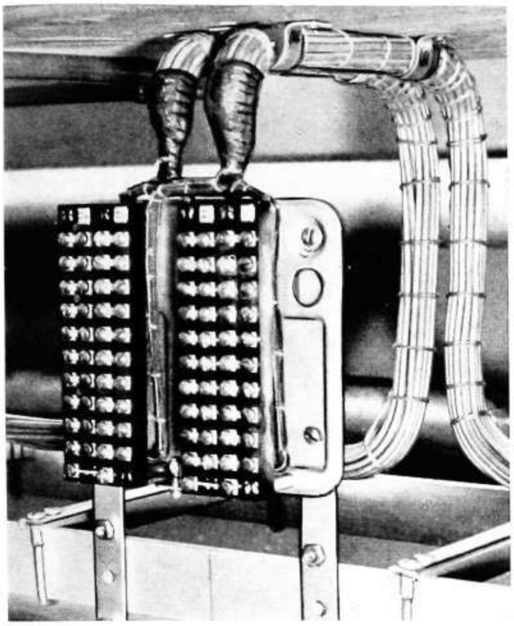


Fig. 7 X 2303

Strapping block

with cover removed

From the strapping block the lines are drawn to distribution blocks. The impulse receivers are set up in pairs on brackets and connected by plug-ended cords *RPM 1013* to the desired distribution circuit (fig. 8).

V.F. Impulse Receiver

Every impulse receiver is equipped for receiving v.f. impulses from five impulse transmitters. In order to be able to distinguish between them, the receiver is equipped with a selecting mechanism for manual or automatic connection of the wanted impulse train.

The v.f. impulses or impulse trains are preceded by a synchronizing impulse. This is the start impulse for the wanted impulse train. At the end of the impulse train a new synchronizing impulse blocks the receiving unit. The blocking can be removed by pressing a button on the v.f. impulse receiver. Continuously recurring impulses or impulse trains will then be received.

In the receiving unit the v.f. impulses are transformed and rectified. The rectified signals actuate an electronic circuit which in turn controls a number of relays.

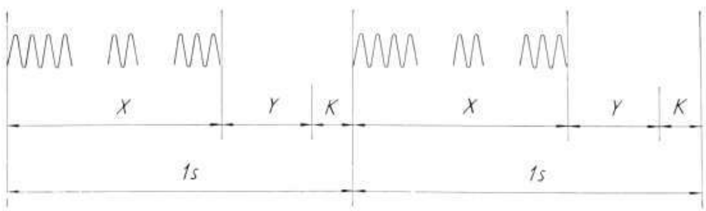
The relay contacts open and close the loop from the test position according to the initially selected impulse train characteristic which is stored on the magnetic foil of the v.f. impulse transmitter.

If the v.f. impulse receiver has been set for reception of continuously recurring impulses or impulse trains, there will be a delay before the impulse train is repeated. The extent of the delay will depend partly on whether the impulse transmitter is set to 1 sec. or 5 secs., and partly on the length of the impulse train.

For the 1-sec. range

X = the length of the impulse train in ms
Y = the break impulse ($X + Y = 910$ ms)
K = synchronizing time 90 ms ($X + Y + K = 1000$ ms)

X 8084



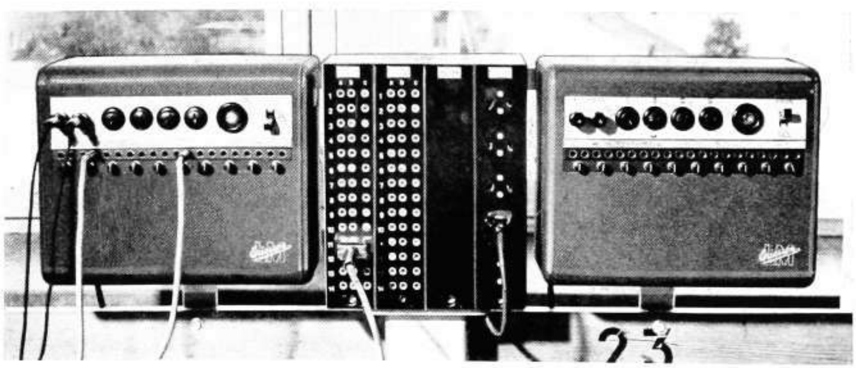


Fig. 8 X 8074

Example of erection of v.f. impulse receivers at test position

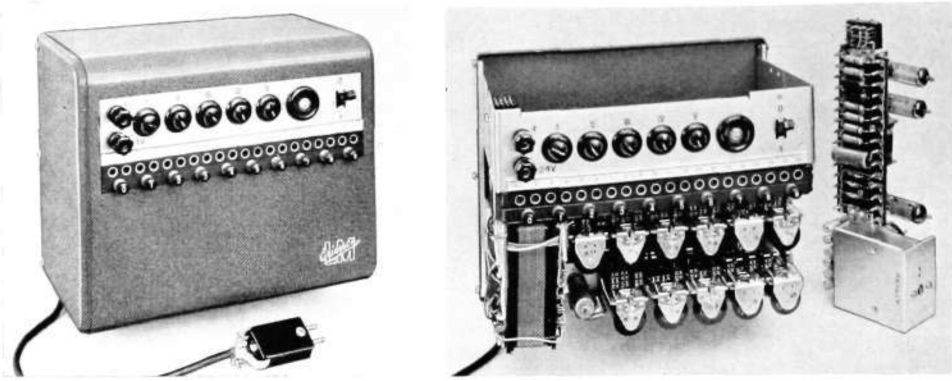


Fig. 9 X 2304 X 2305

V.f. impulse receiver LTM 182777

(right) cover removed and electronic portion detached

For the 5-sec. range

X = the length of the impulse train in ms
Y = the break impulse ($X + Y = 5000$ ms)
K = synchronizing and return time 1000 ms ($X + Y + K = 6000$ ms)

Up to five v.f. impulse receivers can simultaneously receive and convert impulse trains from a single v.f. impulse transmitter without distortion of the impulses.

Conclusion

The amount of equipment needed in the system will depend on the following three factors:

1. Number of different kinds of simultaneous impulse characteristics required to be transmitted
2. Number of different kinds of simultaneous impulse characteristics required per test position
3. Number of test positions required.

The recording of a new impulse train takes only a few minutes. By numbering the various impulse characteristics and drawing a record diagram of them, the recording procedure will be greatly facilitated, especially if the same impulse characteristic is required on numerous occasions.

The system is very flexible and so permits a high degree of utilization of the various units.

The maintenance cost has proved to be very low. The only maintenance required is inspection and lubrication of the v.f. impulse transmitters twice a year.

Keyset-operated C.T.C. System

I BOBERG, L M ERICSSONS SIGNALAKTIEBOLAG, STOCKHOLM

U.D.C. 656.259.22

The first C.T.C. installation in the world was put in service some 30 years ago. Since then many new C.T.C. systems have been developed in different countries, each of which has brought some improvement in rapidity of operation or general reliability. But the systems of operation, and the design of the control and indication apparatus, appear to have been neglected and still look roughly the same as they did 30 years ago. This article describes an entirely new system of C.T.C. operation by means of a keyset. In the last few years L M Ericsson has introduced C.T.C. in Sweden, Denmark, Norway, Poland, Jugoslavia and India.

Centralized Traffic Control—or C.T.C.—has proved an admirable means of improving railway operation. The introduction of C.T.C. on a line will both increase its capacity and reduce the station staff requirements. C.T.C. means that the train despatcher directs all train movements within his section by direct operation of the entire signalling system in that section from a central point, which may be located wherever desired but is usually placed somewhere along the line.

The degree to which C.T.C. can contribute to rationalized railway operation is admittedly little affected by the design of the controlling and indicating equipment at the C.T.C. office. This equipment does, however, appear to have been grossly neglected over a long period. It was not until a few years ago that it began to be realized that C.T.C. could, in fact, be put to very much more effective use if the controlling and indicating equipment were improved. This need has been accentuated by the tendency to place larger and larger sections of track under the control of one office. A more efficient system of control and indication will then lead to direct savings in staff at the C.T.C. office. (This will obviously not apply to small offices which can be managed by one man.) The most important benefit to be derived from greater efficiency in the organization of C.T.C. offices—although not always easy to demonstrate in terms of money—is perhaps the possibility afforded of further improvement in the directing of train movements.

Development of Controlling and Indicating Equipment for Interlocking Plants

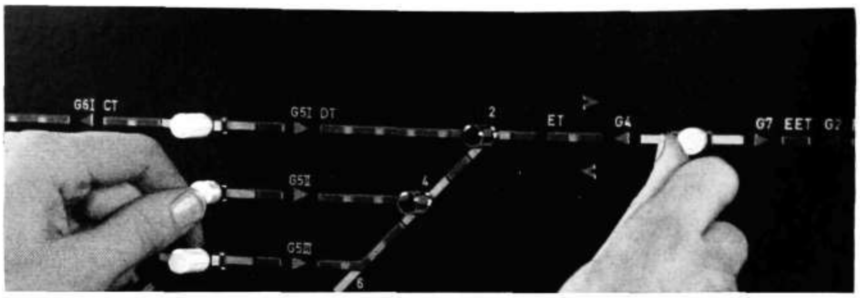
In studying the design of various controlling and indicating apparatus for C.T.C., it may be of interest to consider the development of corresponding equipment for interlocking plants. Interlocking machines came before C.T.C. machines, and there is reason to believe that they influenced the design of the latter. Recently, however, a certain influence in the reverse direction has been noticeable.

It is obvious that the design of the controlling and indicating equipment of interlocking plants has been, and still is, greatly dependent on the devices to be controlled by and indicated to the signalman. When mechanical inter-

Fig. 1 X 8081

Close-up of control machine of modern design for relay interlocking plants

Line-To-Line control of an entire route is effected by throwing two keys simultaneously in the same direction. The keys are placed on the miniature track on the control machine as shown in the photograph.



locking plants were usual, and both points and signals (semaphores) were mechanically controlled, the system could operate only over very short distances. Indications to the signalman were not considered necessary, nor did resources for transmitting them exist. The work was physically heavy. Later, when points and signals could be controlled electrically, the control machines were reduced in size. Control could be effected over greater distances, and the control equipment for a large area could be combined in one interlocking plant. This brought the necessity of indications; they were of a simple character, and the indicating lamps were usually placed on the control machines. When indications became more and more complete, and track circuit control was introduced, the indicating equipment had to be placed on a special track diagram behind the control panel so as to be visible to the controllers from their operating positions.

The interlockings required between the various controls for points and signals, to ensure that faulty operation did not imperil traffic safety, were initially set up by mechanical means in the control panels. Electrical interlockings were introduced in the thirties and in due course led to all-relay interlocking plants. The size of control panels could now be greatly reduced. Once again the indicating equipment could be placed on the control panel, and the methods of control could be simplified. The usual procedure was that signals and points along an entire train route were controlled by a single manual operation (possibly using both hands simultaneously). There are several designs of such equipment. The only method mentioned here is L M Ericsson's LTL (Line-To-Line) method with keys on the miniature track diagram on the control machine. The simultaneous operation of two keys controls the signals and points of the route on which the keys are placed (fig. 1).

With the advent of relay interlocking plants, larger and larger territories could be controlled from one office. The question now arose whether the control panel and track diagram should still be combined or whether they should again be separated. Different methods were adopted by different railways, but the most practical procedure now appears to be to use a single panel provided that it is not larger than that the operator can reach all controls from his chair. If the panel is too large for this to be possible, it should be split into control panel and track diagram. If the control machine can have the controls placed on a sub-miniature diagram, this alternative would seem to be preferable.

It will be apperent that the initial goal of the designers of interlocking apparatus was to eliminate the need of physical strength in the operator. Later efforts were aimed at the design of controlling and indicating equipment of a kind that permitted every operator comfortably and efficiently to control as large a territory as possible from his position at the machine.

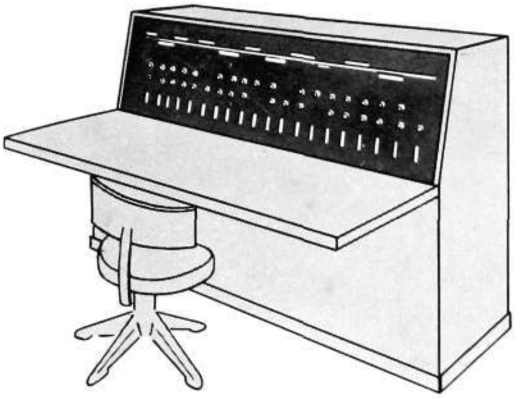


Fig. 2 X 2312

Control machine in C.T.C. office, 1927 model

The Development of C.T.C. Offices up to the 1950-ies

The first C.T.C. system in the world was installed in the U.S.A. in 1927. The line controlled was a very short one, and the little control machine was designed for individual control of points and signals, roughly as illustrated in fig. 2. It probably fulfilled all reasonable requirements at that time. But it is remarkable that the C.T.C. machines produced during the following thirty years closely followed the design of the original model. Most machines delivered even up to 1957 were probably almost identical in appearance and in operating principles to the machine produced 30 years back. In large C.T.C. offices the control machines have admittedly assumed a horseshoe shape and the operator's chair now has runners, but the advance has not been rapid (fig. 3).

It would seem an important point that the C.T.C. operator should have a constant view of the entire track diagram of the territory for which he is responsible. This is quite clearly impossible with the "conventional" design of control machine and operating system. Moreover, according to the notions of our time, it is considered an advantage if the operator can sit still—even if a certain amount of motion has points in its favour. The drawbacks of the conventional design are likely to become more serious in future owing to the tendency to enlarge C.T.C. areas. Quite soon a single C.T.C. office may control an entire railway district covering thousands of miles of track. The track diagram will then have to be divided into sections, as admittedly is done now, but the sections will have to be much larger. It should be possible to cover at least 300 miles and 50 stations from a single control machine of suitable design.

Individual control of points and signals is admittedly fully acceptable for a short length of track. But for large C.T.C. offices the method does not appear satisfactory. In the latter the control must cover entire routes, and should perhaps to some extent be automatic. The larger the C.T.C. office, the more important do these factors become. The introduction of route control on the LTL principle, as described for interlocking plants above, is a case in point. Systems of this kind have been installed by L M Ericsson in Denmark, Norway and Poland.

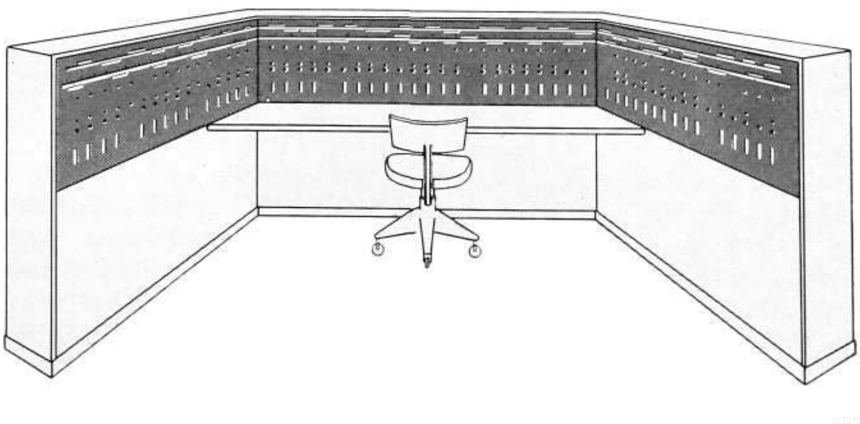


Fig. 3 X 8087

Control machine of conventional type, model 1927—1958

Most C.T.C. offices in the world are still of the design illustrated, and as a rule every point and every signal is still individually controlled. The operator cannot reasonably be expected to have the entire track diagram constantly under his eye while moving about. His chair is normally fitted with runners.

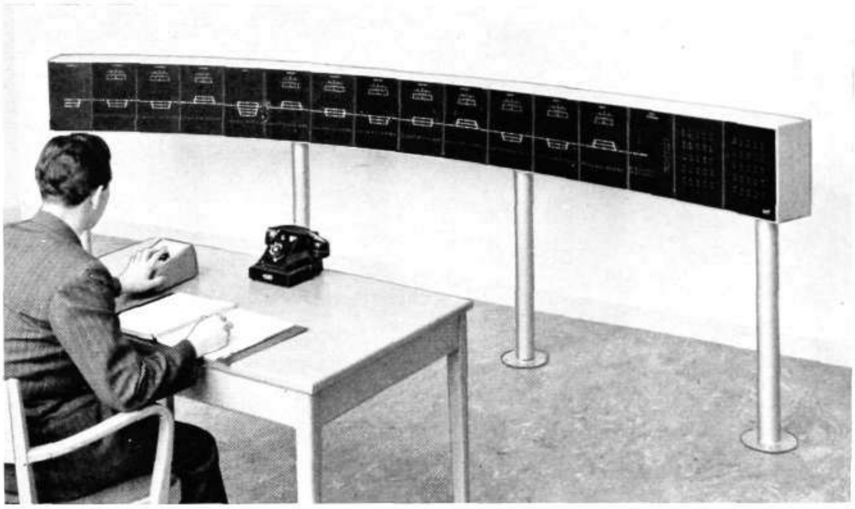


Fig. 4 X 8082

Keyset and track diagram for C.T.C. office as supplied by L M Ericsson

All controls are effected by keying a multidigit number on the keyset. The operator has a full view of the entire track diagram in all situations. (This track diagram was delivered to the Swedish State Railways.)

Keyset Operation

L M Ericsson's first C.T.C. system was delivered in 1938. The control machine was of conventional design, although with equipment for control of complete routes. The equipment is still in service and operating efficiently.

When L M Ericsson started to redesign its C.T.C. system around 1950, primarily in order to step up the rapidity of operation, it was considered advisable at the same time to modernize the control and indication equipment and the method of operation. After careful deliberation and study the following criteria for a C.T.C. office were set up.

1. The operator should be able to actuate all controls from one position.
2. The operator should have a good view of the entire track diagram from his desk.
3. The operator should be able to actuate all controls with one hand (preferably the left hand).
4. The control panel must be capable of standardization for all C.T.C. offices; and several control panels should be capable of operation in parallel, temporarily or permanently.
5. The normal procedure should be control of an entire route. But individual control of signals and points should also be possible.
6. If indication of category of train on the track diagram is desired, the same control panel should be used for this purpose as for other C.T.C. operations.
7. The track diagram should be semi-circular.
8. The operator should be able to transmit from the control panel information which permits automatic control of the C.T.C. system to a varying extent. The track diagram should possess the necessary indicating lamps for this purpose.

Requirements 1 and 2 meant that, at least in large C.T.C. offices, the track diagram must be separate from the control panel. Since it was also required that the control panel should be standardized, it followed that this separation must apply to small offices as well. An example of the placing of the controller and his control panel in relation to the track diagram is shown in fig. 4.

The control panel would meet the requirements of universal applicability (standardization) and be operatable with one hand (requirements 3 and 4) if it was designed as a keyset of the type used on calculating machines. The keyboard could be large or small, with one or more sets of keys for each digit. The small keyboard would require a rather more complicated intermediate relay set than the large one, but the advantages from the control aspect appeared so great that the small keyboard was adopted (fig. 5). Requirement 4, that several control panels could be used in parallel, was thereby easily met.

Since control was to be exercised through the keying of numbers on a keyboard, the numbers would have to be simple enough for the C.T.C. operator to remember at least those in common use. This did not prove difficult, particularly since, for reasons of rapid operation, an entire route would normally be controlled by keying a single code (requirement 5). An example of a logical numbering system for all routes on a single-track line is shown below. This is only one way of arranging the numbering. Many other systems would be equally logical and equally easy to remember. Easily memorable numbering systems can likewise be made up for double-track lines.

Keyset control nos.	*Route*
11	*Approach* from south (*northward*) main track
13	" " " " first siding
15	" " " " second siding
	etc.
21	*Exit northward* from main track
23	" " " first siding
25	" " " second siding
	etc.
12	*Approach* from north (*southward*) main track
14	" " " " first siding
16	" " " " second siding
	etc.
22	*Exit southward* from main track
24	" " " first siding
26	" " " second siding
	etc.

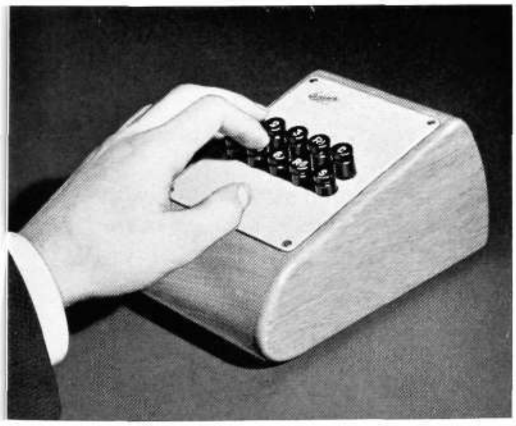


Fig. 5 X 2314

Keyset for C.T.C. operation

The operator keys a four-digit number to control an entire route. When desired, however, he can control points and switches individually by keying other numbers. With other numbering schemes the operator can indicate the category or destination of each train on the track diagram, after which the indication moves with the train from track section to track section. A trained C.T.C. operator, of course, need not look at the keyset when manipulating the keys.

Odd numbers are used for all controls of trains in one direction, and even numbers for all controls of trains in the other direction. The first digit of all controls is odd for approaching trains and even for departing trains.

Each control, however, must consist of four digits, of which the first two represent the station number. The station number can be indicated on the track diagram so as to be easily visible to the controller from his working position. The control of a route for a train entering the main track at station *34* from the south will be effected by keying number *3411* (fig. 6).

Train categories (goods, express etc.) or train numbers (requirement 6) are indicated on the track diagram by the track circuit lamps or by lamps placed beside them. When a new train enters the C.T.C. section, the category of train must be indicated on the track diagram by operation of the keyset. This can be done for instance in the following manner. The controller first keys the number of the station and of the track on which the inbound train has entered the C.T.C. section. He then keys a letter, signifying the category, or

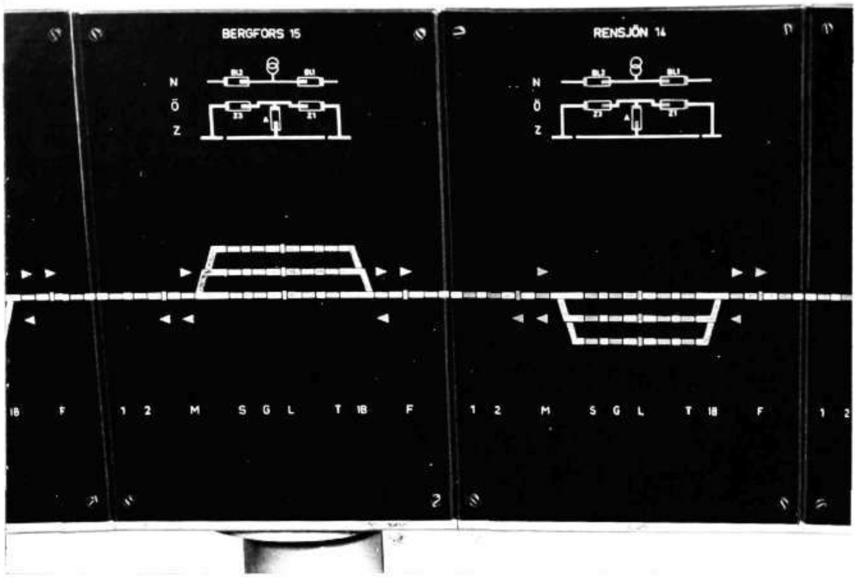


Fig. 6 X 8088

Part of C.T.C. track diagram

Every station has its number, which the C.T.C. operator keys when transmitting a control. This track diagram also shows the positions of circuit-breakers and disconnecting switches in the railroad overhead line and auxiliary transmission line. The control of circuit-breakers and disconnecting switches is effected with the keyset in the same way as control of routes etc.

numerals, signifying the number, of the train. The combination *0112G* would provide the following information:

0 signifies that the subsequent digits and letter refer to the category of train. (The information is not to be transmitted to the C.T.C. control register.)

11 signifies indication of the category of train at station *11*.

2 signifies indication of the category of train on track *2* (at station *11*).

G signifies goods train.

When using a train number system, the combination *0112324* would permit the entry of train number *324* to track *2* at station *11*. The indication of train category or number moves along the track diagram automatically from track section to track section as the train advances.

Requirement 7 needs no special comment. The track diagram is semi-circular as shown in fig. 4.

Requirement 8 stipulated that the control system should permit automatic operation to varying degrees, and that whatever automatic methods were employed should be adequately indicated on the track diagram. This requirement is dealt with in the following section.

Automatic Operation

The execution of a C.T.C. control takes very little time. It amounts to a few seconds, and in a small office the actual operating time is a relatively insignificant factor. But it must be remembered that the main job of a C.T.C. operator is to plan train movements, not to execute the actual controls. In a large C.T.C. office, therefore, it may be necessary either to use several C.T.C. operators or to have a single operator and give him additional technical aids. We may take as example a single-track section comprising 25 stations and carrying 60 trains a day. During the period of heaviest traffic the operator would have to execute controls about twice a minute. (In assessing the amount of work to be performed by a C.T.C. operator, the number of occasions on which he has to execute controls would appear to be a better gauge than the number of controls to be executed.) Even if every action by the C.T.C. operator controls an entire route, he should hardly be made responsible for so great a number of operations if he is at the same time to do his main job of planning train movements.

But the capacity of a train despatcher can be increased by giving him additional technical equipment. This can be arranged in several different ways without needing to add unduly to the expense of the C.T.C. equipment. The Swedish State Railways, for example, have introduced local equipment at the stations for storage of routing orders from the C.T.C. office. The C.T.C. operator can then give advance orders for control of several train movements, and the number of occasions on which he has to execute controls can be easily reduced to less than half. If considered preferable, the storage equipment can naturally be installed equally well in the C.T.C. office. It can also be combined with a certain measure of automatic operation by having station signals and points automatically set for a meet if two trains approach from opposite directions.

The Danish State Railways have chosen another method of reducing the work of the C.T.C. operator. It has been called the "destination indication system"; the destination of every train entering the C.T.C. area is marked on the track diagram by means of the track circuit lamps, or by lamps placed beside them, in the same way as the category of trains. When the train arrives at its destination, the destination lamp on the track diagram darkens and the C.T.C. operator keys a new destination. All signals and points are operated automatically by the destination marking equipment.

Keyset operation of the destination indication system could be carried out for instance in the following manner: When the C.T.C. operator wishes a train on track *2* at station *12* to move to track *2* at station *34*, he keys *0122342:*

0 signifies that the subsequent digits refer to destination marking. (The information is not to be transmitted to the C.T.C. control register.)

12 signifies indication of the destination of a train at station *12*.

2 signifies indication of the destination of a train on track *2* (at station *12*).

34 signifies that the train will proceed to station *34*.

2 signifies that the train will proceed to track *2* (at station *34*).

If for any reason the destination of a train requires to be cancelled, this is done by keying the track number and station number of the present position of the train, followed by *0*. Number *01120* would mean cancellation of the destination of a train on track 2 at station *11*.

Like the storage system employed by the Swedish State Railways, the destination marking system can be combined with automatic equipment which sets signals and points at a station for a meet if two trains approach the station from opposite directions.

Other Designs

Even if L M Ericsson has found that C.T.C operation can best be effected by means of a keyset, it is obvious that other methods may be preferable in special instances. The aforementioned principles of indication of train category and of automatic control by means of storage or indication of destination can be applied to other methods as well.

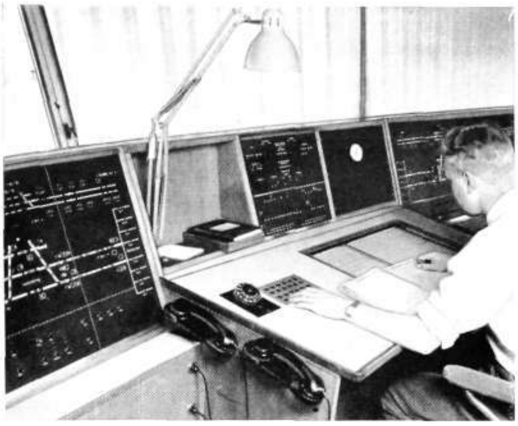


Fig. 7 X 2315

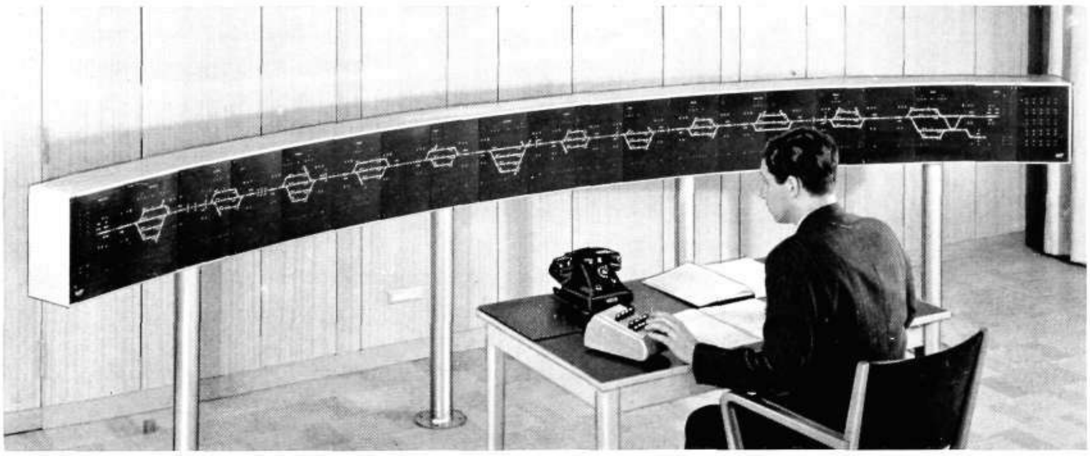
C.T.C. machine and track diagram with Line-To-Line system

In the centre of the machine, beside the traingraph, are certain keys with which the controller can perform all normal operations. For special operations, however, he must move over to the track diagram. (This equipment was delivered to the Danish State Railways.)

Particular mention may be made of a method employed by the Danish State Railways, involving the control of entire routes by means of a Line-To-Line system on the combined control panel and track diagram. In parallel with the Line-To-Line controls, however, are keys which are placed in the centre of the control machine beside the traingraph (fig. 7). These keys can only be used for normal control operations, but preclude the necessity of the C.T.C. operator moving from one part of the control machine and track diagram to another, apart from exceptional cases. The use of the destination indication system, with the controls placed beside the traingraph, means that the C.T.C operator should in practice never need to leave his normal working position.

Experience of Keyset Operation

L M Ericsson's first keyset-operated C.T.C. system was installed on the Swedish State Railways in 1955. The overall experience during these three years has been very satisfactory. The personnel have had no difficulty whatsoever in learning the numbering system, and it has found to be a manifest advantage that the C.T.C. operator should have the entire track diagram constantly under his eye and be able to perform all operations while sitting at his desk.



X 8089

Fig. 8

C.T.C. equipment delivered to Jugoslavian Railways

This office, situated in Doboj, controls the roughly 100 kilometres of single-track line between Doboj and Zenica. The main part of the installation will be completed this year and the remainder during 1959.

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

Carrier System Opened Between Rio de Janeiro and São Paulo

March 6 was the date of the opening in Brazil of the new installations ordered by Companhia Telefônica Brasileira, which will lead to a great increase and improvement in the telephone facilities between the capital, Rio de Janeiro, and the great industrial city of São Paulo. The carrier equipment at São Paulo, which constitutes one terminal of the combined coaxial and radio link system between the two cities, consists of L M Ericsson's system type ZAX 960/2, which has been preliminarily equipped for 180 circuits but can be extended to a final capacity of 960 circuits.

The system was inaugurated by a telephone conversation between the President of the Republic, Juscelino Kubitschek, at the Presidential Palace outside Rio de Janeiro, and the Governor of the State of São Paulo, Janio Quadros, speaking from the São Paulo exchange.

Carrier circuits between the cities of São Paulo and Campinas, another important centre in the State of São Paulo, had already been put in service in 1957. The latter route is likewise equipped initially for 180 circuits and employs a radio link operating in the 4000 Mc/s band.

The Campinas equipment is also of type ZAX 960/2. Despite summer temperatures of sometimes above 40° C, the performance of the systems has hitherto been extremely good.

(Above) Governor Janio Quadros speaks over the new Rio de Janeiro—São Paulo circuit. Second from the right is Sr. Carlos Reis of CTB.

New Members of L M Ericsson Management

In conjunction with the reorganization of the top management of L M Ericsson, Messrs Malte Patricks and Arne Stein have been given special appointments. Mr Patricks will be in charge of coordination and supervision of all telecommunication departments of the parent company, whereas Mr Stein will be responsible within the management for sales questions.

Mr Patricks, who is 54, graduated from the Stockholm Institute of Technology in 1928 and joined L M Ericsson in the same year. During the first years he was in charge of the installation of telephone exchanges abroad, and later of questions relating to Swedish telephone exchanges. From 1940 onwards he was in charge of the company's sales of telephone exchanges to the Swedish Administration, being at the same time responsible for the installation of exchanges in Sweden and abroad. In 1954 he was appointed vice-president and head of the Telephone Exchange Divisions, and since March 1, 1958, has been responsible within the management for the parent company's activities within the entire field of telecommunications.

The other new member of the management, Mr Stein, is 45. After graduating from the Stockholm Institute of Technology in 1937 he worked at the Swedish Telecommunications Administration until 1946 when he joined L M Ericsson. In 1951 he became head of L M Ericsson's Colombian sales company, Cía Ericsson Ltda. Since his return to Sweden in 1954 he has dealt with sales questions in South and Central America in the capacity of market expert, until his present appointment to the post of Director in charge of sales.

Malte Patricks

Arne Stein

Bishop of Stockholm Visits L M Ericsson Cable Works

The L M Ericsson Cable Works at Älvsjö had a distinguished visitor on March 7. The Bishop of Stockholm, Helge Ljungberg, paid a call at the Cable Works in the course of his tour of inspection of the Parish of Brännkyrka. This was the first visit by the Bishop of the Diocese to Brännkyrka since the formation of the new parish.

Apart from the flag which was flying at its mast, no special ceremonies had been arranged and work was in progress as usual in the cabling and other shops. The Bishop was met by a group of representatives of the management and of the workers', foremen's and office staff organizations.

After an hour's tour of the plant, during which the Bishop found plentiful opportunities of making the acquaintance of the personnel, he made a short speech in the Workers' Dining Room, which was filled to overflowing.

(Above) Bishop Helge Ljungberg conversing with Mrs Laurina Jansson at the machine with which she braids telephone cords.

(Right) The robot testing the cabling of a relay bay. The three designers of the apparatus are (from left to right) Karl-Erik Henner, Henry Eggehorn and Valentin Gustavsson.

New Robot Tests Cabling of Relay Bays

Like many other Swedish firms, L M Ericsson has introduced a large measure of automation in its production. The L M Ericsson laboratories have been working for several years on the task of reducing the time taken for products to pass through the factory. One result of this work has now seen the light of day and is ready to be put to use within the Ericsson group: a robot for testing the cabling of relay bays in modern automatic telephone exchanges.

A telephone relay bay contains thousands of wires combined into cables. Each wire leads to two soldering points. The checking of these cables takes a long time if done by hand. It is a very complicated and laborious task to make sure that every wire is in its place, not in contact with another wire, and not broken.

This manual work has now been taken over by the robot, which does it very much quicker. The robot's relays test each wire in succession. By following the process on a Centralograph (L M Ericsson's automatic machine control apparatus) the controller can immediately put his finger on any faulty wire.

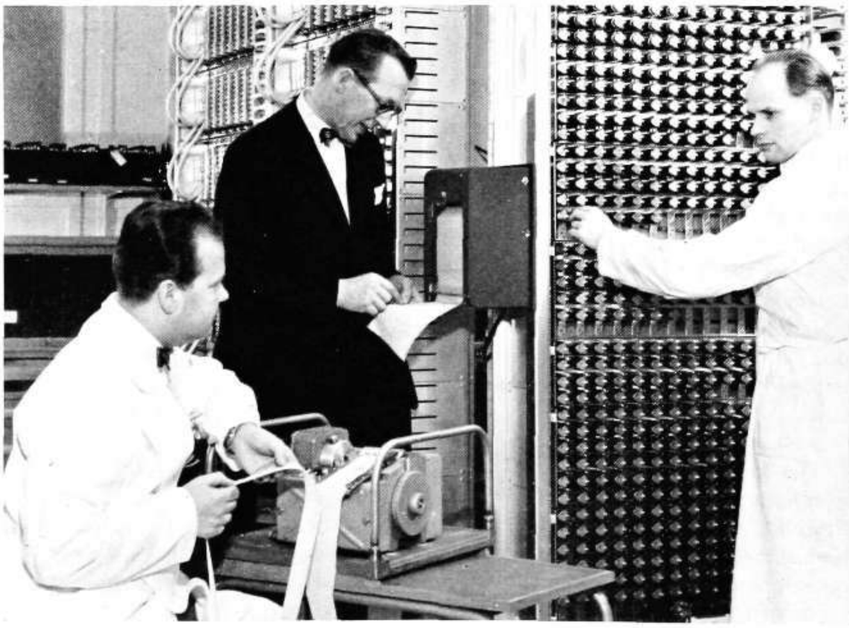
The new robot was designed primarily for use in L M Ericsson's own shops and for the special methods employed there. It is used for the final test of the product.

The robot consists of a program mechanism containing a paper chart in which holes are punched. The combination of holes makes up the program for testing the bay in codified form. Guided by the punched chart, impulses are sent to a relay set which connects the wires in succession to various measuring instruments. Several of these instruments are equipped with transistors. The measurements comprise continuity tests to check that the wire is firmly connected to its soldering points and is unbroken, and tests of insulation between wires and between wires and earth.

Any fault is immediately recorded by the Centralograph which shows the controller exactly where the fault lies so that he can put it right without delay.

It takes about 15 minutes to test a normal bay containing 4000 soldering points. This covers continuity tests, insulation tests, and recording of any wiring faults. The robot's program can include 24000 soldering points. Since a normal relay bay does not contain more than 8000 soldering points, the robot can check three bays on the same program.

L M Ericsson's technicians describe the machine as a long step towards automation. It has provided the impulse for continued work in this direction, especially in the control of finished products.



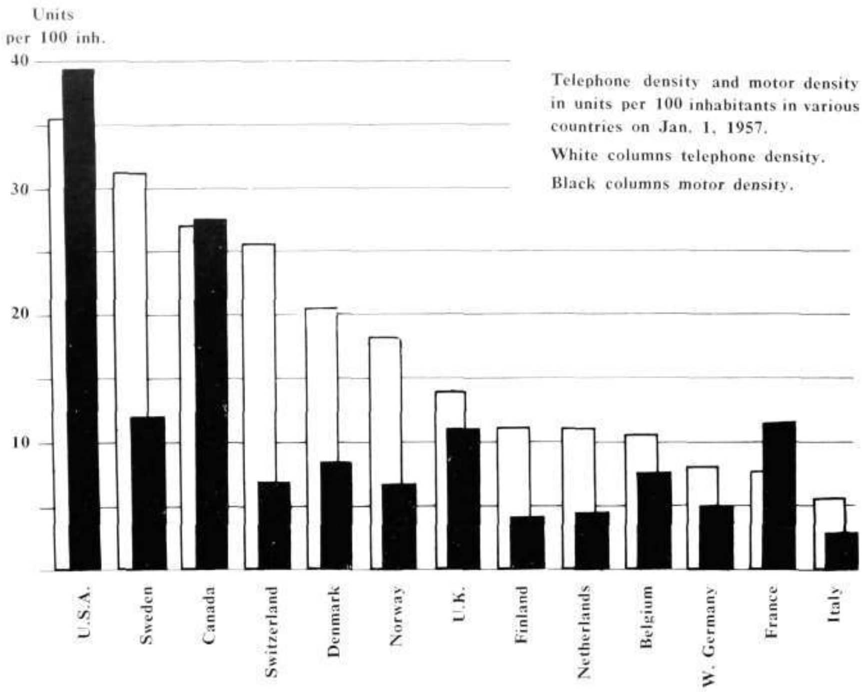
AB Ermex, *manufacturers of L M Ericsson locks, in* conjunction with AB Svenska Karosseri Verkstäderna, Katrineholm, Sweden, have designed a coin mechanism for luggage lockers at railway and underground stations. The object of the lockers is to provide travellers with a safe means of storing small luggage for short periods. Two sizes are available: the locker shown in the photograph is intended for brief cases, shopping bags and other small objects, while the larger model is of the *same width but high enough to hold* a suitcase. The "customer" goes to an empty locker, opens the door and places his belongings in it. After shutting the door, he inserts a coin in the slot, after which he can lock the locker and remove the key.

A group of Dutch industrialists on a visit to Stockholm paid a call at L M Ericsson. Some of them are seen in the photograph, trying out a telephone switchboard in the demonstration room. From left Mr J Kuhlmeyer, Mr J Bolhuis, Mr Ph H Noordval, Mr C Berglund (of L M Ericsson), and Mr A Rom Colthoff.

An international exhibition was held at Amsterdam in September 1957, the main exhibitors being radio manufacturers. L M Ericsson's Dutch company, Ericsson Telefoonmaatschappij, N.V., showed, among other equipment, the Ericorder and Combine-Unit System of Sound Distribution.

A delegation from the Tunisian P.T.T. visited L M Ericsson at Midsommarkransen in February. The photograph below is taken in the laboratory. The three gentlemen in the foreground (right) are the P.T.T. staff manager, Mr Bezzaouia, and Messrs Ben Sheik and Khouadja, chief engineers of the Exchange and Transmission Divisions.

Mr Einar Carlson of L M Ericsson's Cable Works, Älvsjö, Stockholm, is among the youngest to receive the award of the Silver Plaque for 50 years' service with L M Ericsson. Mr Carlson was taken on at the age of 13. The photograph below, taken at the presentation ceremony, shows (from left) Mr A Steiner, Miss I Ekström, Mr Einar Carlson, and Mr A Westling (President of Cable Works).



the wide use of the telephone over a considerable past period. Cars, on the other hand, have only emerged quite recently from the sphere of luxury articles and are now sold in large numbers to families of average income.

In Sweden it is anticipated that by 1965 there will be 25 cars per 100 inhabitants, and in 1975 about 33. According to a method of calculation published in TELE No. 3/1957 the telephone density in Sweden for those years may be expected to be 36 and 38 per cent respectively. Thus by 1975 the difference is likely to be quite small.

	Number telephones millions	Number motor vehicles millions	Ratio
France	3.31	5.00	0.7
Africa	1.55	1.98	0.8
U.S.A.	60.19	64.60	0.9
Oceania	2.53	2.95	0.9
Canada	4.50	4.32	1.0
Latin America	3.47	3.34	1.0
Belgium	0.93	0.70	1.3
U.K.	7.22	5.42	1.3
W. Germany ..	4.32	3.10	1.4
Italy	2.61	1.48	1.8
Asia	4.93	2.59	1.9
Netherlands ..	1.23	0.49	2.5
Norway	0.61	0.24	2.5
Denmark	0.92	0.36	2.6
Sweden	2.31	0.85	2.7
Finland	0.49	0.17	2.9
Switzerland ..	1.29	0.37	3.5
Spain	1.20	0.24	5.0
World total ..	109.8	102.8	1.07

Are there More Telephones in the World than Motor Vehicles?

A comparison between the world's telephones and motor vehicles reveals the surprising fact that these two apparently so different products are almost equal in number. According to the latest statistics, world telephones numbered 110 million at January 1, 1957, while motor vehicles numbered 103 million. The difference of about 6 per cent in favour of the telephone is astonishingly small.

The result is all the more surprising when considering the situation in Sweden. We have become used to regarding the telephone as a necessity of the first order, while the motor car has taken second place. This is clearly revealed by statistics: the number of telephones in Sweden at the beginning of 1957 was 2,310,000 and of motor vehicles 850,000, a ratio of 2.7:1. The corresponding figures in 1955 were 2,100,000 and 650,000, and ratio 3.2 : 1. Thus the present trend in Sweden is that motor vehicles are increasing more quickly than telephones. The 1957 ratio in U.S.A. was 0.9 : 1, i.e. there were more motor vehicles than telephones.

The relation between telephones and motor vehicles in various countries and continents is shown in the adjoining table.

It is remarkable that the telephone-motor vehicle ratio in U.S.A. is roughly the same as in African and Oceanian countries, in fact below 1. In all other countries except France the ratio is greater than 1, i.e. telephones predominate.

The long term prospect is that telephones and motor vehicles will eventually reach approximate parity in countries with a free economy. That this is not so at present in most European countries is chiefly because of

In the second half of February an exhibition was held at the Royal Library of Stockholm with the title "Swedish Press Art 1954-1956". The exhibition, which met with a lively response, presented the best newspapers and journals published during those years, selected by an expert jury. One of the trade journals exhibited was Ericsson Review.

U.D.C. 621.395.44
621.395.521
621.311.6

BÜLOW, A, JONSON, F & KJELLERYD T: *L M Ericsson's 960-Circuit System for Coaxial Cables. II. HF Line Equipment. Power Supply, Supervision and Maintenance, Mechanical Design.* Ericsson Rev. *35* (1958): No, 2, pp. 42—57.

This article completes the chapter on the h.f. line equipment in the series on L M Ericsson's coaxial system ZAX 960/2. It describes equipment for the transmission of power to the unattended repeater stations, and for transforming the power to the voltages required for operating the repeater equipment. In addition, the problems of maintenance and the supervisory equipment are dealt with, and finally details are given of the division of the equipment into bays and panels.

U.D.C. 621.395.633

EGGEHORN, H: *Centralized Impulse Equipment for Final Test Applications.* Ericsson Rev. *35*(1958): No. 2, pp. 58—64.

In the course of the years L M Ericsson has developed and constructed various apparatus and systems as adjuncts in the testing and control of equipment for automatic telephone switchboards. The article describes a centralized impulse equipment for irregular impulse trains.

U.D.C. 656.259.22

BOBERG, I: *Keyset-operated C.T.C. System.* Ericsson Rev. *35*(1958): No. 2, pp. 65—72.

Since the first C.T.C. installation some 30 years ago, the C.T.C. systems have been improved as regards their rapidity and reliability of operation. But the systems of operation, and the design of the control and indication apparatus, are still based on roughly the same principles as 30 years ago. This article describes an entirely new system of C.T.C. operation by means of a keyset introduced by L M Ericsson.

The Ericsson Group

Associated and co-operating enterprises

• EUROPE •

Danmark

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

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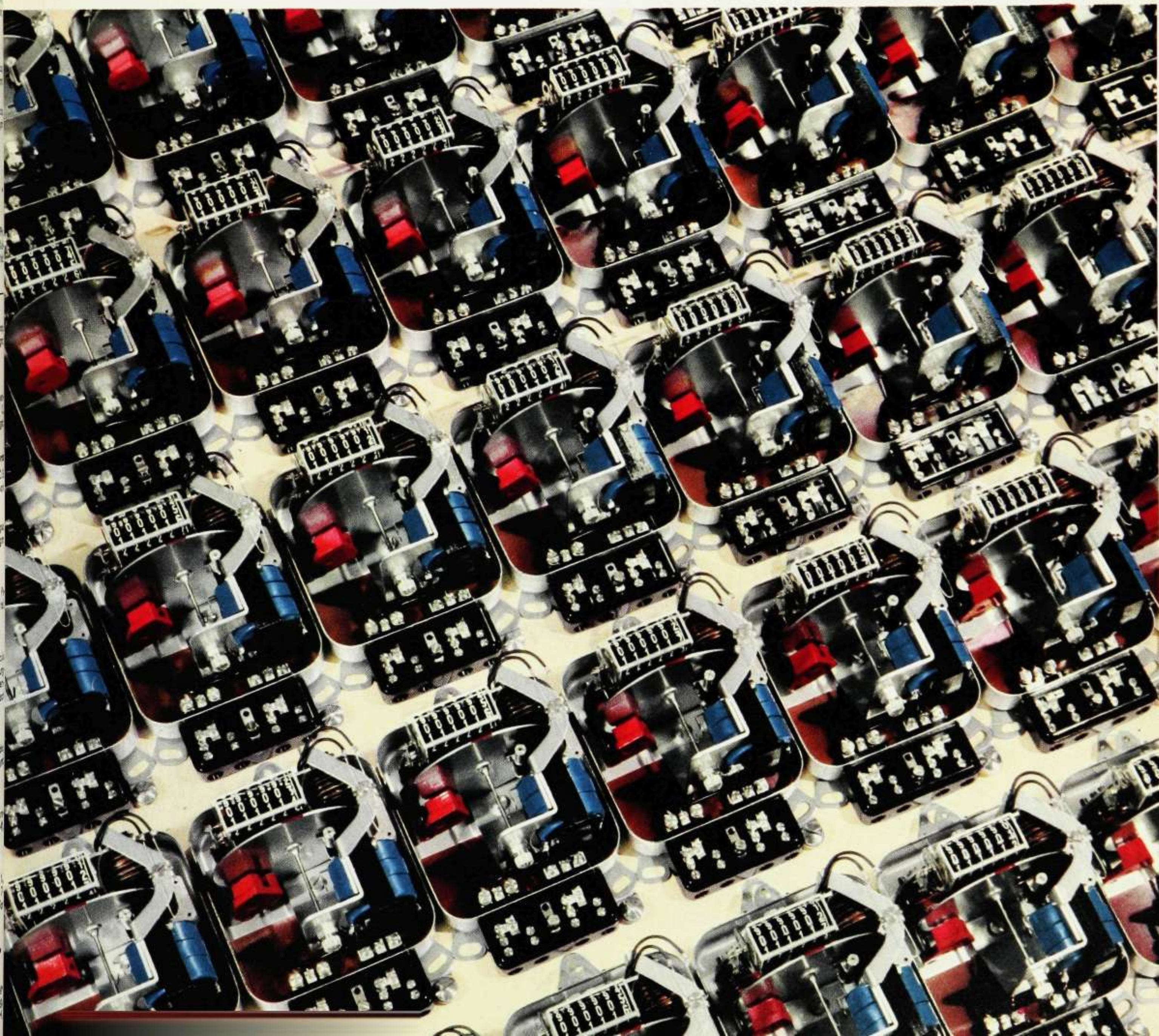

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CONTENTS

On cover: Single-Phase Meters Type VEN 23 from Ermi.

Facilities Offered by Modern Private Automatic Exchanges

H BJÖRK & A HAGLUND, TELEFONAKTIEBOLAGET LM ERICSSON, STOCKHOLM

U.D.C. 621.395.25

Users of private telephone systems are coming to expect a greater measure of convenience and rapidity in telephoning than they have been used to in the past. Entirely new means of meeting these demands have been provided by developments in marker switching as applied to crossbar exchange. Some of the new facilities developed by Telefonaktiebolaget L M Ericsson are described in this article, which deals principally with a private automatic exchange for up to 800 extensions, type ARD 231.

The first obvious requirement on a private automatic exchange is that it shall provide rapid and reliable internal communication. But a modern P.A.X. or P.A.B.X. should also include one or more of the following services to the customer's choice:

1. Group calls
2. Priority
3. Interworking with other exchanges
4. Conference facilities
5. Paging (Staff location)
6. Night watchman control
7. Centralized dictation facilities
8. Immediate access

In certain of L M Ericsson's private exchanges several of these services have been improved, while the following facilities have been added:

9. Call-back facility
10. Automatic interception
    a. Redirection to other telephone number
    b. Redirection to telephone answering machine

For these services supplementary equipment is added to the exchange.

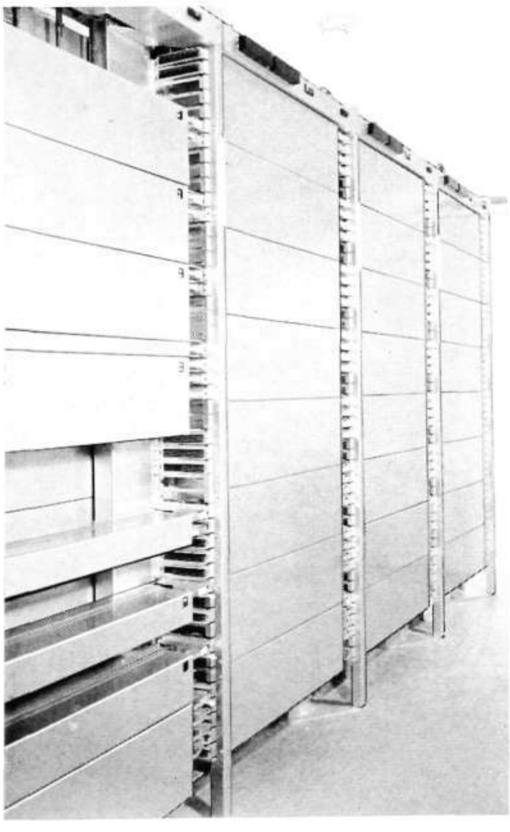


Fig. 1 X 2323

Automatic exchange type ARD for 200—800 lines

Switching bay

1. *Group calls*

In exchanges which employ conventional types of switches the method of operation of the switch has made it difficult to combine extensions, not in sequence in the selector multiple, into a group with a common group number. One consequence of this has been the impossibility of adding further extensions to a group when a certain extension number is already utilized. This drawback has been eliminated in the new exchanges in which, within any one hundred's group, the extensions can be combined into groups of five with a group calling number. The possibility still exists, nevertheless, of calling each extension in the group individually.

2. *Priority*

All extensions with numbers ending in the digit 9 can be given priority. If a priority extension meets an engaged signal, the user can obtain contact with the engaged extension by dialling the digit corresponding to two impulses, i.e. "2" on a dial numbered 1—9, 0. A faint warning tone is issued to the conversing extensions when a third party enters the line. The latter, if he wishes, can deliver a short message and then cut out of the connection by replacing his handset; or he can request the two parties to finish their conversation and hang up, after which the wanted extension is automatically rung.

3. *Interworking with other exchanges*

One extension line is required for every tie line. Three-digit numbers are normally used for calling associated exchanges. If a number of tie lines lead to the same exchange, a group calling equipment will be required as under point 1.

4. *Conference facility*

Every extension can establish a conference connection with any other four extensions simply by means of the dial. If a record of the conference is desired a dictating machine can be connected, in which case the number of participators is reduced from five to four.

5. *Paging*

This service has been considerably improved and expanded. Paging can be initiated from any extension. Despite this, the paging extension can be used for normal telephone communication while paging is in progress. No connecting circuit is occupied during paging. The paging equipment is immediately released when telephone communication is established between the two parties.

One hundred paging combinations are available. These combinations can be used within four different sectors, so providing a potential capacity of 4×100 persons. But as persons who are to be paged in more than one sector will naturally have the same combination throughout all sectors, the total capacity will be reduced accordingly. Two persons can be paged simultaneously, each in his own sector.

When a person is to be sought within more than one sector, the signals start immediately in the sector or sectors that are disengaged. The remaining sectors are switched in as soon as the previous paging has terminated.

The paging equipment is called by a two-digit number. If it is free, it returns dial tone and the caller dials the telephone number of the sought party. An analyser translates the telephone number into a lamp combination, at the same time selecting the sector in which the wanted person is to be sought.

When the wanted person notices his lamp paging combination, he uses the nearest telephone to dial a three-digit page answering number which establishes a normal connection with the calling party. The paging equipment is thereby released.

If the caller is engaged on another call while paging is in progress, the wanted person is connected to the conversation when he answers. This connection is equivalent to a priority circuit, and if the conversing parties conclude their conversation a normal connection is established between the original caller and the paged party.

6. *Night watchman control*

If a patrolling night watchman is to perform his duties effectively, the following provisions must be made:

Automatic issue of alarm if anything untoward happens to the watchman
Rapid establishment of his probable whereabouts when alarm issued
Means of requesting rapid assistance in an emergency
Possiblity of varying rounds and times of passing given points.

These requirements are met by the night watchman control system which can be connected to L M Ericsson's automatic telephone exchange type *ARD 231*. Any extension telephone can be used as control point without special arrangements being required. This makes it simple to vary the rounds. The extension number of the control point and the time of the call are recorded in the control office when the patrolling watchman dials a two-digit number from the control point extension to call the control office. Thus the control office has a record of the time and place of the last call. If an alarm is issued owing to a missing control call within the prescribed time, assistance can be immediately directed to the place where the watchman should be. The watchman is able to contact the control office from the nearest telephone.

Direct contact can be made with the patrolling watchman from the control office by pressing a button. The next call from the watchman then goes automatically to the control office telephone.

If indications are required from locations where no telephone exists, additional circuits can be installed for push button operation.

7. *Central dictation*

Dictating machines for control from a telephone instrument can be connected to the switchboard. If the central transcribing department has more than one dictating machine, the machines are called by a group number. The first free machine is then connected to the calling extension via control relays. The dial is thereafter used for the various controls of the machine such as playback, correction indexing, end-of-letter indexing etc. (See Ericsson Review No. 1, 1958.)

8. *Immediate access*

This facility enables direct calls to be made to certain selected extensions by pressing a button corresponding to the extension number.

9. *Call-back service*

Repeated unsuccessful attempts to reach engaged extensions are irritating and entail poor economy both in the use of the switching equipment and in staff time. The introduction of automatic call-back service has led to a great reduction in annoyance and to better utilization of the exchange. The engaged extension is automatically supervised from the calling extension without occupying any speaking circuit and without preventing the caller from using his telephone for communicating with other extensions during the supervisory period. As soon as both extensions are free, the party who initiated the supervision is called and, when he lifts his handset, a ringing signal is issued to the wanted extension. When the latter answers, a normal connection is established. Accordingly the call-back equipment is not occupied during the conversation but is immediately released for a new call.

If the initiating extension is engaged on another conversation when the supervised extension becomes free, he is reminded of the waiting call by a discreet tone. He then has 20 seconds to complete the present conversation. If he

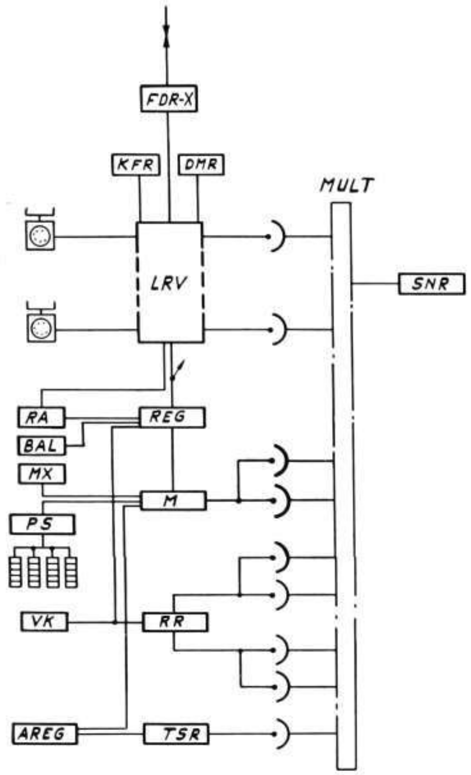


Fig. 2 X 2320

Trunking diagram for automatic exchange type ARD 231

AREG interception register
DMR dictating machine relay set
FDR-X tie-line to other switchboard
KFR conference equipment
M marker
MULT multiple
MX group marker
PS paging equipment
RA register connecting relays
REG register
RR call-back equipment
SNR link circuit
TSR telephone answering machine relay set
VK night watchman service relay set

does so within this time, he is automatically rung by the call-back equipment. If he takes more than 20 seconds, the supervision terminates and he must make a new call in the normal way.

On receipt of engaged tone the caller can put through a new call through the call-back equipment. He dials the two-digit call-back number, waits for dial tone, dials the number of the wanted extension once again and then replaces his handset. His telephone is now free for other calls.

On receipt of a ringing signal from the call-back equipment the caller raises his handset; he hears the ringing tone and knows that he can expect a reply from the called extension.

10. *Automatic interception*

a. *Redirection to other telephone*

This service enables an extension user to redirect his incoming calls to any other extension number in the system. It is a simple means of giving him practically the same facilities as if he had taken his telephone with him.

b. *Redirection to telephone answering machine*

When a person does not wish to be disturbed by unimportant calls, it is possible to direct incoming calls to a telephone answering machine. The telephone answerer announces to callers that the wanted person is engaged and does not wish to be disturbed, but that, if their business is urgent, they can speak to him by dialling a prefix followed by his extension number.

A number of centrally located telephone answering machines can be called for individual recording of brief messages. These machines can be placed at the service of persons who only need them on sporadic occasions and thus do not require a machine of their own. After the recording of a message, incoming calls are automatically directed to the right telephone answerer, which delivers the recorded message.

To make use of these services the extension user dials the two-digit number for the service in question, followed by his own extension number. Cancellation of the service is effected in the same way, but by the dialling of a cancellation number followed by the extension number.

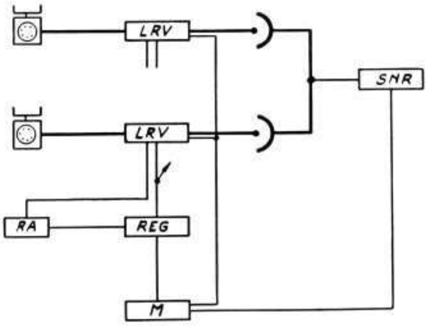


Fig. 3 X 2321

Trunking diagram for normal telephone communication

LRV line equipment
M marker
RA register connecting relays
REG register
SNR link circuit

Automatic telephone exchange ARD 231

This exchange can be used for from 200 to 800 extensions. Up to 44 link circuits can be installed, permitting a corresponding number of simultaneous conversations.

The principal switching elements are crossbar switches and relays which are combined to form the following main units:—line equipments, registers, markers and link circuits.

A line equipment unit serves 10 extensions and consists of a 10-vertical crossbar switch, 10 line relays and 7 group relays. Thus each extension disposes of one vertical of the crossbar switch. The line equipment crossbar switch has 30 positions in the multiple. Twenty-nine positions are used for connection of link circuits and one position for busying and line lockout. Every group of ten extensions possesses two common links for connection of the registers. The registers are made up of crossbar switches and relays. Every group of one

Fig. 4 X 2304

Keyset telephone type DBH 16 for v.f. impulsing

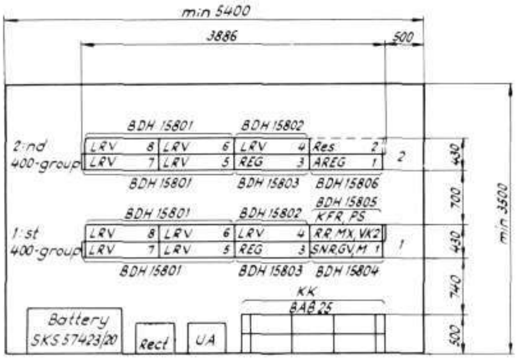


Fig. 5 X 2322

Layout of ARD 231

AREG	interception register
GV	selector for connection of RR to link circuits
KFR	conference equipment
KK	M.D.F.
LRV	line equipment
M	marker and common test and supervisory relays
MX	group marker
PS	paging equipment
REG	register
RR	call-back equipment
SNR	link circuit
UA	desk for test instrument
VK	night watchman service relay set

Free ceiling height : 2500 mm

Rack height : 2200 mm

hundred extensions has access to two registers. The markers and link circuit equipments consist of relays.

The link circuits are multipled to the extension selector banks. In all extension selectors to which a given link circuit is multipled the link circuit reappears at the same multiple position. Consequently, to set up a connection between two extensions, all that is required is that the selectors of the two extensions be connected to the same multiple position. During the period in which an extension is connected to a register, no link circuit is occupied. By the use of a graded multiple it has been possible to arrange for 44 link circuits.

Switching procedure

On the raising of an extension handset the extension line relay operates. The register connecting relays extend the circuit to a free register. The number of the calling extension is recorded in the register. The caller, on receipt of dial tone, dials the number. After each train of impulses the corresponding digit is recorded on a vertical of the register's crossbar switch. Upon receipt of the last digit the register is connected to the marker, which identifies the called extension and tests for the engaged condition. If it is disengaged a free link circuit is seized. The vertical of the called extension operates and the extension is thereby connected to the link circuit. Immediately thereafter the calling extension, which has been identified in the register, is seized and its vertical in the line equipment operates. The register and register link are thereby released and the calling extension is connected to the link circuit. A repeated ringing signal is sent from the link circuit to the called extension, and ringing tone is heard by the caller.

If the called extension is engaged, no link circuit is seized. Instead, the circuit is extended to the position in the selector multiple used for engaged condition and line lockout, immediately followed by operation of the calling extension's vertical. The register and marker release.

Keyset type telephone

Keyset or dial type telephones, or both types together, can be connected to the switchboard.

The use of keyset type telephones enables the rapidity of the switchboard to be utilized to the full. Dial impulsing is in such case replaced by v.f. signalling to a v.f. receiver in the register. The signals are amplified in a transistorized amplifier before being used for operation of the registers. In other respects the switching follows the normal procedure.

Constructional features

The switchboard equipment is accommodated on 2200 mm high racks, which may be single- or double-sided. A double-sided rack occupies 430 × 961 mm of floor space. The racks can be placed in one or more suites; single-sided racks can, if desired, be placed against a wall. All relay sets and switches are plug-in units.

Power supply and ringing equipment

The exchange operates off 24 V, with tolerances between 20 and 30 V. A rotary converter operated off the switchboard battery generates the necessary ringing current and tone signals. The converter and its associated impulsing relays etc. have been combined into a single unit of plug-in type.

P.M.B.X. Type ADF 162 for C. B. Systems

W ADENSTEDT, TELEFONAKTIEBOLAGET LM ERICSSON, STOCKHOLM

U.D.C. 621.395.23

Although we live in the automatic age, there is still a wide use for manual telephone switchboards. In this field as well, L M Ericsson has always striven to offer its customers switchboards of the most modern and efficient design. To this end a new single-position P.M.B.X. has been designed, typed ADF 162, which possesses a number of technical and practical finesses.

The new P.M.B.X. *ADF 162* is a single-position floor type switchboard for C.B. extensions and has a maximum capacity of 180 extensions, 16 exchange lines and 18 cord circuits. It will operate in conjunction with all manual and automatic public telephone systems. The novel features of *ADF 162* are the following:

All equipment except the power plant is placed in the switchboard.

Automatic interrupted ringing as soon as the plug is inserted in the called party's jack. At the same time the caller hears ringing tone. Simple switch-over to manual ringing which allows a less disturbing signal which is a valuable feature at nighttime in hotels and hospitals.

Secrecy of conversation through transmission of warning tone if the operator enters the circuit.

Splitting key which permits operator to converse with one party without the other being able to hear.

Waiting jack with lamp which slowly flashes to remind operator of a waiting call.

Supervisory jack enabling operator to supervise a line while continuing to dispatch calls on other lines.

The switchboard also fulfils the following normal requirements of a modern P.M.B.X.:

Direct dialling facilities for all extensions.

Automatic holding of exchange lines on all incoming calls and on outgoing calls established by operator, so providing transfer and enquiry facilities.

Exchange lines can be switched to night service by means of the normal cord pairs.

No current consumption during night service.

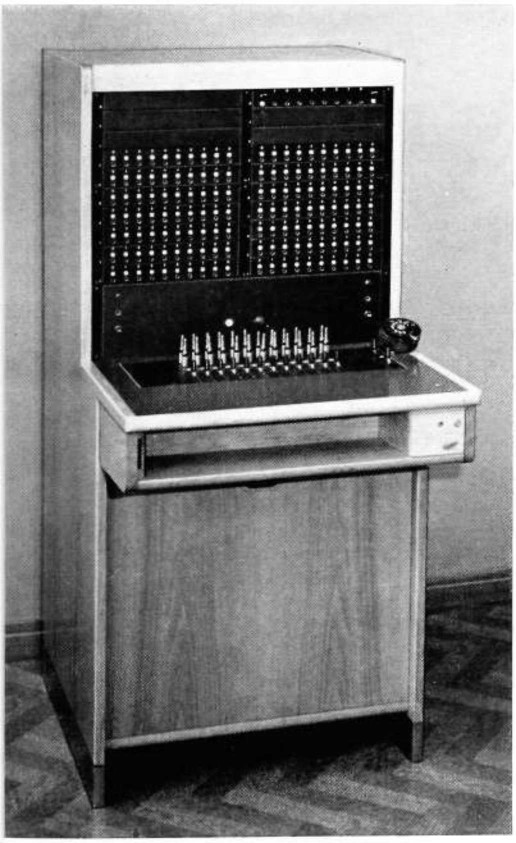


Fig. 1 X 2210

P.M.B.X. type ADF 162

equipped for 140 extensions, 8 exchange lines and 12 cord circuits

Switchboard Construction

As in L M Ericsson's other switchboards, the cabinet consists of oak veneered laminated boards and the keyshelf is lined with green linoleum. A new feature is that the cabinet is shipped in separate parts, so reducing the volume and the risk of damage in transit.

The switchboard is 1322 mm high, 636 mm wide, and 845 mm in depth including the keyshelf.

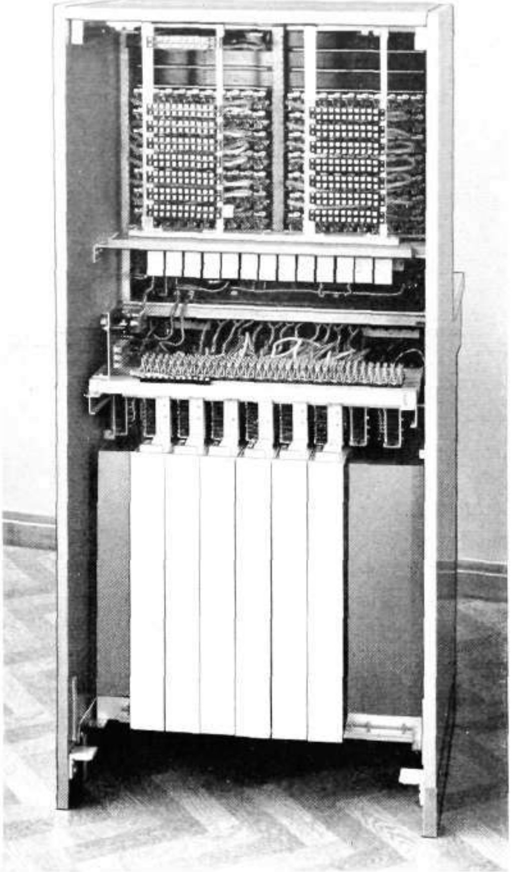


Fig. 2 X 2219

P.MB.X. type ADF 162

rear view with panelling removed

A switchboard type *ADF 162* equipped for 140 extensions, 8 exchange lines and 12 cord circuits is shown in figs. 1 and 2.

All switchboard equipment consists of separate, factory-wired units ready for assembly on site. The advantage of this is that the switchboard can be initially equipped solely for immediate requirements and later added to, when desired, without interruption of the service. Maintenance is also greatly facilitated, as a faulty unit can be readily replaced or removed for repair. It may be mentioned that only one unit has been newly designed for *ADF 162*, and that is the line unit for the exchange lines. The extension line unit is the same as in switchboards ADE 12 and ADF 14, and the remaining units are the same as in the multiposition switchboard ADF 30.

All cabling between the switching sets, position sets and relay sets meets on a *switchboard wiring unit* (fig. 3) to which the other units connect by plug and jack. The switchboard wiring unit also contains the switchboard fuses.

The *position set* (fig. 4), at the bottom of the jack field, contains all common relay equipment, waiting jack with lamp, supervisory jack, pilot lamp for clearing signals, fuse alarm lamp, and two keys for cutting out automatic ringing and connection of night bell.

The *dial* is placed on a bracket at the right of the keyshelf, and immediately to the left of it is a splitting and ringing key unit with lamp (fig. 5).

On the keyshelf is also the *switching set* (fig. 6). This set accommodates the cords, a clearing signal lamp, and a speaking and night connection key.

The *cord relay set* (fig. 7), serving two switching sets, is placed vertically in the rear of the cabinet as seen in fig. 2. The relay set contains transmitter feed and ring trip relays, test relays which prevent the connection of two cord circuits to the position equipment simultaneously, and certain identification relays.

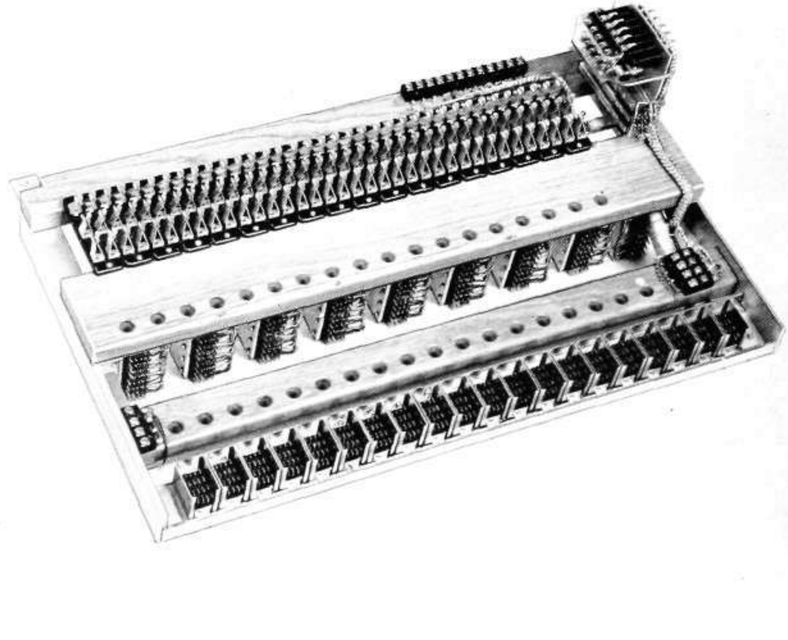


Fig. 3 X 8021

Switchboard wiring unit

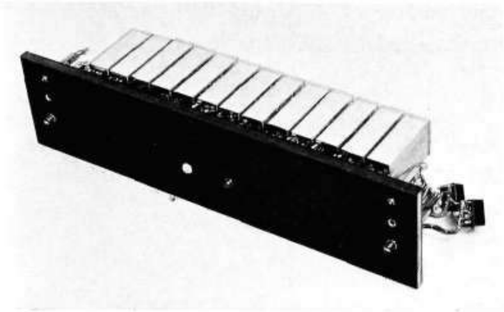


Fig. 4 X 2215
Position set

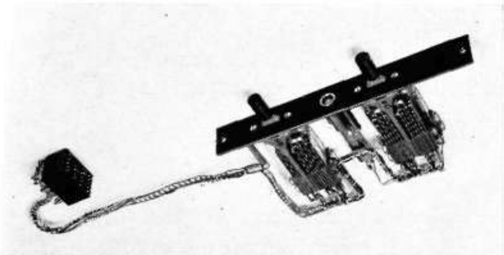


Fig. 5 X 2216
Splitting and ringing key set

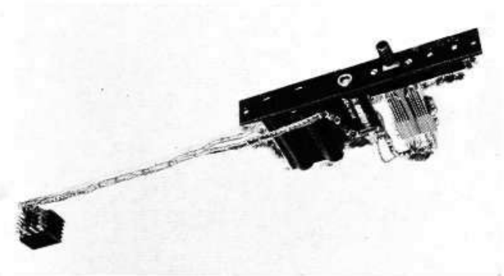


Fig. 6 X 2211
Switching set

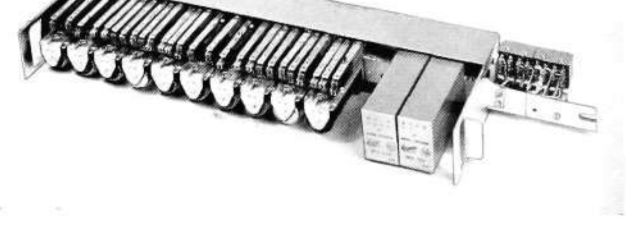


Fig. 7 X 7718
Cord relay set
with front cover removed

The *line units* are of two types, one for extensions (fig. 8) and one for exchange lines (fig. 9). Both types are complete cabled units with terminal block for direct connection of the incoming cables.

The extension line unit contains calling lamps and jacks for 10 lines. The actual calling device consists of a relay jack type *RNC 20*.

The exchange line unit is of a type less usual in C.B. switchboards, since it has drop indicators in place of calling lamps. The advantage of indicators over lamps in a single-position switchboard, in which a single device must be relied on for signalling a call from the public exchange, is the very much greater certainty of the call being indicated at the switchboard. Lamps inevitably burn out after a period of use; and unless they are checked daily, a call from an exchange line may remain unanswered, which always creates irritation. The same argument, of course, applies to the extensions; but if a lamp is faulty on an extension line, it is likely to be immediately reported. On exchange lines, on the other hand, lamp faults merely result in a general complaint that the operator is not answering incoming calls. The indicator used in the exchange line unit is the normal combined indicator and jack type *RNE 15*, which restores automatically when the call is answered.

Normally ten indicator jacks are mounted on one line unit, but in this case the two end indicators have been replaced by pilot lamps, so that the unit contains equipment for eight exchange lines.

Connection to Magneto System

ADF 162 can also be connected to a magneto public exchange, but in such case requires a signal repeater for every exchange line. The signal repeaters are placed in a separate bay. The signal repeater effects automatic transmission of calling and clearing signals when the operator plugs up or removes a cord pair. Under night service conditions the calling and clearing signals are controlled direct from the extension's C.B. telephone.

Technical Data

The maximum capacity of the switchboard is 180 extensions, 16 exchange lines and 18 cord circuits. As the line units consist of detachable units, however, the number of extensions can be increased by reducing the number of exchange lines. With only 8 exchange lines, the extensions can be increased to 190; if exchange lines are discarded altogether, the switchboard can be converted into a P.A.X. for 200 extensions. Theoretically the number of exchange lines could be increased at the cost of the extensions; but such an arrangement would lack any practical value since the number of cord circuits cannot be increased above 18, so that not more than 16 exchange lines could be served.

Fig. 8 X 2213

Line unit for 10 extensions

The switchboard is designed for a supply voltage of 24 V, but will operate satisfactorily between 20 and 28 V. When installed to full capacity, the busy hour current consumption is 2 A.

The resistance of extension lines should not be above 500 ohms, and the insulation resistance not below 15000 ohms.

The resistance values of the exchange lines will be governed by the operating limits of the public exchange equipment, since the drop indicators on the exchange lines permit a line resistance of up to 2000 ohms.

The microphone feed circuit incorporates 2 × 250 ohm transmission bridges.

Fig. 9 X 2214

Line unit for 8 exchange lines

Power Equipment

The switchboard requires a 24 volt d.c. supply and an automatic ringing current generator.

The most dependable source of power is undoubtedly a battery and charging unit for the 24 volt supply, in which case a pole changer, driven off the battery, can be used for the ringing current.

If a.c. mains are available, and there is little risk of current failure, a mains-operated power unit can be used for the 24 volt supply and a frequency transformer for the ringing current.

Wide Range Single-Phase Meter

S E LINDBERG, AKTIEBOLAGET ERMI, ULVSUNDA

U.D.C. 621.317.785.025.1

Electricity meters of today must be able to measure electric energy accurately even under conditions of widely varying load. A single installation consumes large quantities of energy consisting, on the one hand, of small loads from lamps, wireless sets and the like, which are switched on for considerable periods, and, on the other, of stoves, washing machines and other apparatus which impose a high load during much shorter periods.

ERMI manufactures *wide range* meters suited to all types of installations. In the present article a single-phase meter is described, type *VEN 23,* which will measure loads of up to 360 % of its rating within an error of not more than 2.5 %. It is designed to measure single-phase energy with great accuracy even if the line voltage and ambient temperature vary within wide limits.

Error at Varying Load

The factor which limits the effective working range of a meter at *very small loads* is the variable forces of friction which are high in relation to the driving forces involved at these loads. Consequently, the frictional forces should be low and the driving force high.

In the present meter the friction in the register (fig. 2) is very small compared with that in the bottom bearing. Despite the comparatively low efficiency of the worm-gear on the rotor spindle, the friction is not greater than 0.4 mgcm. This low value is obtained by pivoting the register spindles and by the

Fig. 1 X 7735

Single-phase meter VEN 23

(right) with cover removed. The meter components are easily accessible. For ratings up to 10 A the cover is of aluminium and the base of sheet steel. The cover is not enamelled inside.

low weight of the moving parts such as the gear wheels and figure drums. The radius of the spindles at the pivoting point is as little as 0.15 mm (fig. 3), despite their otherwise robust construction with cylindrical portion 1.2 mm in diameter. The six figure-drums and the five pinions weigh only 4 g. Redesign of the rotor hub has reduced the weight of the rotor to only 22 g. Every gram eliminated from the weight of the rotor has a great effect on the friction in the bottom bearing, and so on the life of the bearing.

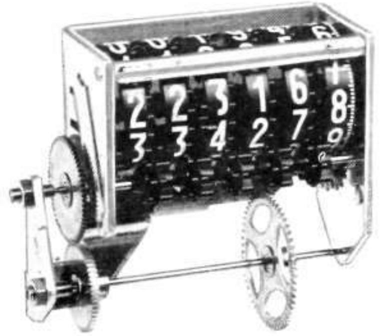


Fig. 2 X 2341

Register of VEN 23

with plastic drums and pinions, and stainless steel spindles with pivot bearings

The torque could be improved by increasing the dimensions of the driving element, and so of the entire meter. But this would be undesirable, and the friction has therefore been reduced instead.

The error curve of a meter under varying load (fig. 4) sooner or later falls to negative values at high loads. The physical reason for this is that the driving flux in the current system brakes the rotor with the square of the current. The smaller the driving flux in relation to the permanent flux of the brake magnet, the less unfavourable will be its effect.

As a first measure to this end, therefore, the meter has been given a strong brake magnet.

It is the magnetic shunt in the current system, however, which contributes most to the straightness of the error curve (fig. 6). The effect of the shunt is that, at loads above 150 % of the current rating, the driving flux of the current system increases very much more quickly than the current through the meter. In this way the rapidly increasing braking effect is compensated until the shunt becomes saturated.

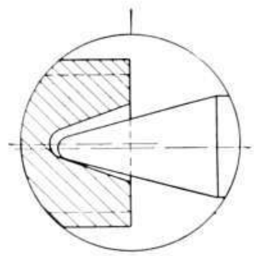


Fig. 3 X 2278

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

But the design of the magnetic shunt is such that it causes the driving flux to concentrate towards the centre, where the voltage flux cuts the rotor, so causing a further increase in the driving torque (fig. 6). At high loads, i.e. at high values of the current I, the shunt has a high magnetic resistance, so that the flux tends to take the path across the limbs of the shunt which face the rotor rather than across the shunt itself.

Effects of Variation in Voltage, Frequency and Temperature

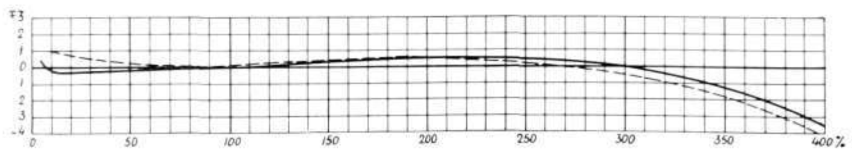
Unfortunately, the term "exact" as applied to measurement does not exist, for a measuring apparatus is always subject to error to a greater or lesser extent. And electricity meters are no exception to the rule.

The diagram in fig. 4, showing the error of the meter at different loads, is typical of the meter when fed with the rated voltage at rated frequency and at a rated temperature of + 20° C, and must be supplemented by data of the meter's behaviour at varying voltage, frequency and temperature.

At varying voltage, frequency and temperature, additional errors arise which are referred to as voltage error, frequency error and temperature error.

Fig. 4 X 8102

The meter can be loaded from values of below 5 % up to 360 % of the current rating without the error in indication exceeding 2.5 %. At intermediate loads from 10 % to 320 % the error curve follows the zero line.



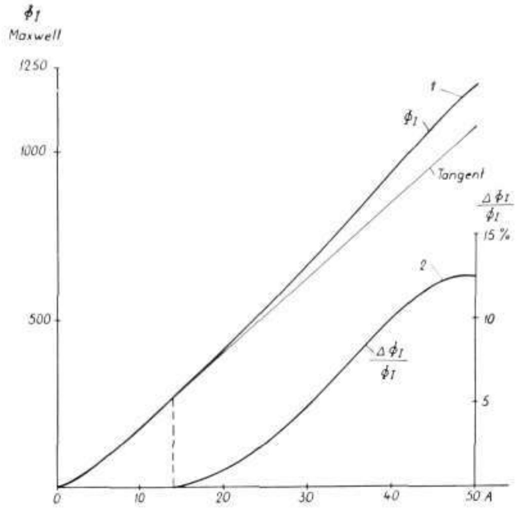


Fig. 5 X 2330

The driving flux due to current Φ_I through the rotor increases more than proportionally up to a value at which the magnetic shunt is saturated.

1 The absolute increase of Φ_I
2 The per cent increase of Φ_I

The line voltage does not generally vary by more than ± 10 %. But meters rated for too high a voltage are sometimes used provisionally in networks which are to be converted from, for example, 127 V to 220 V. If the meter is to be used at around half of the rated voltage, it is obviously necessary to know the magnitude of the voltage, frequency and temperature errors (fig. 7).

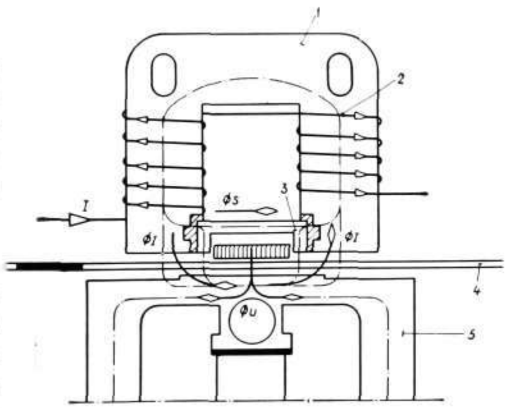


Fig. 6 X 2331

The magnetic circuits of the current system under non-inductive load

1 Core of current system
2 Current coil
3 Magnetic shunt
4 Rotor
5 Core of voltage system

I Current through meter
Φ_I Flux of current system
Φ_S Shunt flux
Φ_U Flux of voltage system

By suitable design of the magnetic shunt in the voltage system, a good balance is obtained between the driving and shunt fluxes (fig. 8). The main flux, generated by the voltage coil, divides into a driving flux through the rotor and a shunt flux, in order to produce a 90° phase displacement of the driving flux in relation to the line voltage. This phase displacement is necessary in order that the meter may register active energy. The magnetic circuit of the shunt is so designed as to compensate for the braking action on the rotor due to the driving flux, the braking action varying as the square of the voltage. This is in analogy with the conditions in the current system under varying load. The shunt flux divides into two branches on the two sides of the large hole in the shunt, where the areas of iron are comparatively small. At the rated voltage they become almost saturated. Between the centre limb and the shunt is an air gap which is filled by a copper disc roughly 0.5 mm thick.

The effects of *variation in frequency* are normally of little significance since the line frequency is generally very accurately regulated. Deviations as high as ± 5 % of the rated frequency very seldom occur. The frequency errors are therefore very small, as seen in fig. 9.

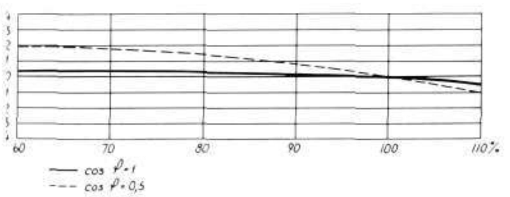


Fig. 7 X 2332

The voltage error is below ± 0.5 % although the voltage varies from 60 % to 110 % of the rated voltage. This is true for cos $\Phi = 1$. For phase lag cos $\Phi = 0.5$ corresponding values are + 2 % and — 1 %.

The effects of *variation in temperature* (fig. 10) are important since meters are often placed out-of-doors in places where the winter temperature may be as low as − 10° C and summer temperature up to + 40° C, i.e. a range of up to 50° C.

Temperature errors of the meter, which are complicated by a variety of causes, are compensated by suitable design of the magnetic circuits, and also by a temperature-sensitive device on the brake magnet. Changes in temperature cause variations in resistance in, among other parts, the voltage coil and rotor, which alter the phase angles of the fluxes and, to some extent, affect their amplitude.

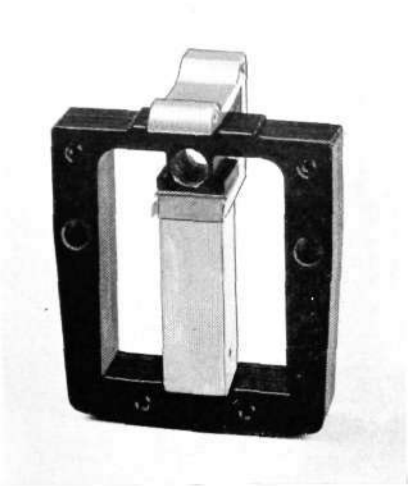


Fig. 8 X 2342

The voltage system consists of laminated cores cut from sheet steel containing 3.5 % silicon, by which the core losses are reduced.

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

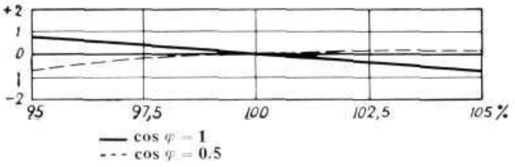


Fig. 9 X 2334

The frequency error remains within ± 1 % for a change of from 95 % to 105 % of the rated frequency.

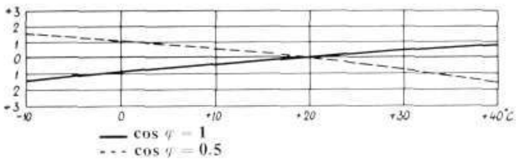


Fig. 10 X 2333

The temperature error is less than 0.5 % per 10° C within the range — 10° C to + 40° C.

Between the two magnetic elements in the lower part of the brake magnet (fig. 11) is a U-shaped strip consisting of a nickel-steel alloy. The parts of the strip in contact with the magnetic elements shunt part of the flux away from the rotor. The alloy, which consists of 70 % iron and 30 % nickel, has the property of being less conductive to flux at high temperatures, so that the braking effect of the magnet increases with the temperature.

The Driving Element

The meter is a small Ferraris motor, the rotor of which is driven by the driving element, consisting of a voltage system and a current system. In order that the disc may rotate at a speed proportional to the power, it is braked by the flux from a permanent magnet. The number of revolutions made by the disc is recorded by a register graduated in kWh.

In the assembly of the *voltage system* the large hole in the magnetic shunt is used for attachment of the low load device, which consists of a resilient piece of sheet steel (fig. 13). The low load device is of micrometer pattern and can be very accurately adjusted.

The centre limb, which carries the coil, is firmly fixed to the voltage frame. There are no screw connections which can become loose in service. In order that the meter may remain stationary when the loading current is zero but the line voltage is applied, a leakage flux is passed via a strip of iron on the voltage system to a piece of iron attached to the rotor spindle. These two pieces of iron have a mutual attraction which is so small that the meter starts at about 0.3 % of the rated power, and which is nevertheless sufficient to prevent the meter from rotating when not under load, even if the line voltage varies by ± 20 %.

The *voltage coil* (fig. 12) has very good insulation. It is surrounded by a case of polythene. The case consists of two halves which overlap over the coil and insulate it so effectively that no flash-over is possible between the thin, delicate winding wire and adjacent metal parts.

The other part of the driving element—the *current system*—has a U-shaped core consisting of silicon-steel laminations (fig. 14). The current coil is divided around the two limbs, between which is the magnetic shunt, made of sintered silicon iron. The shunt is held in position by two brass clamps which at the same time fix the air gap in the shunt circuit.

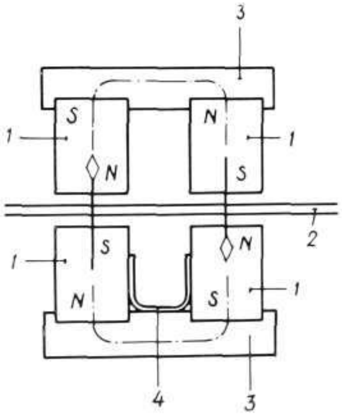


Fig. 11 X 2335

The brake magnet has four magnetic prisms which are so magnetized that the rotor is acted upon by two opposing fluxes.

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

Fig. 12 X 8107

The coil, which has 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.

The wire of the coil has a rectangular cross-section. The meter therefore stands a high overload current, which means that it can be used in systems which are protected by fairly heavy fuses.

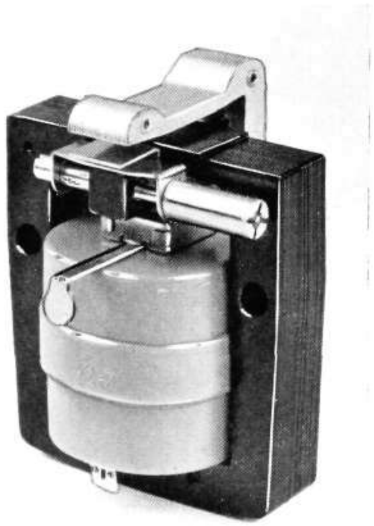


Fig. 13 X 2343

The coil is placed around the centre limb in the centre of the voltage system, and the flux generated by it is conducted by the cores partly through the rotor and partly through a shunt, the chief object of which is to displace the phase of the driving flux 90° in relation to the line voltage.

The Rotor

The driving element acts upon a 1.20 mm thick rotor of 99.8 % pure aluminium, which is diecast to a steel spindle. The entire rotor system is journalled at the lower end in a pivot bearing which terminates in a highly polished ball resting in a sapphire cup, and at the upper end in a highly polished and resilient needle type bearing which revolves in a lubricated sleeve.

The Brake Magnet

The rotor is braked by a powerful four-pole magnet with an air gap of at least 3 mm (fig. 15). This unusually large air gap has been possible thanks to

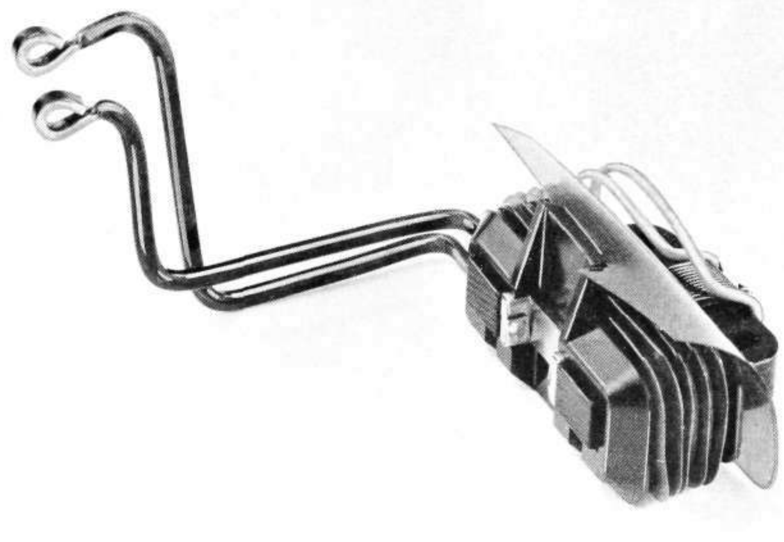


Fig. 14 X 8108

The current system is well insulated, both against surrounding metal parts and between the turns of the coil.

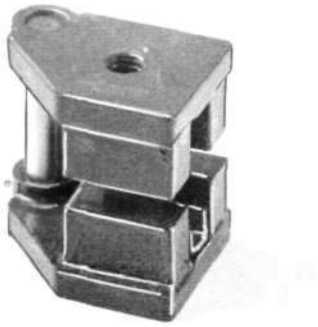


Fig. 15 X 2344

The four magnetic prisms are attached to pole pieces of sintered iron, which are held together by a stainless steel cylindrical pin.

The asymetrical structure eases the magnetization of the magnet.

the high quality of the magnetic material, which has a remanence of 11 500 gs, coercive force of 650 oe, and a $(BH)_{max}$ value of $2.5 \cdot 10^6$ gsoe.

The flux of the brake magnet passes the rotor at two adjacent points, but in opposite directions (fig. 11). This eliminates the forces of vibration which arise when the alternating currents, generated in the rotor by the fluxes of the driving element, cut the permanent flux of the brake magnet. Since the forces are opposed and equal in magnitude, they neutralize one another.

The Terminal Block

The sleeve terminals (fig. 16) permit satisfactory connection of multi-wire leads of 10 mm^2 and 25 mm^2 cross-sectional area for meters rated for 10 A and 50 A respectively. The conical opening, which is so amply dimensioned as to allow even for the conductor insulation, greatly facilitates the wiring up of the meter.

Both the long and the short covers over the terminal block are clamped by a *single* captive screw attached to the block and provided with a seal.

The earlier practice was to place the wiring diagram on the rear of the cover. This occasionally led to fatal errors, as the cover, which fits several types of meter, might be interchanged with that of another meter. On ERMI meters, therefore, the wiring diagram is placed on the rating plate in clear association with the meter data.

The rating plate has space also for a name plate, 13 × 40 mm, for identification figures of the energy supplier.

Insulation

Before delivery every meter is subjected to the 8 kV surge voltage test recommended in the Swedish meter standards.

An alternative model, having a plastic case, is typed *VEN 23B*.

Maintenance

Provided that the correct ratings have been chosen, and that the meter is not exposed to heavy variations in temperature, nor to dust, gases or damp, it will operate correctly without supervision for a very long period. It is extremely difficult to state exactly how long a meter can be left without attention. This would require many years of thorough statistical study. As a result of the improvements which have been incorporated in ERMI meters, however, the period of seven or eight years which was earlier recommended between overhauls can now be greatly extended. Even so, the maintenance of meters is a considerable burden on the supply undertaking. ERMI meters are therefore designed to cut the costs of overhaul and adjustment to a minimum. The various parts of the meter and its calibrating members are readily accessible (fig. 17). The air gaps in the driving element and brake magnet are clearly visible for purposes of inspection; and if a part must be replaced for reorganizational or other reasons, there is no difficulty in doing so.

The stroboscopic marks on the rotor enable methods of adjustment to be adopted which involve a great saving of time (fig. 18). Furthermore, the calibrating members, all of which can be adjusted with a screwdriver, can be continuously set with great accuracy.

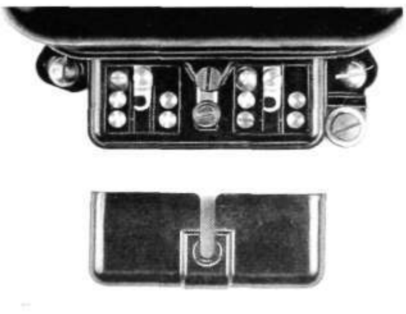


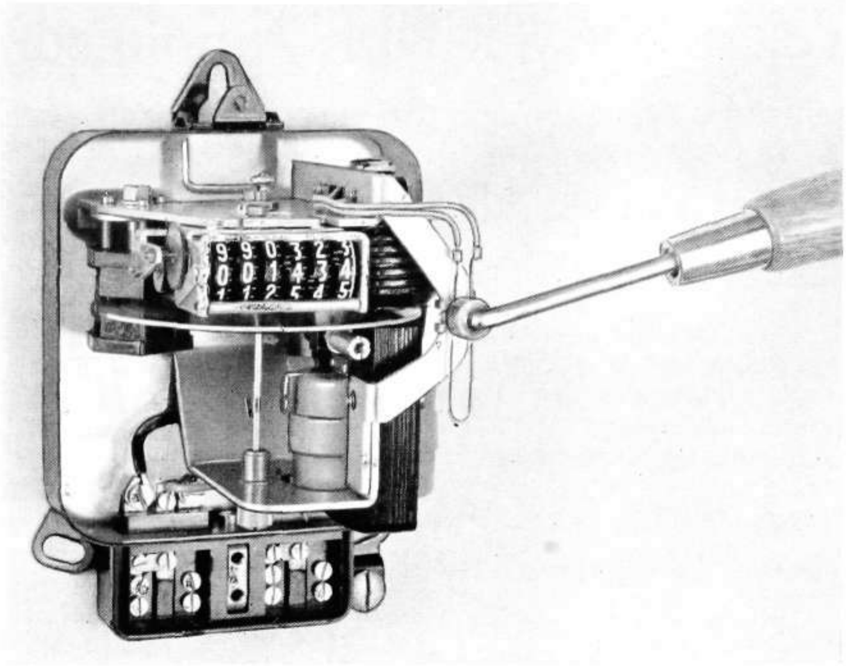
Fig. 16 X 2345

The voltage circuit must be disconnected from the current circuit during adjustment of the meter.

The two swinging straps are used for this purpose. They do not obstruct tightening of the terminal screws.

Fig. 17 X 8109

The clamp for the adjustable resistance in the quadrature loop can be released and tightened with *one* hand since it is firmly positioned on the frame.



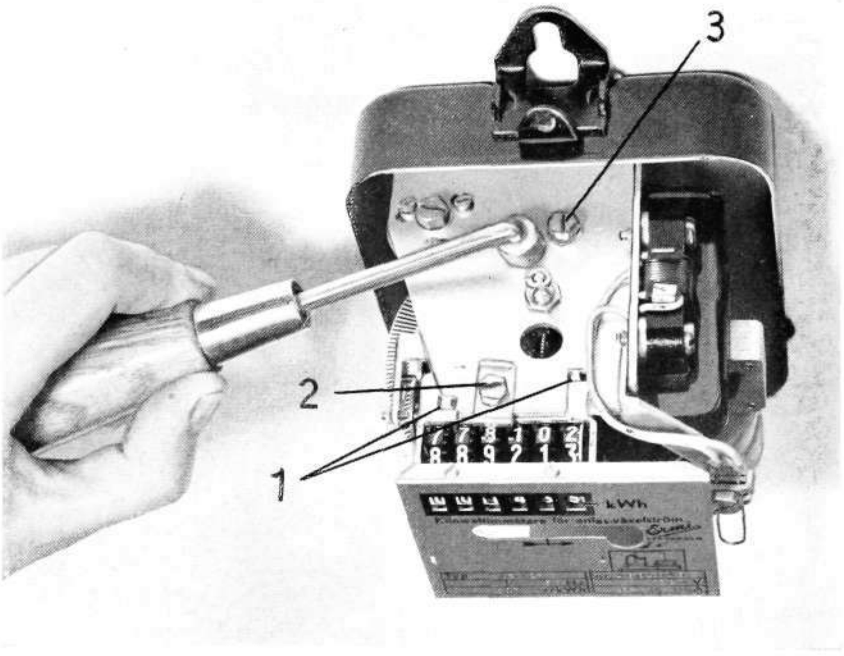
Dismantling of the entire register for overhaul is expensive. For this reason the practice has long been to clean the mechanism by submerging it in petroleum spirit, which dissolves dust and other sediment. The spirit soon evaporates, especially if the mechanism is placed in a slight air current. This simplified method was elaborated for mechanisms with tin drums; and in order that it may be employed for the new registers with their plastic drums and pinions, ERMI has chosen an acrylic resin which is unaffected by petroleum spirit or mineral oils.

As already emphasized, all mechanical friction must be eliminated as far as possible. At the same time, the friction must not change during the years, as the error in indication will then change as well. The spindles of the register are of stainless steel and require no film of oil as protection against corrosion. The pivot bearings likewise require no oil for their lubrication. The register is thus completely free from oil, and the risk of change in the friction on account of aging of oil is totally precluded.

Fig. 18 X 8110

The register has a fixed position in relation to the frame (1), and so to the rotor spindle. It is secured to the frame by a *single* screw (2), which simplifies zeroing of the register in, for example, a long-time test.

The brake magnet is set to the correct braking effect by turning an eccentric (3) with a hollow key. The rotor has 150 marks for stroboscopic adjustment.



Telephone Set with Amplified Reception

I MITNITZKY & P AHLSTRÖM, TELEFONAKTIEBOLAGET LM ERICSSON, STOCKHOLM

U.D.C. 621.395.721:621.375.4

Telefonaktiebolaget L M Ericsson has introduced a telephone set with transistor amplifier for reception, which possesses greatly improved properties compared with earlier designs incorporating a vacuum tube amplifier.

The earlier telephone set type DBH 921 has been modernized by the introduction of a transistor type amplifier, which has made the telephone simpler to handle and simpler to install. It is anticipated that the new set will require no more maintenance than an ordinary dial telephone. Thus, there is every reason to expect very much improved performance in the new telephone *DBH 923*.

The goals set before the designers were as follows:

1. The voltages required by the transistor amplifier shall be supplied via the subscriber's line from the public exchange batteries.
2. The current consumption of the amplifier shall be so low that sending efficiency is affected as little as possible.
3. The ordinary receiver shall be used, and in such a way that successive improvements of the receiver can be put to full use in the new design.
4. As many complete components as possible from the standard set shall be used in *DBH 923*.
5. In order to avoid embarrassment to persons with impaired hearing, *DBH 923* should resemble an ordinary telephone in outer appearance as far as possible.

Fig. 1 X 8103

DBH 923 looks like the ordinary dial set DBH 15

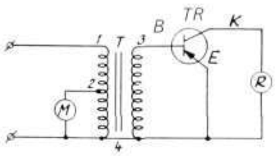


Fig. 2 X 2336

The transistor used as amplifier (with D.C. bias omitted)

B base
E emitter
K collector
M transmitter
R receiver
T induction coil
TR transistor

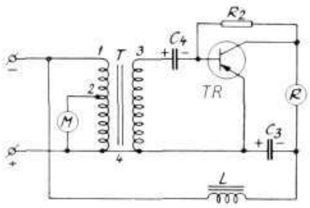


Fig. 3 X 2337

The amplifier with correct bias voltages from the telephone line

C_3, C_4 capacitors
L choke
R_2 resistor

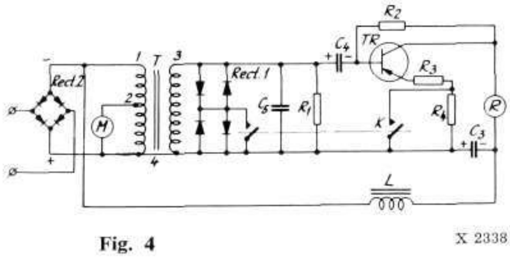


Fig. 4 X 2338

The complete circuit diagram

Rect. 1 shock absorber
Rect. 2 diode bridge
K key

The diagrams in figs. 2, 3 and 4 show how the design has developed from idea to finished product.

The secondary side of the induction coil is connected between the base and the emitter, and the receiver between the collector and the emitter. In order that the transistor shall function as amplifier, there must be a D.C. source so that base and collector receive specific bias voltages in relation to the emitter. This is shown in fig. 3.

The transistor is of pnp-type, and both collector and base must be negative in relation to the emitter. The collector is connected to the negative side of the line via the receiver R and the choke L, and a negative potential is supplied to the base through the resistor R_2 between base and collector. The receiver is connected to the emitter across capacitor C_3, and the base to the induction coil across capacitor C_4.

The complete circuit diagram of the telephone under speaking conditions is shown in fig. 4.

Rect. 2 is a diode bridge which renders the amplifier independent of line polarity. The resistors R_3 and R_4 provide negative feedback. With R_3 and R_4 in the circuit the feedback is strong enough to eliminate amplification, the reception level being the same as in an ordinary telephone. When the handset key is depressed, R_4 is short-circuited and a gain of 12 db is obtained. The key also acts upon *Rect. 1*, which is coupled as a varistor (shock absorber). *Rect. 1* fulfils two purposes: it protects the transistor and the electrolytic capacitors against voltage surges, and prevents strong signals from being amplified to a level at which the sound pressure in the ear attains the threshold of feeling, i. e. produces a sensation of pain. This is accomplished irrespective of the transistor gain since, with the key depressed, the shock absorber sets in at a lower signal voltage. Depression of the key short-circuits half the shock absorber, while at the same time full amplification is obtained through the short-circuiting of R_4. Signals which would cause no discomfort at an ordinary level of reception, but would do so at 12 db, are therefore limited by the fact that half the shock absorber is short-circuited at the input of the amplifier. The capacitor C_5 prevents high frequency signals from being detected by the transistor, and R_1, stabilizes and lowers the input impedance of the amplifier, so that the load on the induction coil is roughly the same as in an ordinary telephone.

The transmission characteristics of *DBH 923* in different feed systems are tabulated below.

	System	SRE/0	MRE/0	
			without gain	with gain
		db	db	db
DBH 92301	24 V; 2 × 400 ohm	+ 6	— 4	— 16
DBH 92351	48 V; 2 × 400 »	+ 4.5	— 4	— 16
DBH 92371	48 V; 2 × 250 »	+ 3	— 4	— 16

SRE = sending reference equivalent relative to SFERT
MRE = receiving reference equivalent relative to SFERT

Figs. 5 and 6 show the frequency response without gain and with gain.

The transmitter and receiver insets used in *DBH 923* are L M Ericsson's standard insets, which are described in Ericsson Review No. 4, 1956.

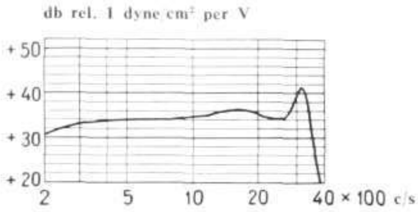


Fig. 5 X 2339

Frequency response at zero gain

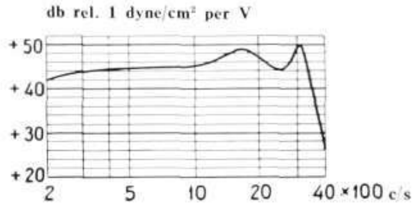


Fig. 6 X 2340

Frequency response with key depressed (12 db gain)

Fig. 7 X 8104

DBH 923 with cover removed

Fig. 8 X 8105

The key is conveniently placed and requires little pressure

The aim has been that the change in impedance shall be as little as possible, whether or not the gain is switched on, and is, on an average, only about 10 % at different frequencies. The set is matched to the international standard of 600 ohms.

In external appearance *DBH 923* resembles the ordinary dial set DBH 15, as is seen from fig. 1. The mounting of the amplifier in the telephone set is shown in fig. 7.

Thanks to the diode bridge there is no need to observe the line polarity, and *DBH 923* can therefore be connected to a telephone line just like any other telephone.

The transistor amplifier, being fed from the line, has no need of either plate or heater batteries.

The importance of all these factors will be apparent to administrations and subscribers alike.

Switching on and off the gain is done very simply with a key in the handset (fig. 8). When depressed, the key provides the two makes as seen in fig. 4. This arrangement provides a simple means of enabling the same telephone to be used by persons with impaired and with normal hearing. A gain of 12 db has been found to represent a practical compromise. The use of a key prevents acoustical feedback when the handset is occasionally put aside during conversation.

Apart from its obvious uses for the hard of hearing, *DBH 923* will naturally be of advantage on long lines in local networks, on insufficiently amplified trunk lines, on telephone lines for power supply undertakings, railway companies, and so on.

Another important field of use is in moderately noisy premises such as hotel reception offices, restaurants, airport waiting rooms, bus and railway stations, workshop offices, and department stores.

Fig. 7

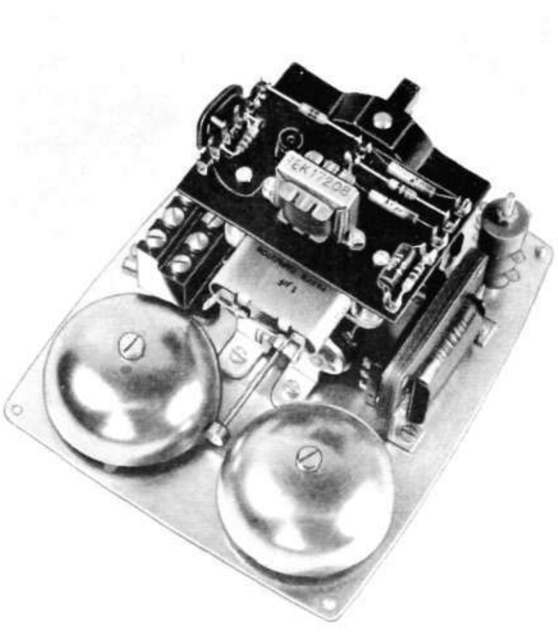


Fig. 8

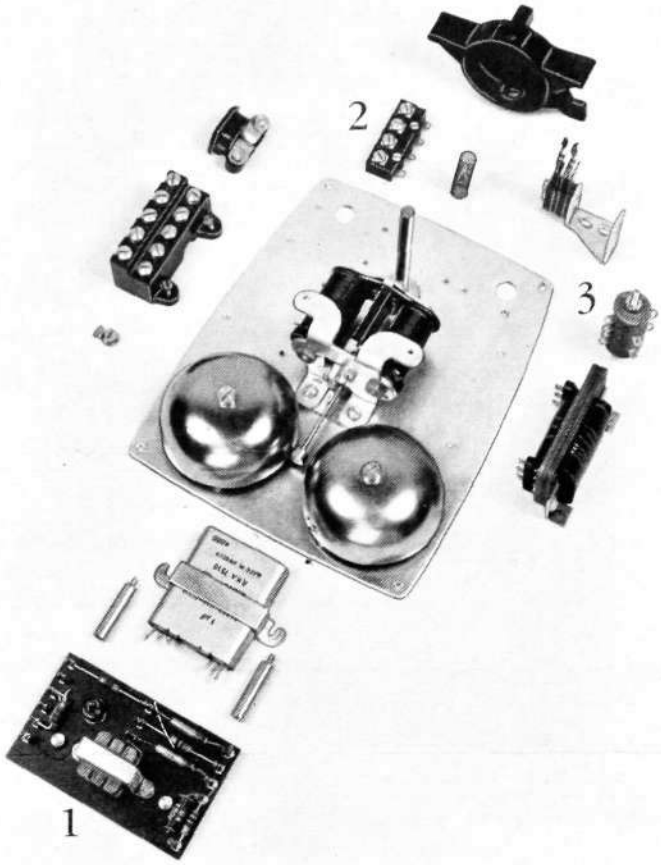


Fig. 9 X 8106

The components of DBH 923

The numbered parts alone are peculiar to the DBH 923 set

The components of *DBH 923* are shown in fig. 9. The new units, not used in DBH 15, are:

1. Transistor amplifier 360975

This unit contains the necessary amplifier components such as the transistor, the resistors R_1—R_4, the capacitors C_3—C_5, and the choke L. C_3 and C_4 are electrolytic capacitors of tantalum type, which give the amplifier a higher degree of reliability and longer life than the ordinary electrolytic capacitors of aluminium type.

2. Terminal block NEM 1111

3. Rectifier pile-up RKT 15401 containing diode bridge and shock absorber.

One model of the telephone *DBH 923* adapted for the Swedish telephone system has been approved by the Royal Board of Telecommunications.

New Electron Tubes for Wide-band Amplifiers

S EDSMAN, AB SVENSKA ELEKTRONRÖR, STOCKHOLM

U.D.C. 621.385:621.375.121

The greater quantities of information that are now required to be transmitted on coaxial cables or radio links have placed higher demands on the ability of electron tubes to amplify wide ranges of frequencies. To fulfil such requirements tubes must have higher transconductance and at the same time lower capacitances.

The following description of the pentode 5847/404A, the triode 5842/417A and the tetrode 7150 embraces all the properties which make these tubes especially suitable in wide-band amplifiers.

With a view to increasing the transconductance of electron tubes while keeping the capacitances low, use has been made of increasingly small diameters of grid lateral wire. The three tubes *5847/404A*, *5842/417A* and *7150* all have frame grids with a lateral wire of only 6.5 μ diameter. *5847/404A* is a pentode for both low and intermediate frequencies. *7150* is a tetrode for the same applications, but can also be coupled as a triode for use as a low noise tube in input circuits. *5842/417A* is a low noise triode for grounded grid input stages at intermediate frequencies.

Figure of Merit

The wide-band properties of an amplifier may be expressed as the product of gain and band width. This product is determined by the figure of merit (G) of the amplifier tube. At low frequencies (LF), at which impedance transformation between the amplifier stages is impossible, the figure of merit may be expressed as

$$G_{LF} = \frac{g_m}{C_I + C_O}$$

where g_m = transconductance of the tube in mA/V, and C_I and C_o are the total working capacitances in the input and output circuits in pF. At intermediate frequencies (IF) the figure of merit will be

$$G_{IF} = \frac{g_m}{\sqrt{C_I \cdot C_O}}$$

provided that optimum impedance transformation can be achieved between the input and output circuits.

From these two formulae the desirability of increasing g_m, or reducing C_I and C_o, is clearly apparent. At IF the main effort should be to reduce C_o. In *7150* the output capacitance C_{out} of the tube itself has been reduced to only 2 pF.

The data of the three types of tube are given in Table I.

Tube Capacitances

Data sheets usually give the tube capacitances in cold state only. Nor do the values include sockets or pins; nor, of course, coupling and circuit capacitances. It is seen from fig. 1 that the input capacitance C_{in} increases very considerably with the cathode current. When the cathode is heated, C_{in} increases even when the plate current is cut off by a large grid bias. When the bias is reduced the current increases, but at the same time the input capacitance increases still further due to changes in the space charge. The output capacitance

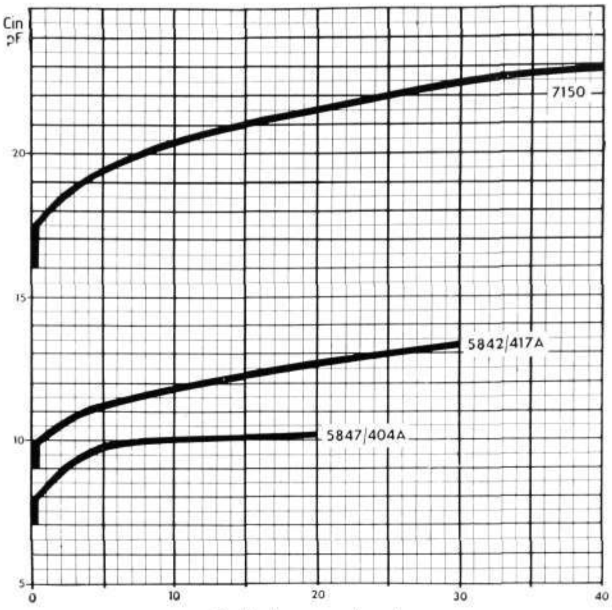


Fig. 1 X 8081

The input capacitance C_{in} of tubes 5847/404A, 5842/417A and 7150 increases from 7, 9 and 16 pF respectively in cold state to 10.2, 13 and 22.8 pF at normal cathode current

C_{out}, on the other hand, is not affected to any great extent by heating of the tube or increase in the cathode current. C_{out} does increase, however, if an external shield is used, whereas the other capacitances remain virtually unaffected.

The input capacitance is also increased as a result of the coupling between the input and output circuits caused by the control grid—plate capacitance C_{gp}. The increase will be equal to $F \cdot C_{gp}$, where F is the amplification of the tube. At *LF* this product will usually be insignificant compared with C_{in}. At *IF*, on the other hand, the coupling between the input and output circuits of the tube may cause a difference in amplification at the lower and upper band limits, leading in severe cases even to instability. For grounded grid stages the cathode—plate capacitance C_{kp} is the unwanted coupling between the input and output circuits.

Power Output and Distortion

In low frequency systems the relation between the fundamental frequency and the second and third harmonics (A_{k_2}, A_{k_3}) represents the magnitudes which determine what negative feedback is required, for the generated crosstalk must not exceed given values. Figs. 2a and 2b show A_{k2} and A_{k3} as function of the plate impedance R_b at different outputs for tubes *5847/404A* and *7150*. The pentode and tetrode data alone are given; negative feedback cannot be introduced in triodes owing to problems of phase shift. It is not usually possible to achieve greater plate impedances than 1000—2000 ohms. To obtain higher outputs, therefore, it is necessary to use two or more tubes *5847/404A* in parallel, or to use *7150*.

At intermediate frequencies a higher circuit impedance is generally attainable. The plate impedance, however, is limited owing to loading of the input conductance (g_{in}) of the subsequent tube. Since g_{in} increases with the square of the frequency, there will be considerable damping of the circuits at high frequencies. Since g_{in} also increases with increasing cathode lead inductance, triple cathode leads have been provided for *7150*.

Noise

An extremely important characteristic is the tube noise, since it determines the lowest level which the transmitted signal may assume on the input side of the following amplifier. This affects, for example, the distance between the

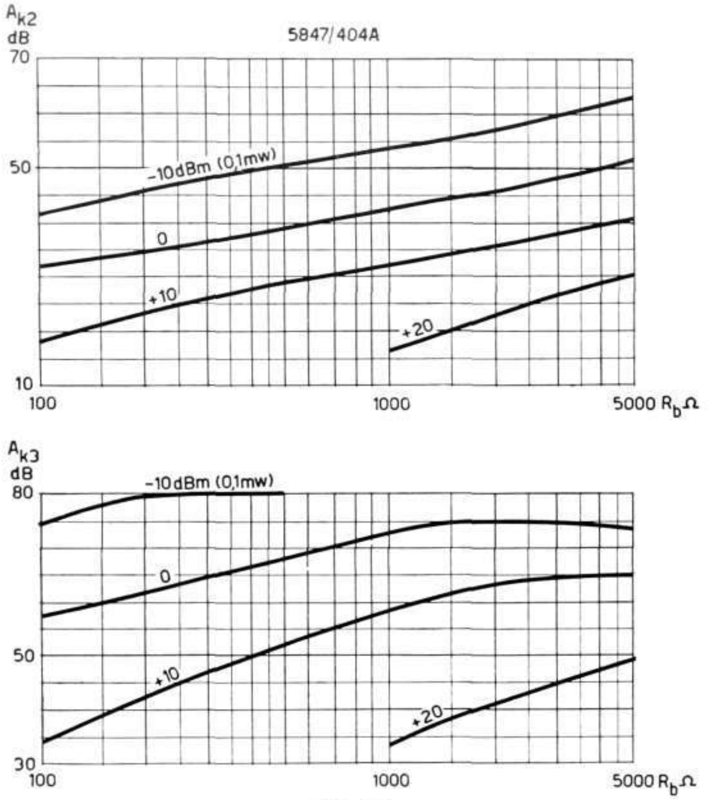


Fig. 2 a

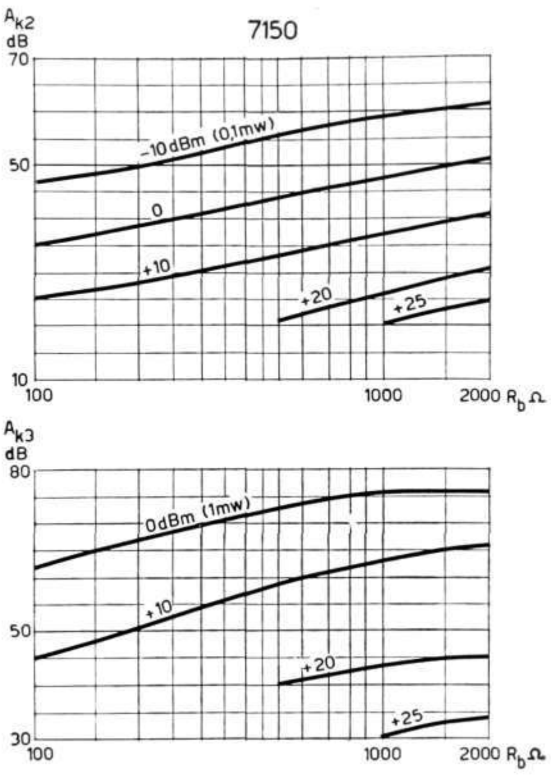


Fig. 2 b

Fig. 2 a X 7734

Relation between fundamental frequency and second and third harmonics A_{k2} and A_{k3} as function of the load impedance R_b at different outputs for tube 5847/404A under typical conditions of operation

Fig. 2 b

The same data as in fig. 2 a, but for tetrode 7150

line amplifiers. The calculated equivalent noise resistances (R_{noise}) are given in Table I. At low frequencies, however, considerable additions of noise may occur due to "flicker effect". In particular, the occurrence of interface resistance between the oxide coating and cathode sleeve must be prevented. At high frequencies this resistance is bypassed by the capacitance between the oxide coating and cathode sleeve, but at low frequencies the reactance is no longer negligible. Apart from lower amplification at low frequencies, this resistance, owing to its high operating temperature, adds a considerable amount to the noise. In the tubes described in this article, however, the cathode material is such that the interface resistance is minimal even after several years of operation.

At intermediate frequencies, owing to the absence of negative feedback, use can be made of triodes, which have the advantage of causing less noise. *5842/417A* is specially designed for such applications. In narrow band amplifiers operating at 150 Mc/s a noise factor of 2.5 db has been measured. At larger band widths, and the frequency of 70 Mc/s usual in such cases, the noise factor is about 5 db in circuits optimized for minimum noise factor.

Special Characteristics

Since, in *5847/404A* and *7150*, some internal shields have been connected to one end of the heater-pins 3 and 5 respectively, this end should be grounded. In *7150* there is a direct flow of electrons from the cathode to the shield when the latter is positive in relation to the cathode. The voltage drop across the cathode resistor, however, stops the flow of electrons if the right heater-pin is grounded.

The mechanical stability of these tubes can perhaps best be illustrated by the test performance of *5847/404A* when vibrated with a sinusoidal amplitude of ± 1 mm at 25 c/s. This corresponds to a peak acceleration of 2.5 g. The alternating voltage measured across a plate impedance of 2000 ohms was only about 5 mV, as against the 500 mV allowed by international standards.

Table 1

	Tube type							
	5847/404A		5842/417A		7150			
Dimensions								
Base (EIA)	E—1		E9—1		9-pin special			
Bulb	T6 1/2		T6 1/2		T9			
Diameter, max.	7/8″		7/8″		13/16″			
Maximum Ratings								
Grid resistance	0.1		0.05		0.05			Megohm
Grid current	0		0		0			mA
Cathode current	35		35		50			mA
Control grid dissipation	0		0		0			W
Screen grid dissipation	0.75		—		1.5			W
Plate dissipation	3.0		4.0		4.0			W
Bulb temperature	120		120		130			°C
Typical Operation								
(Abbreviations will be understood from fig. 3)	PENTODE		TRIODE		TETRODE		TRIODE	
E_f	6.3		6.3		6.3		6.3	V
I_f	0.3		0.3		0.45		0.45	A
E_{bb}	150	160	130	150	125	135	125	V
R_k	110	600	360	60	45	260	33	ohm
E_{c+}	0	8.5	9	0	0	8	0	V
I_b	13.5	13.5	27	25	25	26	34	mA
I_{c2}	4.0	4.0	—	—	10	10	—	mA
g_m	13.0	13.0	27	25	34	34	47	mA/V
r_p	200	200	1.6	1.7	40	40	0.85	kohm
μ	—	—	44	43			40	
R_{noise}	500	500	110	120	180	180	60	ohm
Capacitances								
C_{in} (tube cold)	7		9		16		18	pF
C_{in} (typical operation)	10.2		13		22.8		24.8	pF
C_{out} (without extern. shield)	2.5		1.8		2		7	pF
C_{out} (with external shield)	2.9		2.6		3.6		8.6	pF
C_{gp}	0.03		—		0.03		—	pF
C_{kp}	—		0.5		—		0.6	pF
Figure of Merit								
G_{oLF} (tube cold)	1.37		—		1.9		—	
G_{LF} (typical operation)*	0.73		—		1.0		—	
G_{oIF} (tube cold)	3.1		6.2		6.0		4.2	
G_{IF} (typical operation)*								
without external shield	1.7		3.2		2.9		2.7	
with external shield	1.6		2.9		2.5		2.5	
Input Conductance								
g_{in} at 100 Mc/s	2000		4000		2200			μA/V

* The additions tabulated below for tube holders and coupling capacitances have been made for the various tubes to get total circuit capacitances in typical operation. To obtain the optimum figure of merit, the external shield should be excluded since in most cases it is not required.

	5847/404A	5842/417A	7150	
At low frequency	5		8	pF
At intermediate frequency				
Input circuit	3	3	5	pF
Output circuit	2	2	3	pF

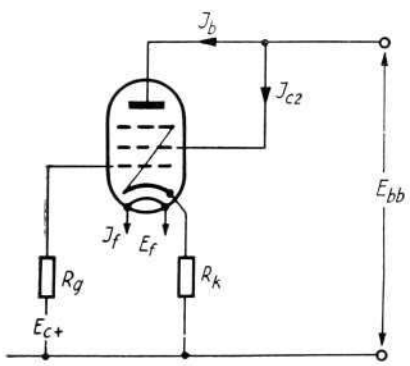


Fig. 3 X 2329

Life

The life of the tubes depends largely on the design of the plate, since this determines the working pressure in the tube. Triodes, with their more closed systems, usually have a far inferior life to the more open tetrode and pentode systems. Low screen grid and plate voltages are also favourable in view of the low electrode dissipations, and consequently low working temperatures, but under these conditions it is more difficult to attain high figures of merit and an adequate grid swing without grid current loading.

For *7150* it may be predicted that the mean life in service will approach or exceed 50000 hours, a figure which is also attained by *5847/404A*. As regards *5842/417A* with its more closed structure and high cathode currents, and in certain cases critical applications (e.g. low noise stipulations), the mean life is usually approximately 10000 hours. Consequently, it is an advantage to use a triode-coupled tetrode or pentode instead of a triode. *7150* is well adapted for use in triode coupling (see table I). *5847/404A*, on the other hand, cannot be used as triode in grounded grid stages since the capacitance between the plate and the suppressor grid, which is internally connected to the cathode, is about 1.5 pF, so that C_{kp} would be too high.

Up to now *5847/404A* and *5842/417A* have been used together in the same amplifier. The new type, *7150*, however, can be used in all amplifier stages both at intermediate and low frequencies.

News from All Quarters of the World

(Above) Dr. Fusesi, Professor of Telecommunications (fourth from left), Brigadier General Hugo Afonso de Carvalho, Principal, Col. Heitor Bonapace, Professor of Electronics, flanked by (from left) Messrs. P. Madsen, D. Lundström and M. Kischner, and (right) Mr. V. Muniz of Ericsson do Brasil. Behind them is seen part of the presented equipment.

L M Ericsson Presents Models of Switchboards to Brazilian Army Technical School

At a ceremony on June 20 at the Brazilian Army Technical School at Rio de Janeiro, L M Ericsson presented to the school three working models of the company's different automatic telephone systems. The presentation was made by representatives of its affiliated company, Ericsson do Brasil Comércio e Indústria S.A. The equipment is intended for use in practical demonstrations in courses in telecommunications.

LM Ericsson Tribute to World Champions: Ericofon to Each Member of Team

The World Football Championships in Stockholm were a triumph for Brazil, whose magnificent team beat Sweden by 5–2 in the final at the Råsunda Stadium. The World Champions were applauded by King Gustaf Adolf and Queen Louise, backed by 50000 cheering spectators.

The Brazilians' joy over their victory was a moving spectacle. The Swedish King was very popular with the winning team when he came down onto the ground to congratulate them after the match (photo above). The man holding the trophy is the Brazilian manager, Paulo Carvalho.

As a mark of esteem and admiration for the world champions' brilliant play and fine sportsmanship, L M Ericsson presented each member of the team with an Ericofon. In the photo below are seen four of the virtuosi of the noble art of football, (from left) Garincha, Pelé, Gylmar and Didi, who seem to enjoy L M Ericsson's new one-piece telephone.

New Automatic Exchange in Panama

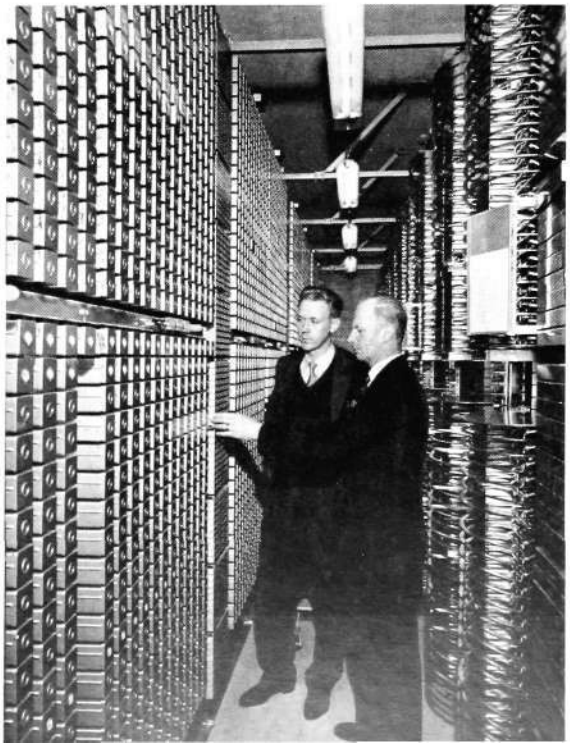
A new automatic telephone exchange, the fourth in Panama C., was opened on July 14. This exchange, of L M Ericsson 500-switch type, has an initial capacity of 1000 lines, of which 500 P.B.X., bringing the total Panama network up to 15740 lines. Including party lines, the number of subscribers is now above 18000. The installation work was done, as earlier, by Cía Panameña de Fuerza y Luz.

Among those present at the inauguration were the Minister of Public Works, Mr. Roberto López Fábrega, the Archbishop, Monseñor Francisco Beckmann, the President of Cía Panameña de Fuerza y Luz, Mr. Thomas Oglesby, and the Head of the Telephone Department, Mr. Walter A. Daniels.

Following the Archbishop's blessing of the new exchange, an opening call was made between the President of Panama, Ernesto de la Guardia, and the Minister, López Fábrega.

(Above) The Minister of Public Works, Mr. Roberto López Fábrega, used an Ericofon to make the first call to the President of Panama through the new telephone exchange. Behind him (from the left) are Messrs. Luis E. Kjorstad, T. V. Oglesby, W. A. Daniels, Rune Gustafsson (L M Ericsson's representative) and Salcedo Levy.

Mr. Evert Stålhagen of the Swedish Telecommunications Administration inspects the Biskopsgården automatic exchange (below) in company with Mr. Gunnar Fredholm who is in sole charge of maintenance of the exchange.



New 500-switch Exchange in Gothenburg

A new automatic exchange was recently opened at Biskopsgården, Gothenburg. It is equipped with L M Ericsson 500-line switches and, when installed to full capacity, will serve 10000 subscribers. In the first stage the exchange has been equipped for 4000 lines, but by the autumn it will be possible to connect another 2000 subscribers.

The installation work is in the hands of L M Ericsson's installation group in Gothenburg.

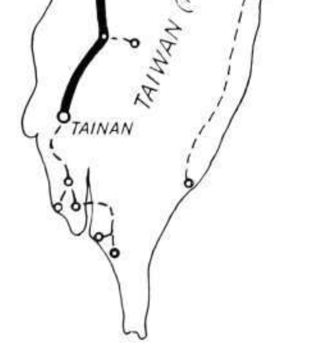
C.T.C. on Carrier for Formosa

The Formosan State Railway system covers some 1000 kilometres of track. The network consists chiefly of a west coast line from north to south of the country, and of a shorter east coast line. At present the two lines are not interlinked. The gauge is 1067 mm, which is narrower than the standard international gauge. Formosa also has a privately owned railway network extending over some 3000 kilometres and operated mainly by sugar refineries.

The railways are a very important means of communication in Formosa, and in recent years the capacity has proved altogether inadequate. As a first step, C.T.C. is to be introduced on the west coast line between Tainan and Changhua, but it is intended that the system shall be extended to Chunan.

In January this year tenders were called for, comprising signalling and C.T.C. equipment for the Tainan-Changhua line. The order, issued in May, went to L M Ericssons Signalaktiebolag and comprised deliveries of equipment, including supervision of installation work, for US $ 1,900,000. The equipment is to be delivered within 12 months.

The Tainan–Changhua line is single-track, about 150 kilometres in length with 26 stations. The C.T.C. office is to be at Changhua. An overhead line will be used for transmission of the C.T.C. information between the C.T.C. office and field stations, and, in view of the length of the railway and the large volume of traffic, will be divided into two sections, of which the northern section, nearest the C.T.C. office, will be controlled direct and the southern section will be controlled via carrier circuits in the northern section.



In the map above, the heavy continuous line marks the Tainan-Changhua section for which C.T.C. has been ordered. The heavy dotted line marks the planned extension to Chunan. The light dotted lines represent the remaining railway system.

L M Ericsson Builds New Auto-Exchanges in Indonesien

L M Ericsson has recently delivered a further automatic exchange to Indonesia, for the town of Magelang in Central Java. This crossbar exchange, at present equipped for 1000 lines, is the second delivered to Indonesia within a short period; an exchange of the same type for 3000 lines was opened at the end of last year at Solo, the latter being the first of its kind not only in Indonesia but in the whole of Asia. A large number of distinguished personages from State, Municipal and Military bodies were present at the official opening.

Large orders have been placed with L M Ericsson for additional exchanges in Palembang, Padang, Pakan Baru, Bukkit Tinggi, Djambi and Tandjong Kerang, all in Sumatra; also for transmission equipment for two 12-circuit systems on overhead lines between Padang, Bukkit Tinggi and Pakan Baru.

Indonesia has been an important L M Ericsson market during the past fifty years: a large number of public and private telephone exchanges have been delivered, and also selective calling telephone systems for the Indonesian Railways.

(Top left) Mr. Samdjoen, Director-General of the Indonesian P.T.T., making a speech at the opening of the Solo exchange, a view of which is seen in the photo top right. In the lower photo the Governor of Central Java, Mr. Mangunnagoro, is seen making the first trunk call from Solo to the Governor of Western Java, then on a visit to Bandung.

Carrier System Santos —São Paulo

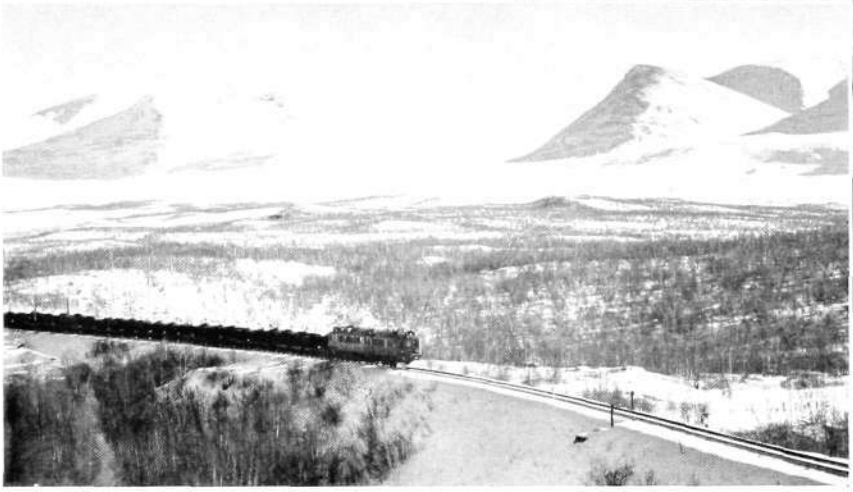
On June 7 the new Companhia Telefônica Brasileira carrier system linking Santos and São Paulo was opened to traffic. The main part of the equipment, including 70 kilometres of coaxial cable and 7 intermediate repeater stations, was supplied by L M Ericsson's affiliated company, Ericsson do Brasil Comércio e Indústria S.A.

The carrier equipment, type ZAX 960/2, will initially provide for 360 simultaneous calls between São Paulo and Santos, and when fully extended will have a capacity of 2000 calls.

This plant forms part of the enormous programme of C.T.B. and the Brazilian government for increasing the telephone facilities in the State of São Paulo. As reported in Ericsson Review No. 2, 1958, carrier systems have previously been installed between São Paulo and Campinas and between Rio de Janeiro and São Paulo.

A cocktail party was arranged by Ericsson do Brasil in conjunction with the opening ceremony. The gentlemen in the photograph are (from left to right) Dr. J. A. Wiltgen, Cia. Telefônica Brasileira, Mr. Adrian van Winkel, Ericsson do Brasil, Dr. Alvaro de Souza Lima, head of the São Paulo State Water & Electricity Board, and Dr. Carlos Reis Filho, Cia. Telefônica Brasileira.

L M Ericsson C.T.C. in Operation North of Arctic Circle



(Above) The C.T.C. office in Kiruna. The C.T.C. controller establishes train routes by operation of a keyset.

(Left) The ore line with the Lapporten pass in the background.

A new C.T.C. installation was completed by the Swedish State Railways in May and officially opened for service on June 1. The C.T.C. office is in Kiruna, from which the signalling system of the more than 80-mile line between Kiruna and the Norwegian frontier is controlled. This is the world's most northerly C.T.C. installation, the whole line running north of the Arctic Circle.

The installation comprises 12 remote-controlled stations, each having three or more tracks. The line is chiefly used for iron ore freights between the Lapland ore fields and the Norwegian port of Narvik, but also carries some passenger traffic. No road communications exist at all. The region is very sparsely populated, and very little passenger traffic occurs at the intermediate stations. For this reason it has been difficult to find personnel to man certain stations. The introduction of the C.T.C. system has made it possible to withdraw all train dispatching personnel from the stations and so reduce the Railways' operating costs. The chief advantage of the C.T.C. installation, however, is the improvement in railroad operation and the consequent increase in the transport capacity of the line.

The signalling and C.T.C. equipment was supplied by L M Ericssons Signalaktiebolag, while the installation work was carried out by the Swedish State Railways. The wiring of the relay bays for the C.T.C. equipment was done at the workshops of L M Ericssons Signalaktiebolag in Stockholm.

L M Ericsson's 1958 Conference on Maintenance Questions

This year's conference on maintenance of automatic telephone exchanges, the third of its kind, was held at the end of May and beginning of June. On this occasion the administrations invited were those of Latin America, and the majority of our South and Central American customers were represented at the green baize table at Midsommargården, opposite the head factory at Stockholm, around which the discussions took place. The Swedish Telecommunications Administration (Televerket) was also kind enough to send two delegates.

The discussions at the conference were mainly concerned with the economic aspects of maintenance, and with methods and possibilities of reducing the cost and improving the efficiency of maintenance routines in telephone networks in general and at telephone exchanges in particular. In a tour of the Scandinavian countries after the conference the delegates were given the opportunity of seeing how L M Ericsson equipment functions. The trip started in Åland, in the Finnish archipelago, where the small, reliable rural exchanges aroused considerable interest. Thereafter, in Örebro, the delegates saw how a Swedish engineering section at Televerket operates. At Aalborg and Aarhus in Denmark experience was gained of L M Ericsson's city exchange systems of crossbar type operated by the Jutland Telephone Administration. In particular, the new exchange at Aalborg with its advanced maintenance technique attracted considerable attention. The last visit was to the large trunk exchange of the Copenhagen Administration at Borups Allé.

During their time in Stockholm the conference visited plants in the Stockholm Telephone District. In the photo Mr. S. A. Moberg, Sectional Engineer of Televerket, is seen (left) describing the features of the Handen telephone exchange to a group consisting of (from right) Messrs. R. Novakowski, USA, R. C. Sussekind, Brazil, P. Tancred, Brazil, A. Soltero Gonzales, Mexico, H. S. Andersson, L M Ericsson, and C. B. Muros, Brazil.

U.D.C. 621.395.25

BJÖRK, H & HAGLUND, A: *Facilities Offered by Modern Private Automatic Exchanges.* Ericsson Rev. *35*(1958): No. 3, pp. 78—82.

Some of the new facilities developed by Telefonaktiebolaget L M Ericsson are described in this article, which deals principally with a private automatic exchange for up to 800 extensions, type *ARD 231*.

U.D.C. 621.395.23

ADENSTEDT, W: *P.M.B.X. Type ADF 162 for C.B. Systems.* Ericsson Rev. *35*(1958): No. 3, pp. 83–86.

L M Ericsson has always striven to offer its customers manual telephone switchboards of the most modern and efficient design. To this end a new single position P.M.B.X. has been designed, typed *ADF 162,* which possesses a number of technical and practical finesses.

U.D.C. 621.317.785.025.1

LINDBERG, S E: *Wide Range Single-Phase Meter.* Ericsson Rev. *35* (1958): No. 3, pp. 87—93.

In this article a single-phase meter is described, typed *VEN 23,* which will measure loads of up to 360 % of its rating within an error of not more than 2.5 %. It is designed to measure single-phase energy with great accuracy even if the line voltage and ambient temperature vary within wide limits.

U.D.C. 621.395.721:621.375.4

MITNITZKY, I & AHLSTRÖM, P: *Telephone Set with Amplified Reception.* Ericsson Rev. *35*(1958): No. 3, pp. 94—97.

Telefonaktiebolaget L M Ericsson has introduced a new type of loud sounding telephone set, *DBH 923*. The use of transistors has given the telephone greatly improved properties compared with the earlier design incorporating a vacuum tube amplifier.

U.D.C. 621.385:621.375.121

EDSMAN, S: *New Electron Tubes for Wide-band Amplifiers.* Ericsson Rev. *35*(1958): No. 3, pp. 98—102.

To fulfil the higher demands on the ability of electron tubes to amplify wide ranges of frequencies, tubes must have higher transconductance and at the same time lower capacitances. This description of the pentode *5847/404A*, the triode *5842/417A*, and the tetrode *7150* embraces all the properties which make these tubes especially suitable in wide-band amplifiers.

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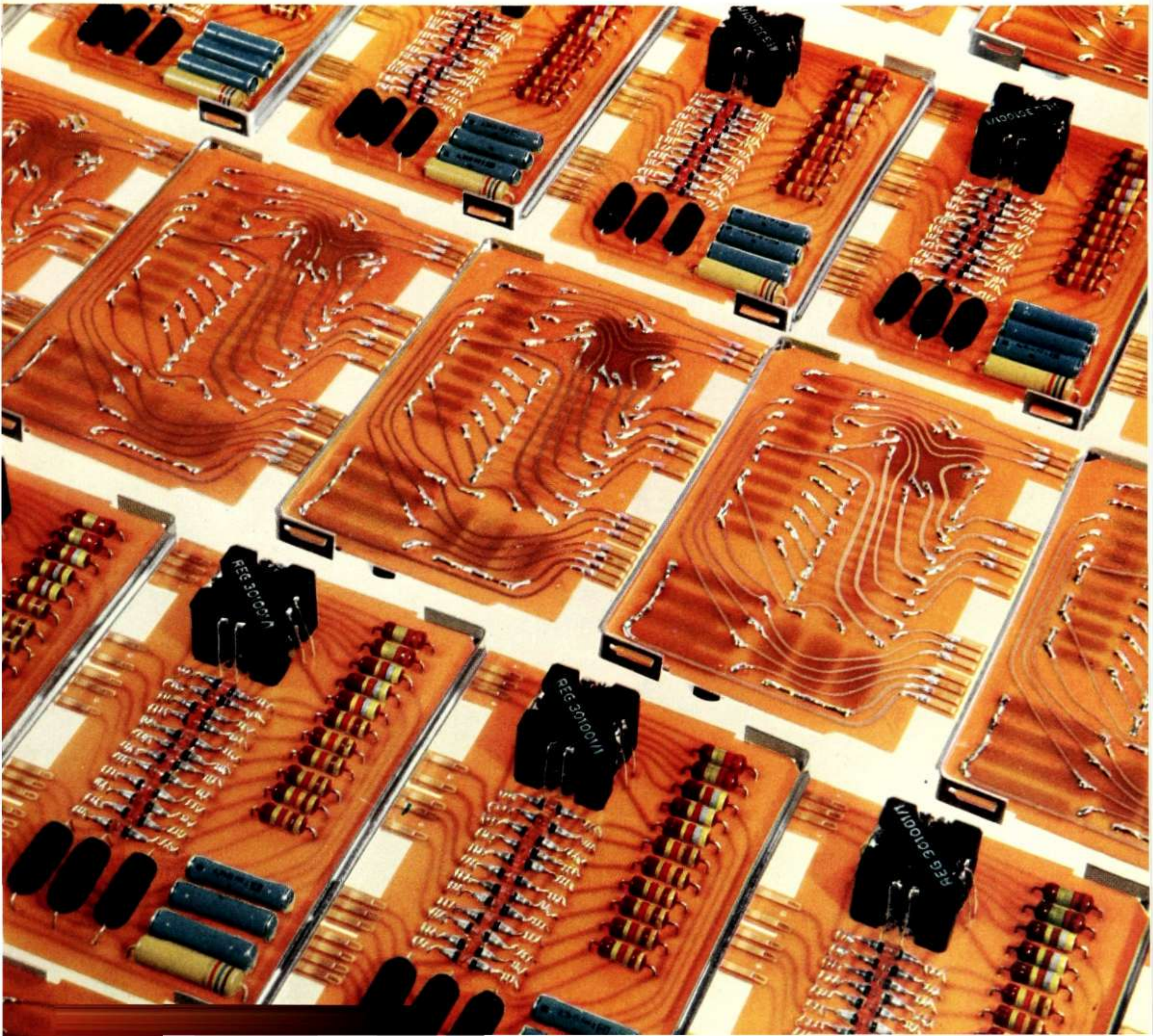
ERICSSON Review

4
1958



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CONTENTS

On cover: Printed circuits ROA, L M Ericsson's new assembly method for electronic equipments in telephone exchanges.

Centralographs as Fault Recorders at Telephone Exchanges

Å HOLMQVIST & G STRIGÅRD, ROYAL BOARD OF TELECOMMUNICATIONS, STOCKHOLM

U.D.C. 654.937.2:621.395.66

The CENTRALOGRAPH as a service observation instrument in automatic telephone exchanges was referred to in Ericsson Review No. 1, 1958, in conjunction with a description of the L M Ericsson traffic route tester. In L M Ericsson's automatic transit exchanges it is also used for the recording of faults discovered by markers and v.f. receivers.

The present article deals with Centralograph applications in automatic exchanges of the Swedish Telecommunications Administration, where its use differs from that in the L M Ericsson normal supervision systems.

The L M Ericsson Centralograph is used in industry for the supervision of manufacturing processes and of the functions and degree of utilization of machinery. The Centralograph is a recording instrument equipped with a number of printing units which record data on a moving chart. The record appears in the form of dashes and digits in a series of columns. The printing units have magnetic coils which are actuated by external impulses. The chart and the ink ribbon are driven either by a synchronous motor or by an impulse motor.

The Swedish Telecommunications Administration (Televerket) has developed a special application for the Centralograph in telephone exchanges for supervision of automatic switching processes.

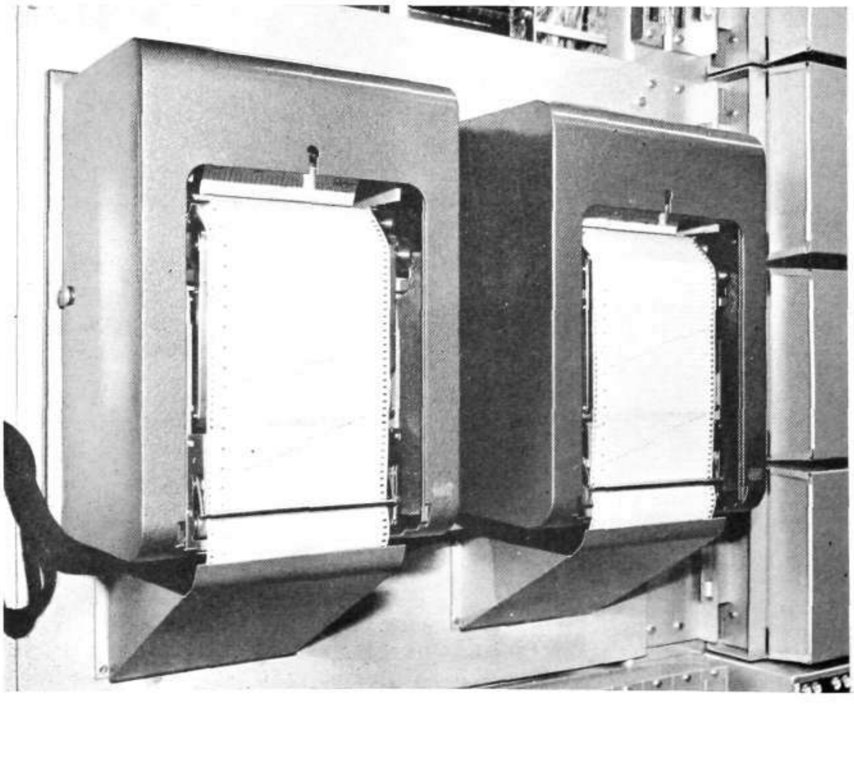


Fig. 1 X 8118

Two Centralograph recorders mounted on one rack in a telephone exchange

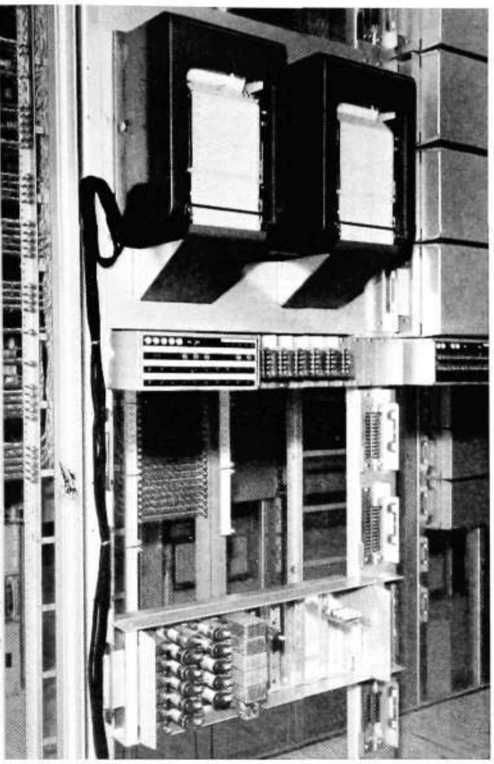


Fig. 2 X 2362

The relay set controlling the Centralograph recorders is mounted below them on the same rack

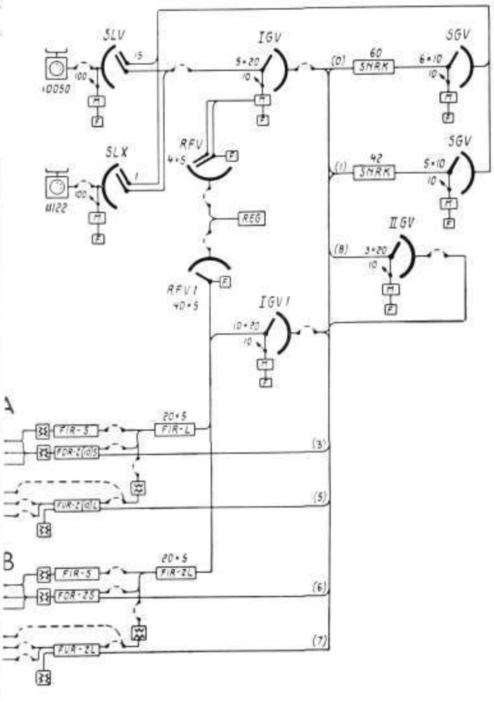


Fig. 3 X 2358

Trunking scheme of telephone system ART 204

A junctions to transit exchange and group centre
B junctions to terminal exchange

In automatic telephone exchanges operating on modern crossbar switching systems the Centralograph is used for recording faults discovered by the automatic fault indicating devices specially developed for these systems. The fault indicating devices come into operation if the connection of a call through the various switching units is delayed. If a connection is delayed for other reasons than lack of circuits, the signals from the fault indicating device are transmitted to the Centralograph. A special code is marked on the Centralograph chart indicating the location of the fault within the exchange and the designations of the switches concerned, with their conditions according to the stage the connection had reached when the fault occurred.

The type of Centralograph used for fault recording in automatic telephone exchanges of the Televerket marker system has thirty printing magnets which record horizontal lines 2–3 mm in length on a 30-column chart. Two Centralographs, having altogether 60 printing units, are required for fault recording. The printing and feed of the chart are controlled from a special relay set. The chart is advanced after each fault recording, and the feed can be varied from 5 mm up to 20 mm by means of different strappings in the relay set. From this relay set the impulse motors of the two Centralographs are fed with 1/1 second reversed polarity impulses.

Two Centralograph recorders mounted together on a rack in a telephone exchange are shown in fig. 1. The control relay set is mounted below them on the same rack (fig. 2).

In order to understand the operation of the Centralograph as fault recorder in the Televerket marker system, and how and to which switching units in the exchanges the Centralograph is connected, one must first have some knowledge of the trunking scheme of the telephone exchange and of the switching processes to be supervised. A brief description will therefore be given of the procedure in an average-sized exchange with the trunking diagram shown in fig. 3.

A calling subscriber (*10050*) is connected by the marker *M* in the combined linefinder and final selector unit *SLV* to a first group selector *IGV* having a free marker *M*. This marker extends the connection to a register-preselector *RFV* which hunts for a free register *REG*, which, when found, returns dial tone to the subscriber. The subscriber now dials the wanted number (*11122*). After *REG* has received three digits (*111*), the marker in *IGV* is recalled and *REG* sends a code signal to it for positioning of *IGV* on the required thousands group (outlet *1*). The marker hunts for a free circuit to a last group selector *SGV* having a free marker. Through-connection then takes place in *IGV* and the marker is released. *REG* now sends the last three digits of the subscriber's number in the form of code signals to the marker of *SGV*, and *REG* and *RFV* are cleared. *SGV*'s marker is now connected to the marker for the required hundreds group (*1*) in *SLV*. The last two digits (*22*) are sent on a control wire to the marker in *SLV*. The marker in *SGV* hunts for a free route via *SGV* to *SLV* and to the called subscriber line. Through-connection takes place in *SGV* and *SLV*, the relay set *SNRK* is connected to the circuit and the markers in *SGV* and *SLV* release. Among other functions, the *SNRK* relay set tests for busy condition on the called subscriber's line and transmits ringing signals until the subscriber answers. In the case of external calls *REG*, guided by the first two digits of the subscriber's number, operates *IGV* to outlet *3* leading via the *FDR* junction relay set to the required exchange, where connection to an *REG* is obtained via *FIR-L* at *RFV*. *REG* at the home exchange repeats the dialled number to *REG* at the called exchange. Connection to the called subscriber takes place in roughly the same way as already described.

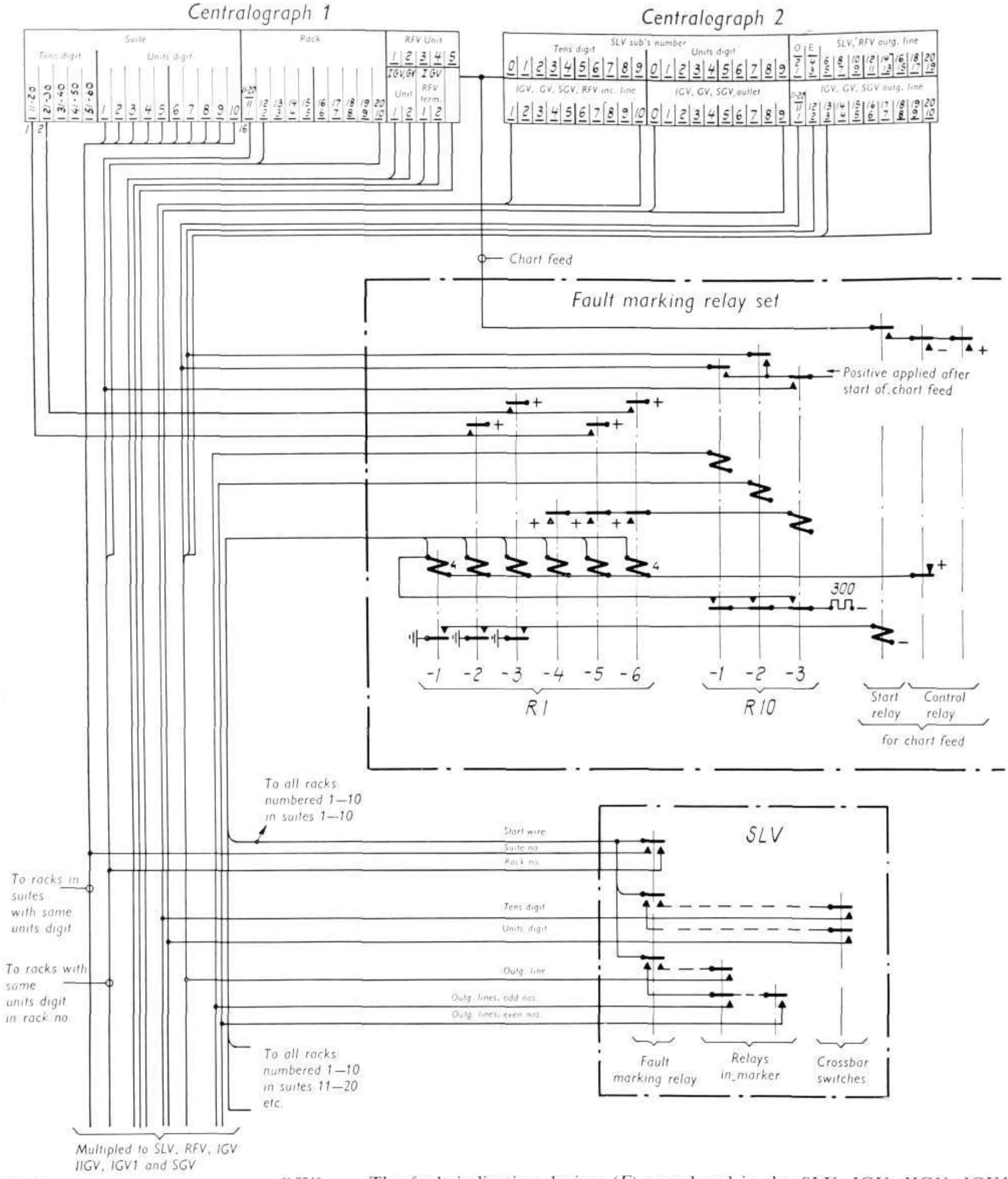


Fig. 4

Skeleton diagram

X 7745

The fault indicating devices (*F*) are placed in the *SLV*, *IGV*, *IIGV*, *IGV1*, *RFV*, *RFV1* and *SGV* units and consist for the main part of two relays and control circuits which pass over contacts on relays and crossbar switches. The operation of one relay is delayed about one second by means of an electrolytic capacitor. If the connection through the selector unit is delayed beyond this period, for other reason than lack of circuits, the relay in question operates and connects into the circuit the fault indicating relay, which closes the control circuits to the printing magnets of the Centralograph. The position of the fault within the exchange is indicated by marking of suite, rack, number of incoming line and, in certain cases, the switching condition.

The fault indicating device described above is not exactly similar for all switching units. For example, the fault indicator in *SLV* has also a blocking function.

In the event of a fault indication the primary switching routes through *SLV* are blocked for about half a second, so that a call arriving within this time is switched through other routes. Thus a fault does not prevent setting up of a connection to or from a given number, or even through the entire *SLV* unit during low traffic periods. In the group selectors *IGV*, *IGV1*, *IIGV* and *SGV* the fault indicating devices can automatically block the group selectors for 60 seconds. This prevents a faulty *GV* unit from causing repeated faulty connections. The *SGV* fault indicating device also contains a relay (unbalance relay) which checks that the control circuits for transmission of tens and unit digits to the *SLV* marker are in order and not subject to leakage.

The connection of the Centralograph recorders to the control relay set and to the fault indicating devices in the exchange will be apparent from the following description and from the skeleton diagram in fig. 4.

If a fault occurs in, for example, the *SLV* rack, the fault indicating relay is operated. This relay connects the start wire to the fault indicating wires which lead to the printing magnets in the Centralograph recorders via contacts on relays and crossbar switches in the *SLV* rack. The printing magnets which have fault indicating wires connected to the start wire operate in series with a low resistance relay *R1–1* in the fault indicating relay set. Relay *R1–1* starts the control relays advancing the Centralograph charts. The positive potential is removed from the start wire and the printing magnets and *R1–1* release. Once the chart has been fed forward one step, the control relay set is ready to receive a new fault recording. Relays *R1–1*, *R1–2* and *R1–3* record faults from racks *1–10* in suites *1–10*, *11–20* and *21–30*, respectively. The operation of relay *R1–2* or *R1–3* actuates printing magnet *1* or *2*, indicating the suite series. Relays *R1–4*, *R1–5* and *R1–6* record faults from racks *11–20* in suites *1–10*, *11–20* and *21–30*, respectively. These relays close the operating circuit of relay *R10–3*, which in turn energizes relay *R1–1*, whereupon the chart feed starts and the fault indicating circuits of the printing magnets are opened. Relay *R10–3* closes the operating circuit of printing magnet *16*, which is energized for a moment after the chart has been fed forward a few millimetres. A mark in column *16*, which is displaced in relation to other marks, therefore indicates that the rack on which the fault is recorded is in the series *11–20*.

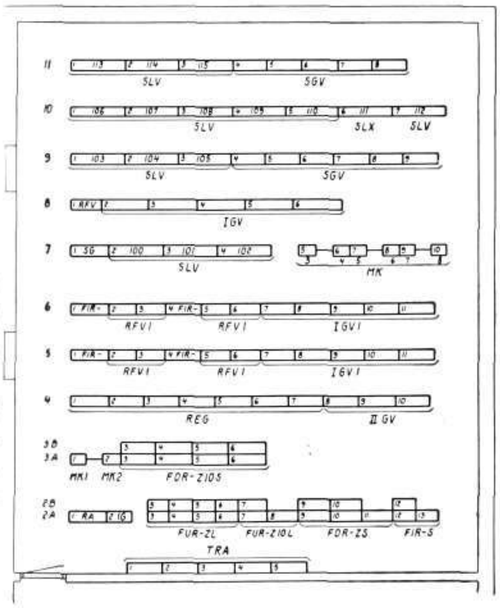


Fig. 5 X 2359

Rack lay out

Relays *R10–1* and *R10–2* are energized from *SLV* and *RFV* racks via the fault indicating wires, which indicate odd and even numbers of outgoing circuits respectively. *R10–1* is also energized from *IGV*, *GV* and *SGV* racks with fault indicating wires for outgoing circuits within the *11–20* group. Relays *R10–1* and *R10–2* cause a displaced mark on the chart like that caused by the operation of relay *R10–3*.

As regards the functions of the control relay set over and above those already described, it may be mentioned that it contains a supervising relay (cam disc relay) which, after 35 fault recordings, sends a minor alarm signal to the exchange alarm panel. By means of a strap connection on this relay, the chart feed can also be stopped after 35 fault recordings in order to reduce chart consumption as a result of regularly recurring faults. The blocking of the group selectors by a fault indication, referred to above, is also supervised by *FR-C*.

The method of interpreting the fault recordings on the Centralograph charts to identify a faulty connecting device can best be illustrated by a few

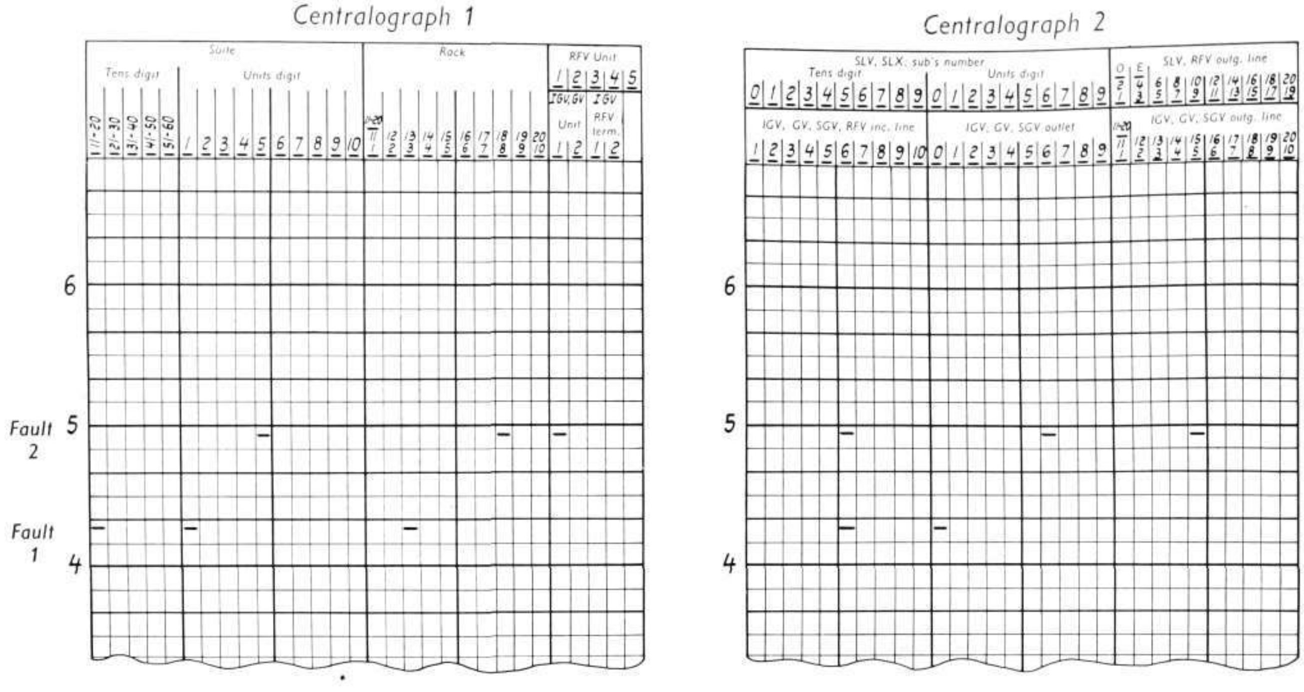


Fig. 6
Example of fault recording

X 7746

examples. Fig. 6 shows examples of different fault recordings. The designations above the chart appear on a strip which is mounted in the Centralograph and identify the records in each column. Certain columns have alternative meanings depending on the type of rack which has originated the fault indication. This is found from the suite and rack identification on centralogram I and the rack lay-out (fig. 5).

Example

Fault 1 is recorded against suite *11* and rack *3* and therefore refers to an *SLV* rack.

Centralograph *2* shows that subscriber *50* has not been connected through; the fault occurred before an outgoing circuit was encountered. This is indicated by the fact that there is no recording in columns 21–30.

Fault 2 is recorded against suite *5* and rack *8* and refers to an *IGV1* rack. For *IGV1* (and *IIGV*) the lower part, *GV*, of the designation applies.

Centralograph *1* indicates that the fault occurred in unit *1*, and Centralograph *2* that the sixth incoming line has been connected to decade (outlet) *6* and outgoing line *5* before the fault occurred. For some reason the marker of the *IGV1* unit has not been released after the connection.

Usefulness of Centralograph for Fault Recording

The use of the Centralograph for fault recording is not only an advantage for fault tracing in a telephone exchange but also provides certain information on the quality of service rendered by the exchange. The Centralograph is also a valuable aid in testing new equipments or extensions of existing equipment.

As will be appreciated from the foregoing account, the Centralograph indicates in which connecting device a fault has occurred and, in some cases, in

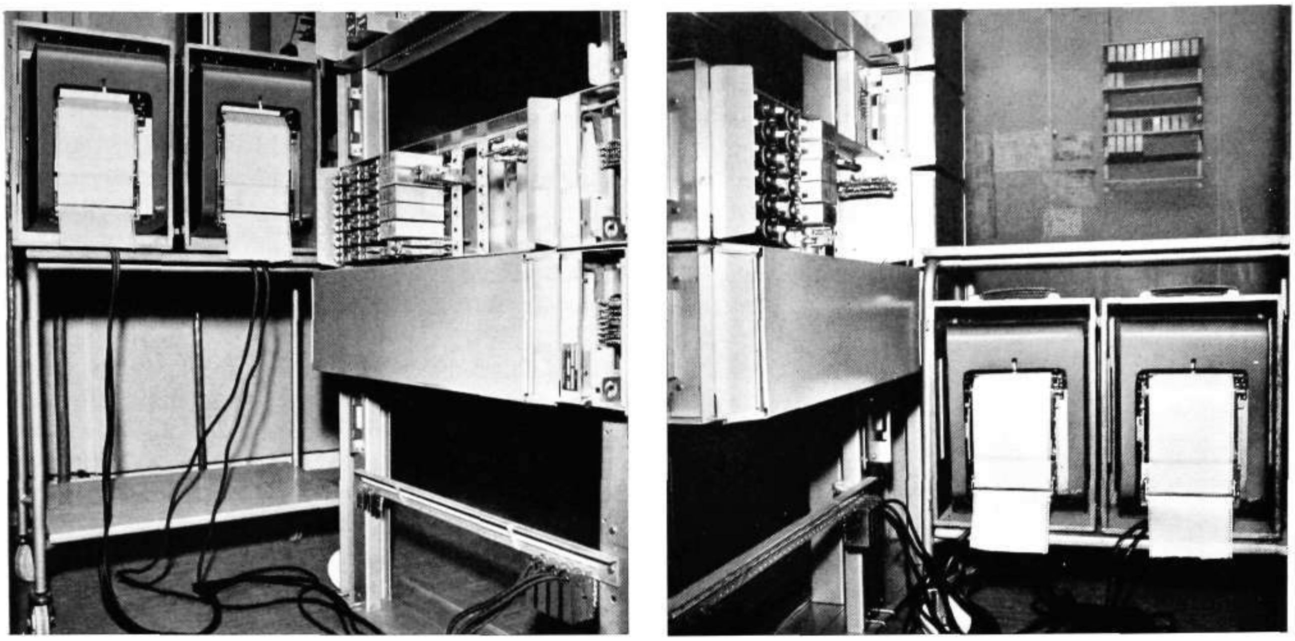


Fig. 7 X 8119 X 8120

Different methods of connecting portable Centralograph recorders for fault tracing in small telophone exchanges

which part of a connecting device the fault may be looked for. It is by no mean certain, however, that the cause of a single fault can be elucidated. The faulty circuit has usually been restored, and it is only in exceptional cases that a faulty device is locked up in the faulty position. Normally, therefore, the fault must be reconstructed by establishing the connection with the connecting devices shown by the Centralographs to have been engaged when the fault occurred. By repeated attempts of this kind the fault tracer can discover the cause of the fault and the weakness in a given switching unit, at least if the fault remains or is recurrent.

If one wished definitely to put one's finger on temporary faults, the connection would have to be locked when the fault occurred so that the maintenance staff could directly see the faulty position of the switch. In marker systems with common switching devices, which are designed for very brief occupation on every connection, there would be difficulties in locking a faulty connection, especially as the maintenance force is not so numerous as to be able to remedy faults immediately. The essential point, therefore, is to ensure that the common switching devices are not occupied longer than necessary, but only during such time as is required to print the necessary data on the Centralograph chart. As a rule one must be content if faults can be located which persist or are constantly recurrent. Faults of a more sporadic nature, and which are due to unfavourable circumstances or to transient conditions, must be allowed to remain until they reach the point at which a fault tracer can get the fault to repeat itself after a reasonable number of attempted connections and so arrive at the cause of the trouble.

In small telephone exchanges, where there is no daily attendance for maintenance and fault tracing, the Centralograph recorders are not permanently installed but use is made, instead, of portable recorders (fig. 7). These are used only for special fault tracing operations, routine testing or testing of new exchange equipment during the first month of operation. In these small exchanges use is made of call counters, connected to the control wires of the fault indicating devices in such manner that they indicate the total number of faults in different groups of switches. Normally one counter is used for all *SLV* within the same thousands group, one for all *SGV* within the same thousands group, one for all *IGV*, one for all *IGV1*, one for all *IIGV*, and one for each bay of *RFV* or *RFV1*. These counters provide some idea of the fault frequency and the quality of service rendered by the exchange.

When a fault tracer or routine tester visits one of these exchanges, he is able to decide from the figures indicated on the counters whether there are constantly recurring faults in the switches of the exchange. By connecting the portable Centralograph recorders to the exchange equipment, he can get more detailed information which enables him to locate the faults.

In general it may be said that the more advanced the exchange system, the greater should be the benefit provided by the Centralograph for fault recording. Even if it must be admitted that the translation of the code printed on the Centralograph charts is at times somewhat troublesome, and that sporadic faults are difficult to reconstruct, nevertheless the Centralograph has been, and still is, of great use in assisting in fault finding at the marker exchanges of the Swedish Telecommunications Administration.

L M Ericssons 960-Circuit System for Coaxial Cables

III. Terminal Equipment

B FILIPSON, TELEFONAKTIEBOLAGET L M ERICSSON, STOCKHOLM

U.D.C. 621.395.44
621.395.5

L M Ericsson's terminal equipment for the 960-circuit system is described in this and a subsequent number of Ericsson Review. The present article deals with the parts of the equipment which are directly concerned with the transmitted signal band, and the oscillator equipment is dealt with in a subsequent number.

The definition of an h.f. line was given in Ericsson Review No. 3, 1957, page 74, where the h.f. line was defined as an equipment which transmits a given frequency band from one terminal station to another with a certain stated loss or gain. By terminal station is meant a station containing the equipment in which the above frequency band is formed and divided up – the sending side and the receiving side respectively.

Multiplex Equipment

Before all 960 telephone circuits have been grouped in the band 60–4028 kc/s for transmission over the coaxial line they have passed through four stages of modulation. Equipment for this is built into three different bays with the first two modulation stages placed in one bay and each of the two subsequent stages in its own bay. The bays also contain in general the corresponding demodulation stages for receiving or dividing up the frequency range 60–4028 kc/s.

The signalling equipment and channel amplifiers are located in a separate bay called the Voice Frequency Bay.

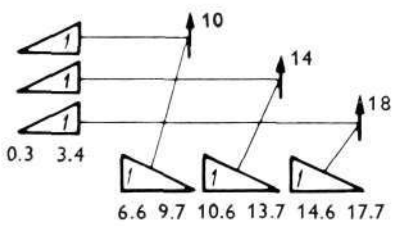


Fig. 1 X 2347
Modulation plan for the formation of a sub-group

Channel Translating Equipment

By channel translating equipment is meant here the v.f. equipment and modulation equipment for forming the basic groups in the frequency range 60–108 kc/s. The formation of basic groups is carried out in two stages of modulation, viz. channel modulation and sub-group modulation. As will be seen in the modulation plan, fig. 1, the first modulation stage consists of combining three channels to form a sub-group lying in the frequency range 6–18 kc/s.

A basic group in the frequency range 60–108 kc/s is then obtained after the second modulation stage from four such sub-groups, see fig. 2. The frequency allocation of the basic group is that recommended by CCITT (CCITT groupe primaire de base B) and here the channels are inverted with channel 12 lowest and channel 1 highest in frequency.

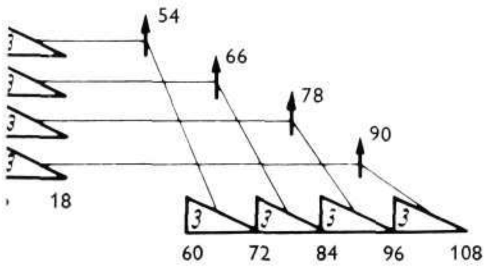


Fig. 2 X 2348
Modulation plan for the formation of a basic group

Instead of modulating direct to the frequency range 60–108 kc/s, i.e. only one modulation stage to the basic group, an intermediate stage, the sub-group 6–18 kc/s has been used. This decision was made for two reasons:

a) it was decided to use filters with coils, not crystals for the channel filters;

b) the method using sub-groups consisting of three channels requires the least number of types of filter and carrier frequencies to form the basic group.

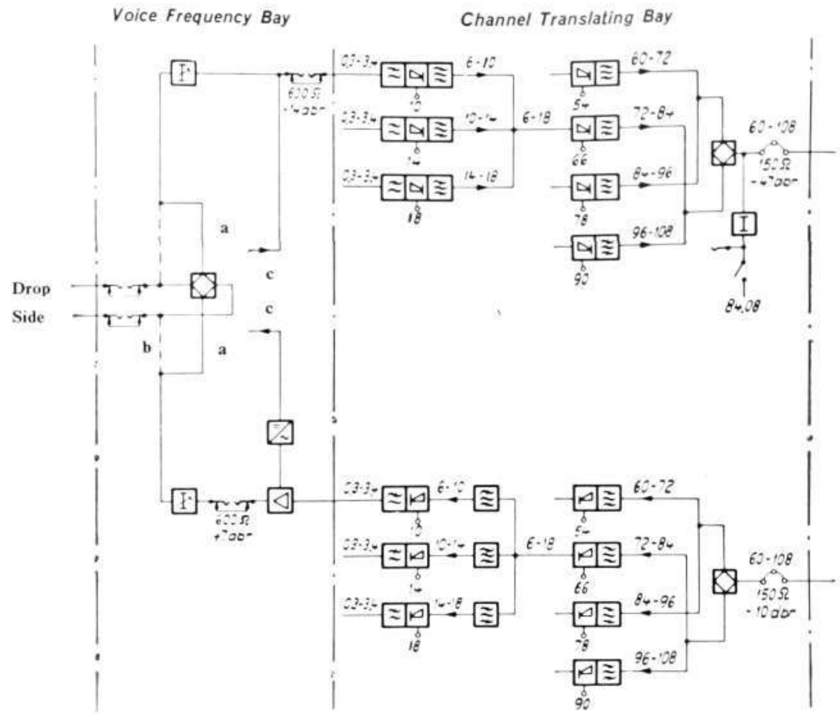


Fig. 3 X 8313

Block schematic of the channelling equipment

- a two-wire termination
- b four-wire termination
- c signalling path

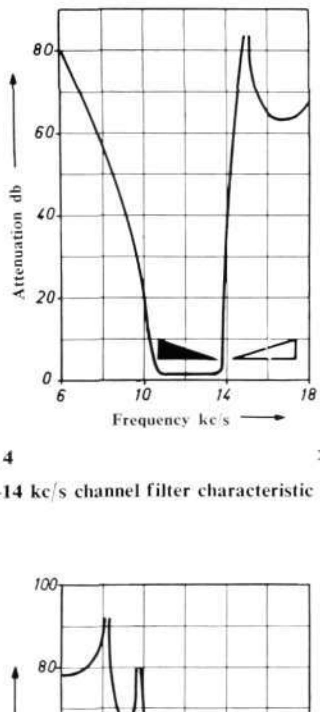


Fig. 4 X 2364

10—14 kc/s channel filter characteristic

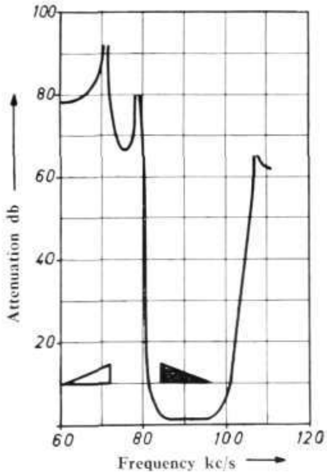


Fig. 5 X 2365

84—96 kc/s sub-group filter characteristic

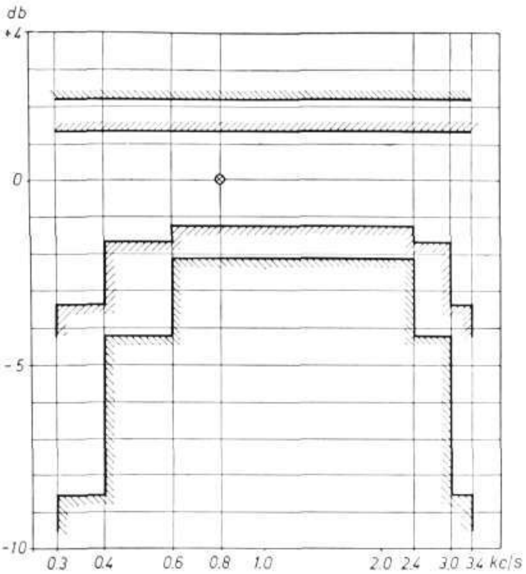
Fig. 3 shows the block schematic of the v.f. and modulation equipment, which mechanically is mounted in two bays called Voice Frequency Bay and Channel Translating Bay respectively. These, however, are so intimately connected with each other that they are always tested together and technical data are most often given for both bays.

The Voice Frequency Bay contains v.f. equipment for sixty circuits. Adjustable pads for adjustment of level on the drop side are provided on both sending and receiving sides.

Test jacks for all circuits are grouped in a central field. On the receiving side there are in addition the channel amplifiers. The signalling equipment is described later in a separate section. Each channel amplifier has a gain of about 40 db and has two stages with current feedback. Circuits for enabling small corrections to be made to the gain at the flanks of the v.f. band are provided in the feedback loop.

The Channel Translating Bay, which contains the modulation equipment mentioned above, also contains equipment for sending and receiving up to sixty channels, i.e. sending and receiving of up to five basic groups on the h.f. side. The block schematic in fig. 3 shows two modulation stages for the formation of a basic group. The type of modulator used in these stages is the ring modulator, in which, as is known, the carrier and the incoming signal frequency band are suppressed or balanced out on the output side. The sidebands which are used are separated by the band-pass filters from the sidebands lying on the other side of the carriers and also from the interference frequencies. The band-pass filters in the first modulation stage are connected together with a special connecting or compensating filter, while in the second modulation stage only a simple hybrid is used. These connexions are required so as to maintain the impedance constant within the pass band of the filters so that they do not interfere with each other.

The effective speech band occupies the frequency range of 300–3400 c/s of the range of 0–4 kc/s reserved for the channel. The frequency ranges 0–300 and 3400–4000 c/s which are not used for speech transmission are required for obtaining the loss in the channel filters 6–10, 10–14 and 14–18 kc/s, the pass bands of which are really 6.6–9.7, 10.6–13.7 and 14.6–17.7 respectively. Figures 4 and 5 show a typical filter characteristic of one of the band-pass filters in each of the two modulator stages. The requisite carrier frequencies 10–18 and 54–90 kc/s are obtained from separate oscillator equipment which is described in a later number of Ericsson Review.



X 2351
X 9145

Fig. 6

Frequency response measured v.f. to v.f. of channel modulating and demodulating equipment looped at the group distribution frame

LM Ericsson's values of limits for equipment using out-band signalling

CCITT recommended limits for any continental circuit

Fig. 6 shows the values of the limits used by L M Ericsson for the frequency response measured v.f. to v.f. of channel modulating and demodulating equipment looped at the group distribution frame. The CCITT recommended limits for any continental circuit are also included for comparison purposes.

The sending modulator in the first stage also acts as an amplitude limiter to prevent overloading of subsequent stages.

The intelligible far-end and near-end crosstalk is suppressed more than 75 db.

The 84.08 kc/s group reference pilot recommended by CCITT is injected at the output of the group sender as shown in the block schematic fig. 3. This pilot frequency, by means of which the groups can be checked, is obtained from the oscillator equipment and is injected in parallel at a level of −20 dbm0 into each of the five groups in the bay.

Group Translating Equipment

The third modulation stage is the stage where a supergroup is formed from five basic groups and vice versa (see the modulation plan, fig. 8). The frequency allocation of the supergroup 312–552 kc/s is that recommended by CCITT. The block schematic for the group translations is shown in fig. 9, and as will be seen, an amplifier is included in both the sending and receiving sides as well as modulators and band-pass filters. The group amplifier, which has two tube stages with negative feedback, has a gain which is nominally 34 db and adjustable in steps of about 1 db within 4.3 db on either side of this value. Ring modulators are used here as in the previous modulation stages. The band-pass filters which select the lower sideband are connected by means of a hybrid. The attenuation frequency characteristic of one of these filters is given in fig. 10. A fully built out bay contains equipment

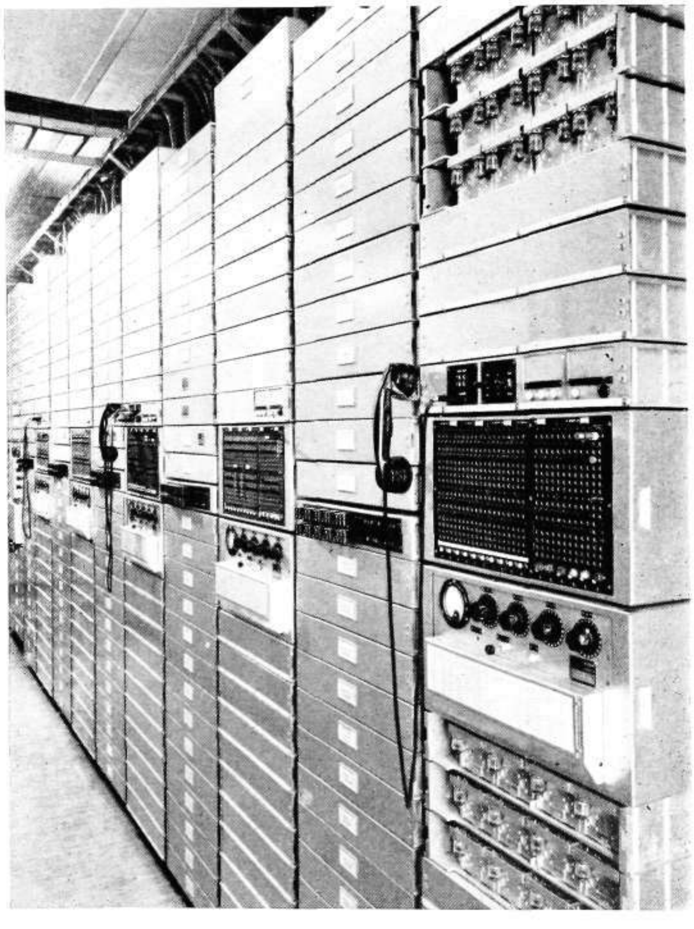


Fig. 7 X 8116

Row of Channel Translating Bays and Group Translating Bays

The shelves without covers in the Channel Translating Bay at the extreme right contain channel amplifiers (below) and v. f. signalling receivers (above) for twelve circuits

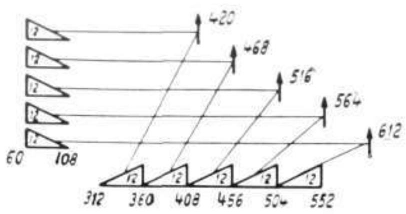


Fig. 8 X 2352

Modulation plan for the formation of a basic supergroup

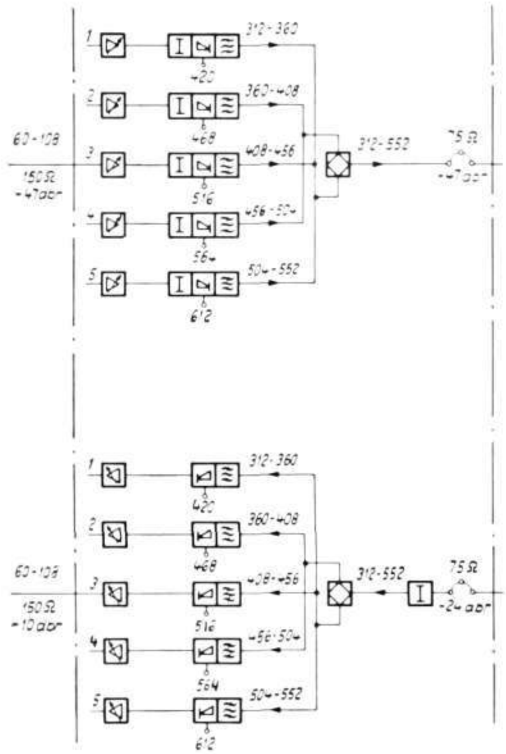


Fig. 9 X 2353

Block schematic of the group translating equipment

Fig. 10 X 2354

408—456 kc/s group filter characteristic

Fig. 11 X 8121

Group modulator unit

The modulator assembly, which is seen at the top of the unit is of plug-in type and can easily be exchanged

for eight supergroups in the sending direction and eight in the receiving direction. The units are of plug-in type and the bay can be successively built out from one to eight supergroups.

When translating a basic group to or from a supergroup, the output level of the group reference pilot lies within ± 0.5 db. The output level of the other frequencies within the basic group frequency band 60–108 kc/s lies within the limits $+ 0.4$ and $- 0.6$ db relative to the output level of the pilot frequency.

The intelligible far-end and near-end crosstalk between basic groups is suppressed more than 80 db.

The noise in a quiet, unloaded system for the first three modulation stages measured at a point having a level of 0 dbr and looped at the supergroup distribution frame does not exceed 35 pW for an average channel. The noise in a loaded system measured as described for a quiet system but with a noise loading of -15 dbm0 per channel does not exceed 50 pW for an average channel and does not exceed 90 pW for the worst channel.

As given in the introductory article in Ericsson Review No. 2, 1957, CCITT have allocated to the terminal equipment a value not exceeding 2500 pW of the total permissible average noise power not exceeding 10000 pW measured at a point having a level of 0 dbr in a nominal maximum circuit. The nominal maximum circuit can be divided up into three identical sections, and for one-third of the CCITT nominal maximum circuit the terminal equipment is thus allocated a value not exceeding 830 pW. In the coaxial system *ZAX 960/2*, a value not exceeding 130 pW for one-third of the CCITT nominal maximum circuit is obtained from the channel translating equipment and group translating equipment, and the remaining part not exceeding 700 pW has been allocated to the supergroup translating equipment, in all three modulations and demodulations.

Supergroup Translating Equipment

The final formation, and on the receiving side the division, of the coaxial line frequency range 60–4028 kc/s occurs in the fourth and last modulation stage. This frequency band is sent out to the h.f. line. As will be seen from the modulation plan, fig. 12, this band consists of sixteen supergroups numbered 1 to 16 with increasing frequency. The separation between consecutive supergroups is 8 kc/s wide except that between supergroups 1 and 2 and between supergroups 2 and 3, the separation in these two cases being 12 kc/s. Supergroup no. 2 passes through without modulation, as its frequency allocation coincides with that of the basic supergroup 312–552 kc/s. The spaces between the supergroups are used for sending out pilots to the h.f. line as has been described in previous articles.

Fig. 10

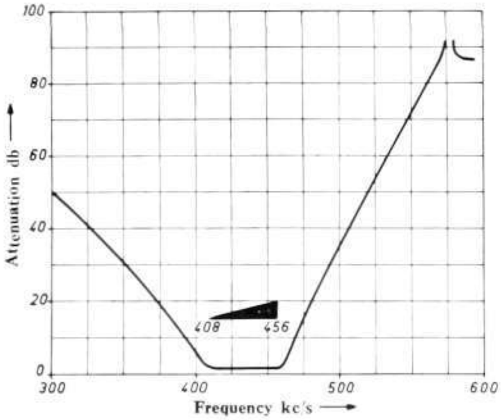
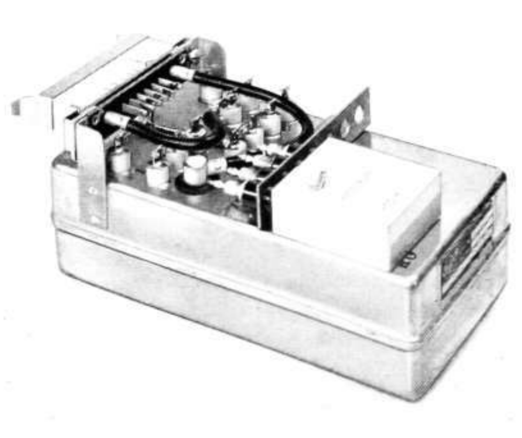


Fig. 11



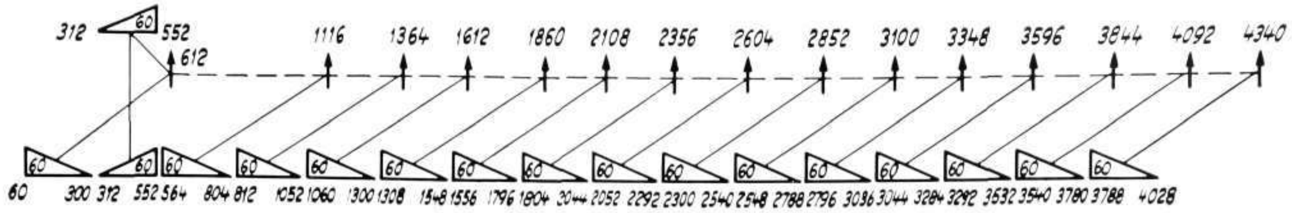


Fig. 12 X 7736

Modulation plan for the formation of the line group

Modulation and selection of the required sidebands is carried out here in principle in the same way as in previous modulation stages. The so-called Cowan modulator has been chosen for modulation and demodulation of supergroups nos. 6–16; the ring modulator has been used for the lower supergroups. As opposed to the ring modulator, the Cowan modulator does not suppress the direct carrier leak but requires less carrier power than the ring modulator.

A block schematic of the Supergroup Translating Equipment is shown in fig. 13. As will be seen, the injection and removal of the CCITT recommended 411.92 kc/s supergroup reference pilot for supervision of the supergroups, and also the 60 kc/s frequency comparison pilot for comparison of the frequencies of the oscillator equipment are made in this equipment. The level of injection of the first pilot is –20 dbm0 and that of the latter pilot is –10 dbm0. The 411.92 kc/s pilot frequency is obtained from the oscillator equipment and is fed in parallel to sixteen injection units from which high impedance injection is made into the different supergroups. On the receiving side the supergroup pilot is extracted and passes to a pilot receiver which controls a regulating network. This maintains the level of the supergroup pilot after the supergroup amplifier on the receiving side constant to within ± 0.5 db for variations of input level within ± 5 db. For further details, please refer to the section on supervision later in this article.

The gain for frequencies within the band 312–552 kc/s for one supergroup modulation stage, sending or receiving, is held within the limits ± 0.6 db relative to the level of the 411.92 kc/s supergroup reference pilot. In

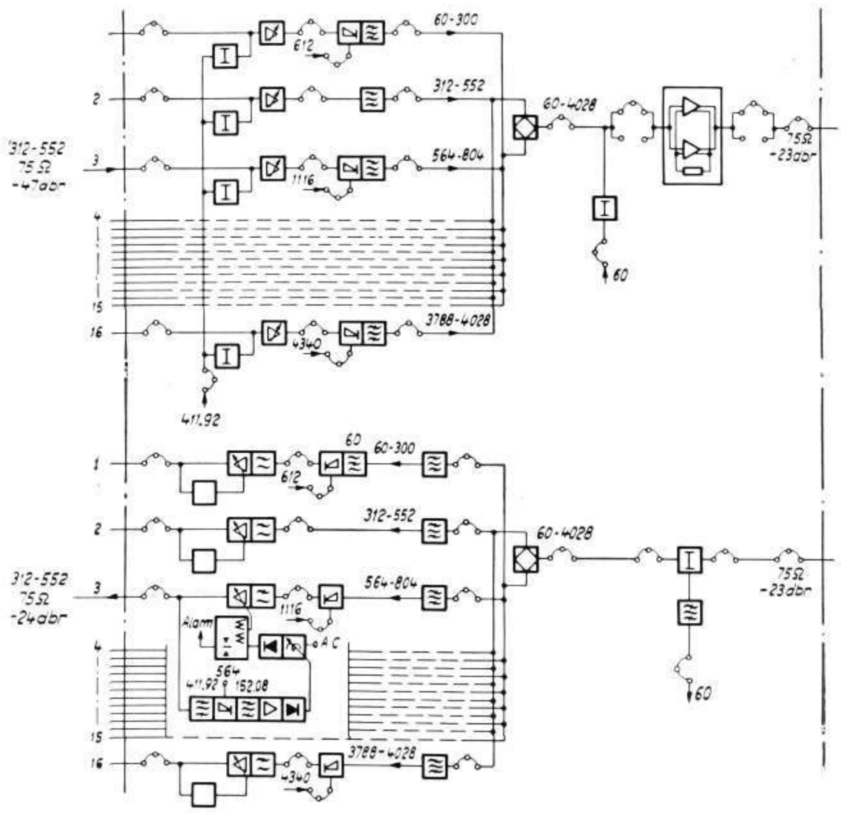


Fig. 13 X 8114

Block schematic of the supergroup translating equipment

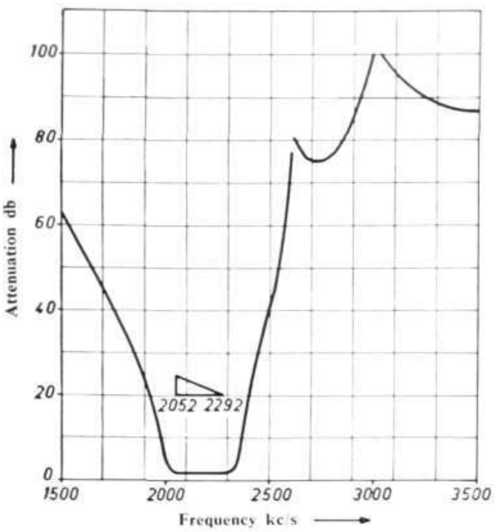


Fig. 14 X 2355

2052—2292 kc/s supergroup filter characteristic

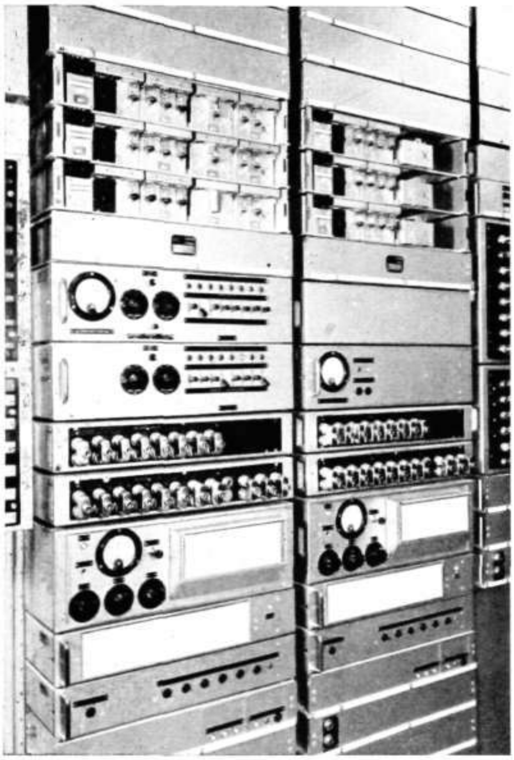


Fig. 15 X 2360

Supergroup translating bays containing supergroup translating equipment for 16 supergroups, receiving (left) and 16 supergroups, sending (right)

The shelves without covers for 3 supergroups in the receiving bay contain from the left: correction unit, supergroup amplifier and the 411.92 kc/s pilot receiver. In the sending bay are seen the corresponding units with the 411.92 kc/s pilot injection unit to the right of the amplifier.

addition, the maximum slope of a group having a bandwidth of 48 kc/s does not exceed 0.45 db and of a channel of bandwidth 4 kc/s does not exceed 0.25 db. A separate correction network with a correction circuit for each lower and upper flank of the band is connected into the feedback loop of each of the supergroup amplifiers. The slopes of the flanks of the filter characteristic are thus adjusted with these correction networks so that the above limits are maintained.

The intelligible far-end and near-end crosstalk between supergroups is suppressed more than 80 db.

The noise in an unloaded system, measured for the sending and receiving sides together at a point having a level of 0 dbr does not exceed 65 pW for an average channel and does not exceed 150 pW for the worst channel. The noise in a loaded system with the supergroup modulation loaded with white noise only at a level of −15 dbm0 per channel does not exceed 90 pW for an average channel at a point having a level of 0 dbr.

Supergroup Amplifier

The basic supergroups 312–552 kc/s are amplified 15.5 db in the sending direction and 23.5 db in the receiving direction in the supergroup amplifier. This amplifier, which in principle is identical when used for sending and receiving sides, consists of a two stage wide-band amplifier with a large amount of negative feedback. As with all amplifiers which are to amplify a large number of channels, great care has been taken as regards the reliability of operation. Thus each of the two stages has two tubes connected in parallel. Due to the large amount of negative feedback the gain does not change if any of the tubes fails in the two stages, and exchange of tubes can be made without interrupting operation. The gain can be varied ± 4.3 db from the nominal gain in steps of approx. 1 db by means of a pad at the amplifier input.

When supergroup regulation is provided, the receiving amplifier has a thermistor in the feedback loop; see later in this article under the section on supervision. In addition, the receiving amplifier, unlike the sending amplifier, has a low-pass filter at the input to attenuate the carrier leaks in the upper supergroups nos. 6–16, where the Cowan modulator previously mentioned is used.

Sending Amplifier 60–4028 kc/s

The coaxial line group frequency band 60–4028 kc/s formed on the sending side is amplified 29.5 db in a straight amplifier, which is identical with that used in the h.f. line equipment. This amplifier has already been described in Ericsson Review No. 3, 1957.

The equipment for supergroup modulation is mounted in two bays designated Supergroup Translating Bays which can be provided either with sending and receiving equipment in separate bays capable of being built out from one to sixteen supergroups, or with sending and receiving equipment in the same bay capable of being built out from one to eight supergroups, i.e. from supergroups nos. 1–8 or nos. 9–16 respectively. Fig. 15 shows two supergroup translating bays equipped with sixteen supergroups, sending and sixteen supergroups, receiving respectively.

Through Connexion

Terminal stations in their purest form i.e. stations where termination of all traffic is made down to channel, occur rarely or never. It is most usual for terminal stations to contain some equipment for through connexion of one of the basic groups or basic supergroups in the frequency range 60–108 kc/s and 312–552 kc/s respectively. This was mentioned in the introductory article in Ericsson Review No. 2, 1957. In the present article, only L M Ericsson's equipment for through connexion of basic supergroups 312–552 kc/s will be dealt with. By through connexion of supergroups is meant that a number of basic supergroups with a frequency range of 312–552 kc/s are

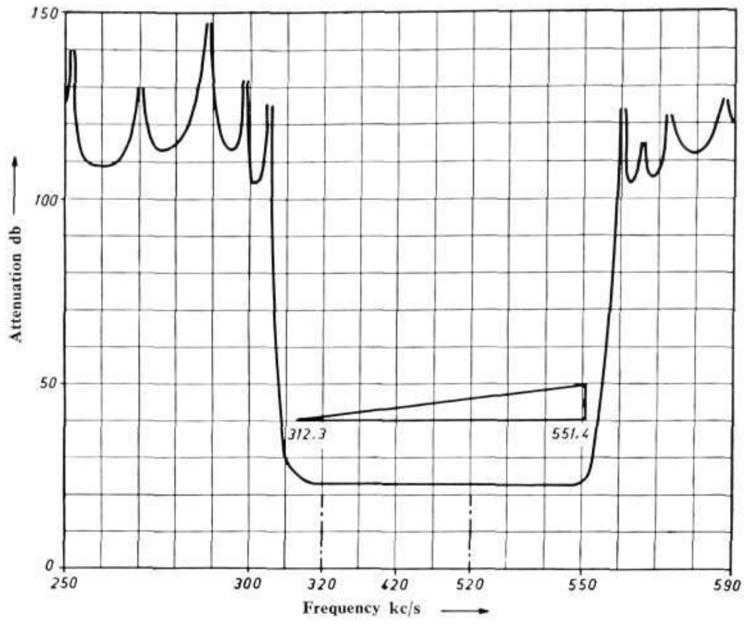


Fig. 16 X 8115

Through supergroup 312—552 kc/s filter characteristic

connected through to another h.f. line. This means that the two supergroup translating stages for two systems are connected together on the receiving and sending side. Owing to the crosstalk requirements these cannot be connected directly and the supergroups must first pass a through connexion filter with a pass band of 312–552 kc/s. The filters which select the sixteen supergroups in the line frequency range 60–4028 kc/s also pass a part of the adjacent supergroups. After demodulation these "remnants" which lie on either side of the 312–552 kc/s supergroup are obtained. When the supergroup is terminated or passes on the group translating bay, these remnants do not produce any effect as they are attenuated without difficulty in the filters in the group translating bay. However, when the supergroup is to be sent back for remodulation to another h.f. line, these remnants cause crosstalk between supergroups, and it is necessary to use a through connexion filter which suppresses such interference frequencies. As regards intelligible crosstalk with through supergroup connexion, CCITT recommend that the intelligible and unintelligible crosstalk shall be attenuated more than 70 db in the through supergroup filter. The attenuation-frequency characteristic of L M Ericsson's through supergroup filter is shown in fig. 16.

In addition, CCITT recommend that the demodulated line pilots e.g. the 2792 kc/s line pilot, which comes into supergroups nos. 11 and 12 as 308 kc/s and 556 kc/s respectively shall be attenuated by not less than 40 db when through connected. In designing L M Ericsson's through supergroup filter, it was found suitable from an economic point of view to divide this stop attenuation between the through supergroup filter and the supergroup translating equipment. Thus a 308 kc/s stop filter was placed in the supergroup no. 11 receiving path and a 556 kc/s stop filter was placed in the supergroup no. 12 receiving path. These filters together with the through supergroup filter provide a total stop attenuation of not less than 40 db.

The difference between the receiving and sending levels on the supergroup side of the supergroup translating bay is 23 db, which corresponds to the loss within the pass band of the through supergroup filter for the 412 kc/s reference frequency.

The same supergroup can be through connected several times and it is therefore clear that close tolerances must be held on the pass band of the through supergroup filter so that too large variations in attenuation over the supergroup band are not obtained. In L M Ericsson's through supergroup filter the variations of attenuation within the pass band are within ± 0.35 db relative to the attenuation at the 412 kc/s reference frequency. When a supergroup is through connected, its position is often changed in the 60–4028 kc/s line group band when going out to the new h.f. line. The supergroups numbered 1–16 thus change their position number when through connected. This is done in view of crosstalk and also that the signal-to-noise ratio shall be the same as far as possible for each supergroup.

As transmission takes place in two directions, A–B and B–A, two through supergroup filters are required per supergroup. Each through supergroup filter is mounted on a panel. This panel is mounted in a separate bay, designated Through Supergroup Filter Bay. The bay has a capacity of thirty-two through supergroup filters i.e. filters for through connexion of sixteen supergroups.

Signalling Equipment

Three variants of the VF Bay have been designed, to cater for the following types of signalling:

1-VF in-band signalling
2-VF in-band signalling
Low level out-band signalling

1-VF in-band signalling

Signalling is normally made using a frequency of 2400 c/s and a level of –6 dbm0. The v.f. signalling receiver is in general designed in accordance with the recommendations of CCITT.

The VF Bay for 1-VF in-band signalling is provided with equipment for sending and receiving the signalling and also terminating sets. Signalling from the exchange can be made with a ringing voltage or d.c. on separate signalling wires.

2-VF in-band signalling

Signalling is made using frequencies of 2040 and 2400 c/s at a level of –9 dbm0. The v.f. signalling receivers are designed completely in accordance with the recommendations of CCITT.

The VF Bay for 2-VF signalling is provided with equipment for receiving signalling. The bay is terminated four-wire on the voice frequency side. A separate hybrid bay can be used when terminating sets are required.

Low-level out-band signalling

Signalling is made using a frequency of 3825 c/s at a level of –18 dbm0.

The VF Bay for out-band signalling is provided with equipment for sending and receiving the signalling and also with band-stop filters to prevent interference in the signalling channel and in the speech channel. Signalling is carried out using static relays.

The signalling in the sub-group frequency range is injected between the stop filters and the sub-group modulators. On the receiving side, the signalling in the corresponding frequency range passes to the signalling receivers. The channel amplifiers are used for amplification of the signalling in the sub-group frequency range. D.C. impulse signalling is used from the exchange side.

With low-level out-band signalling it is possible to use either continuous or discontinuous systems of signalling.

Supervision

Like the h.f. line equipment, the terminal equipment is checked and supervised with the help of different pilot frequencies. In L M Ericsson's coaxial system the group reference pilot frequency 84.08 kc/s is used for checking groups and the supergroup reference pilot frequency 411.92 kc/s is used for checking supergroups.

Fig. 17 X 2361

Selective measuring set for checking of group pilots and supergroup pilots

Group Checking

The 84.08 kc/s pilot can be obtained either stabilized or unstabilized from the oscillator equipment. It is injected at a high impedance and in parallel to five groups per bay. The pilot injection unit is provided with a switch for manually switching in and out the pilot to the five groups. The nominal pilot level is −20 dbm0 and adjustment of the pilot level to this value can be made by means of potentiometers in the pilot injection unit. The groups are not supervised continuously, but level checking is carried out manually at fixed intervals of time, usually about once a month. Measurement in this case is carried out at a high impedance and in parallel while the carrier system is in service with a special measuring set consisting of two portable units, see fig. 17. With this measuring set it is possible to measure the level of 84.08 kc/s group reference pilot in the basic group frequency range 60–108 kc/s and in any of the five positions in the basic supergroup frequency range while the system is in service. The level of the 411.92 kc/s supergroup reference pilot can also be measured on the same measuring set and this is carried out in a similar way as for the 84.08 kc/s pilot in the basic frequency range and also after modulation. One of the portable units contains the indicating meter. When measuring the 84.08 kc/s pilot in its basic group frequency range, only this unit is required. The other unit contains a modulator, amplifier and a mains supply unit. The meter shows zero deflexion for the correct pilot level. Adjustment of the level to the correct value to an accuracy of ± 0.5 db is made where necessary by means of the switch at the input of the group or supergroup, sending or receiving amplifier in question.

Supergroup Checking

As mentioned previously, the 411.92 kc/s supergroup reference pilot is used for checking or supervision of supergroups. This is injected at the input to the supergroup sending amplifiers as shown in the block schematic, fig. 13. Injection of the pilot is made at a high impedance and at a level of −20 dbm0. The unstabilized pilot is obtained as two supplies (regular and stand-by) from the oscillator equipment. These two supplies are individually stabilized in pilot amplifiers mounted in the supergroup translating bay, sending, which contains equipment for supergroup translation. The outputs of the pilot amplifiers are connected to a level testing unit which tests the level of the pilot supply which is in service, i.e. normally the regular supply. If there is a deviation in level of more than 0.9 db from nominal the stand-by supply is connected in automatically and an alarm is given.

Manual testing and regulation of the levels of the supergroups at the sending and receiving stations can be made in a similar manner to that given above for the groups and the same measuring set is used for this purpose.

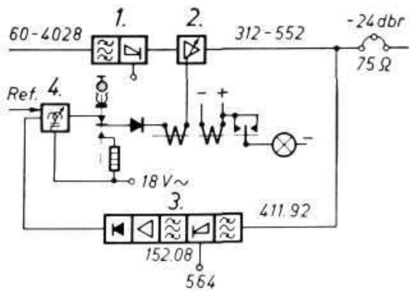


Fig. 18 X 2356

Supergroup regulation

1. Supergroup filter and modulator
2. Supergroup amplifier, receiving
3. 411.92 kc/s pilot receiver
4. Transductor

The larger the number of groups of channels, the more important is the supervision, and as regards supergroups and their modulation equipment it has been found suitable to supervise these continuously and to have automatic level regulation. This applies especially when there is through connexion of supergroups. L M Ericsson's supergroup translating bay, receiving, can be provided with this facility and a block schematic of the supergroup regulation is shown in fig. 18. The 411.92 kc/s pilot receiver is connected at a high impedance in parallel with the output of the receiving amplifier. Demodulation of the 411.92 kc/s is made after the band-pass filter to 152.08 kc/s and this frequency is selected. A current which is proportional to the pilot level is obtained at the output of the pilot receiver after amplification and rectification. This current is fed to a transductor or magnetic amplifier. This also contains a neon stabilizer tube for stabilizing the reference voltage which provides the reference current through one of the transductor windings. The pilot current is compared with the reference current. The difference between them is amplified in the transductor and applied to the supergroup regulation amplifier as a regulating current via a balanced relay for level alarm. The supergroup amplifier has a thermistor in the feedback circuit and the regulating current flows through its heater winding and thereby indirectly regulates the gain. The working winding of the thermistor is connected in the feedback lead in series with a resistor and is also shunted by another resistor. In this way the regulation of amplification is limited to ± 8 db. If a fault should occur in the pilot receiver or in the transductor, or if the pilot should be disconnected, a stand-by regulating current can be switched in, the value of which corresponds to the regulating current at the nominal pilot level.

The pilot current, reference current and regulating current can all be measured on a meter in a separate panel in the bay.

The supergroup regulating equipment holds the output level after the receiving amplifier constant to within ± 0.5 db with variations of input level within ± 5 db.

Alarm is sent out by means of a level alarm relay if the output level deviates from nominal by more than 1.0 db.

Tube Checking Equipment

All tube currents can be checked manually on a meter mounted in a centrally located current distribution panel. To improve the supervision of tubes in the group and supergroup amplifiers, the terminal bay where the tubes are situated can be provided with a tube failure alarm equipment for continuous supervision of each tube.

The tubes in the amplifiers mentioned above are checked on the cathode side and an alarm is sent out if the current in any tube falls by more than 40 % from a given reference value. Checking of the tubes in the 60–4028 kc/s sending amplifiers in the supergroup translating bay is made on the anode side. In this case an alarm is obtained if the anode current in the tube falls or rises by more than 25 % from the reference value. Localization of a faulty tube is carried out manually, first by group localization and then with the help of the meter in the current distribution panel mentioned above.

In brief, the principle of the tube alarm equipment is that the anode or cathode current which is to be checked causes a voltage drop across a resistor in the amplifier. To this resistor is added a rectifier device which is so designed that an abnormally large change of voltage across the resistor causes a large reduction of the a.c. impedance between two points in the rectifying device. These two points for all tubes are connected in parallel to an impedance sensitive device. This consists of a two stage feedback amplifier which self-oscillates at a frequency of about 4 kc/s as long as the impedance mentioned previously remains high. The device is loaded with a relay, which on tube failure causing the self-oscillations to cease, sends out an alarm.

The tube alarm equipment consists of a panel in which the rectifying device is mounted, and a small unit for the impedance sensitive device.

Printed Circuits — A New Production Technique

G NEOVIUS, TELEFONAKTIEBOLAGET LM ERICSSON, STOCKHOLM

U.D.C. 621.395.3—217
621.3.049.7
621.395.6—217

The new printed circuits ROA 211–214 described in this article have been designed for electronic apparatus used in telephone exchange relay sets. The base board with its components plugs into a new type of connector block mounted on the relay set. Printed circuits eliminate the need for many of the various fittings previously used for small components.

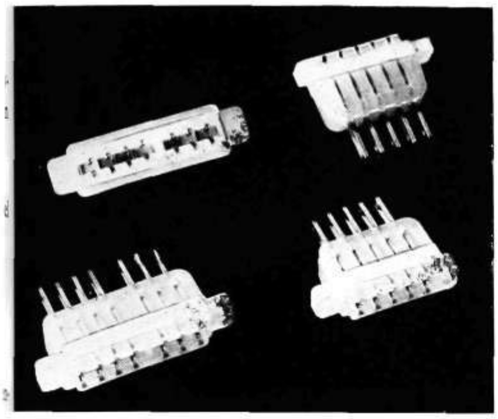


Fig. 1 X 2375

Forked contact connector blocks RNV 21202 and RNV 21201 for 7 and 5 terminals respectively

Radio and transmission equipment has undergone a major evolution in recent years. Electron tubes are being increasingly replaced by transistors, printed wiring has introduced a new circuit technique, and many components have been redesigned to fit into the new environment.

Developments in transistor and miniature component design are leading to an increased use of electronics in the engineering of telephone exchanges. Previously electronic equipment had to be placed in separate racks containing the power supply units and other arrangements necessary for the electron tubes. Now the electronic circuits can be incorporated in the relay sets with which they are associated functionally, and can be supplied from the normal exchange battery. The electronic equipment in telephone exchanges – oscillators, amplifiers, v.f. signal receivers, etc. – can be conveniently made up from the same components as have been developed for the corresponding transmission equipment. The commonly employed method of assembling these equipments is the use of printed circuits, which offer great advantages, especially from the production aspect. Wiring faults are eliminated, testing is simplified, and production costs are reduced, especially on long runs when the process can be mechanized.

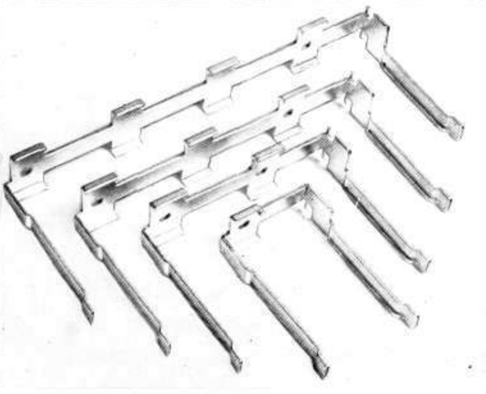


Fig. 2 X 2376

Brackets 625957-60

In our most usual types of relay sets, BCD, BCG and BCH, the relays are horizontally mounted with a horizontal spacing of 53.5 mm and vertical spacing of at least 32 mm. The depth of the set under the cover is about 100 mm. The most suitable dimensions for the printed circuit boards were therefore one, two, three or four times 53.5 mm in width, and 98 mm in depth. The component height above the board has been made equal to the standard height for transmission equipment, 23.5 mm. Etched boards of these types, i.e. excluding components, have been coded *TVA 211–214* according to their size.

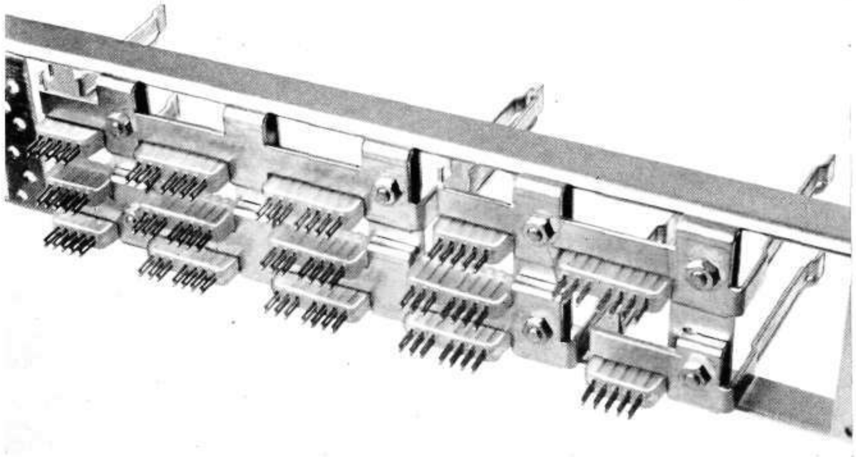


Fig. 3 X 8125

Relay strip with connectors and brackets fitted

At bottom left are seen connectors for a two-tier printed circuit

Fig. 4 X 2377

Flat terminal 716011 (top) and forked contact 625911

One of the design requirements was that printed boards and relays should be placeable in any position in the relay set. It was therefore necessary to retain the previous shape of the relay strip, as determined by the arrangements for attaching the relays, and the connectors and their fittings were designed accordingly. Thus one of the end connectors had to be made shorter than the others so as not to encroach on the space taken up by the coil of the adjacent relay. The forked pins of this connector mate with the five flat terminals projecting from the printed board. The other connectors – on boards which take up more than one relay position – mate with groups of 7 terminals on lugs along the remainder of the board. The two sizes of connector are shown in fig. 1.

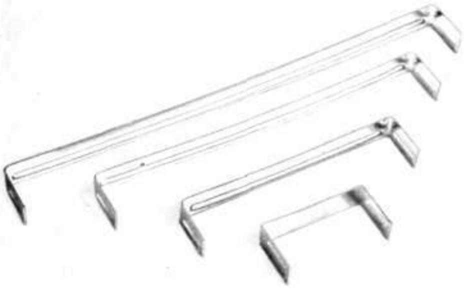


Fig. 5 X 2378

Frames 625961/1—3 and the smallest 625962

The connectors are attached to the relay strip by a bracket (fig. 2). The bracket at the same time guides the printed board into position and reinforces its sides. The fixing screws, one for a single-position board and two for other boards, are first secured to the strip with a nut which serves as spacer between strip and bracket. A second nut on each screw locks the bracket to the strip. When the bracket is screwed to the strip, it is at the same time moved to the left so that the 5-pin connector is locked between the bracket and strip. The other connectors are held in position between the bracket and strip, but have a certain lateral play. When the printed board is plugged into the relay strip, the right-hand group of terminals is guided into the 5-pin connector. Partitions in the 7-pin connectors fit into cut-outs in the corresponding lugs on the printed board so that the connectors are forced into their correct lateral positions. These mechanical arrangements preclude the necessity for narrow manufacturing tolerances for relay strips, connectors and wiring boards. The method of securing the connectors to the strip is shown in fig. 3. The connector blocks are injection mouldings of nylon 6–10 (Ultramid 5).

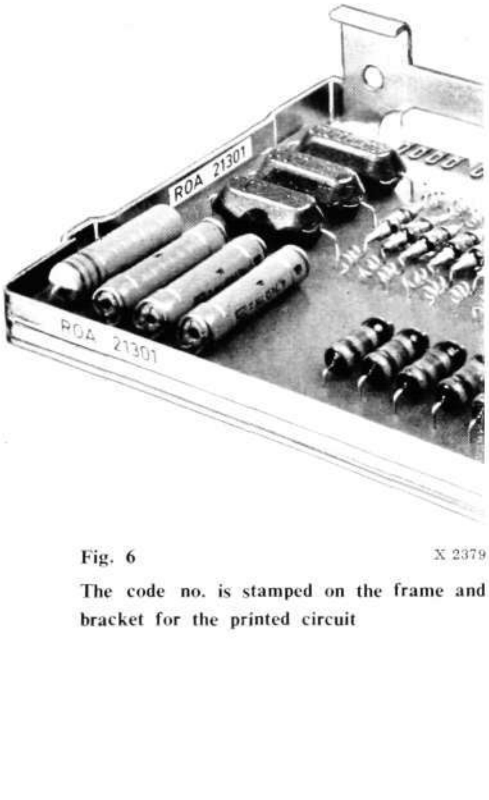


Fig. 6 X 2379

The code no. is stamped on the frame and bracket for the printed circuit

The connector blocks have two forked contacts mating with each terminal. This arrangement provides four separate points of contact with every flat terminal. The forked contacts and flat terminals are shown in fig. 4. The forked contacts are made of tin bronze and the flat terminals of brass, both being silver-plated and then gold-plated to 2–3 μ. They are designed for a high standard of contact performance even at very low signal voltages.

The front edge of the printed board is reinforced by a frame which is prestressed in manufacture so that it can be snapped into recesses in the side of the board. The various frames are illustrated in fig. 5. The frame also serves as a hand grip. The code no. of the printed circuit (i.e. including components) is stamped on the frame, while the code no. of the board forms part of the etched pattern. To prevent confusion, the printed circuit no. is also stamped on the left-hand shank of the bracket, as shown in fig. 6.

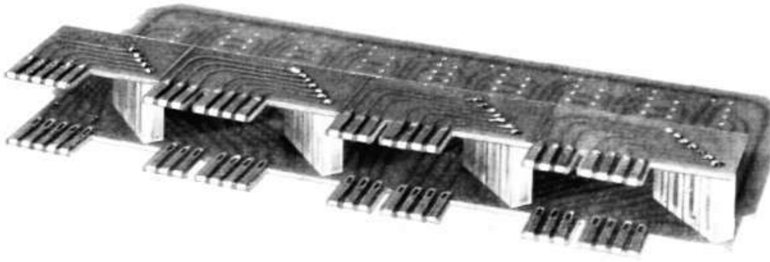


Fig. 7 X 8126

Printed wiring board in two tiers

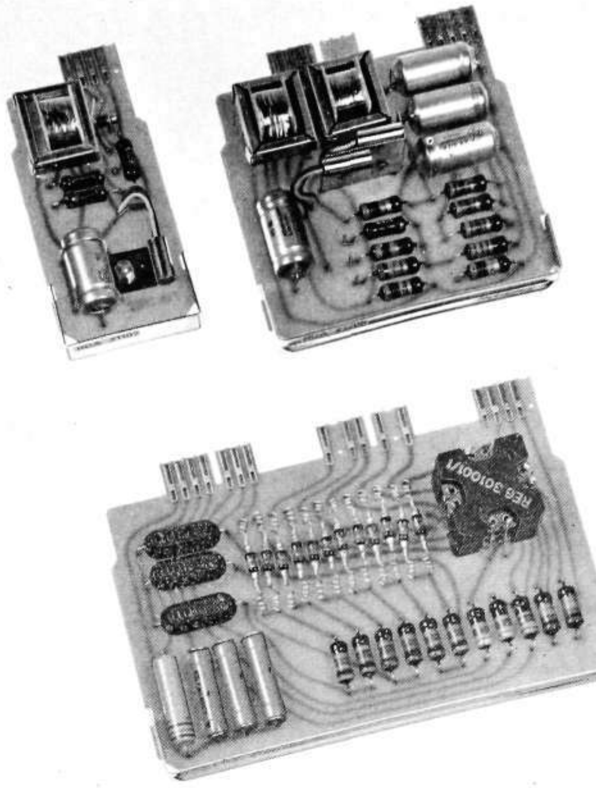


Fig. 8 X 8127

Three models of printed circuits

(Top left) ROA 21102, oscillator for 1000 c/s; (right) ROA 21205, operator's listening amplifier for Gothenburg transit exchange; (bottom) ROA 21301, static relay for Copenhagen trunk exchange, international section.

The maximum number of contacts per single-position board is 5, 12, 19 and 26. In some applications these numbers have been found to be too small. In the case of the three larger boards the number of contact points can be doubled by adding an upper tier as in fig. 7. Between the two boards are spacers with slots for running the conductors from the upper tier to the lower. The conductors are bent around and soldered to the etched wiring and in this way hold together the two boards. The brackets are shaped so as to carry the connectors on the upper tier as well, as seen in fig. 3.

Fig. 8 shows three printed circuits in current use.

Multi-Line Telephone for Enquiry Services and Booking Offices

A DAHLGREN, TELEFONAKTIEBOLAGET LM ERICSSON STOCKHOLM

UDC 621.395.26

Telefonaktiebolaget L M Ericsson has designed a multi-line telephone, that is a telephone with several multipled lines, for offices catering mainly for incoming traffic. The kinds of organization for which this telephone is specially suited are information services of different kinds, travel bureaux, booking offices etc.

The multi-line telephone is intended for use in place of normal telephone instruments at offices where several persons jointly serve an incoming group of telephone lines, as at booking offices or information services of different kinds. The difference between a multi-line instrument and an ordinary telephone is that the former, in addition to having an individual line to the exchange, can serve twelve incoming lines which are multipled over several or all of the office instruments, and that it is supplied with a headset instead of handset.

The multipling of the incoming lines enables a call to be answered by the first free operator. Thus in offices equipped with multi-line telephones the work is evenly divided among all members of the staff, which leads to efficient utilization of lines and other equipment, and to good service in that the delay in attending to callers is reduced to a minimum.

The use of a headset in place of a handset means that the operators have both hands free to make notes, search through card indexes, etc., which again improves their efficiency and ensures quicker service.

The multi-line telephone offers other advantages as well. It may be equipped, for example, for transfer of an incoming call from the station at which it is answered to a master station, or for holding the call while enquiring for information from the chief of the group. An instance of this use is when one person is in charge of special business, or for directing special enquiries to the head of the office.

A complete multi-line telephone system consists simply of the multi-line telephones themselves, rack-mounted relay sets for the incoming lines, and a power plant. The system operates on 24 V.

Fig. 1 X 2371

Multi-line telephone AEA 1121 with headset

Constructional Features

In addition to a dial and other normal components of a telephone instrument, the multi-line telephone *AEA 1121* contains seven lever keys, fourteen lamps and a test relay.

The case is of green-enamelled aluminium. For ease of maintenance and inspection, all the components except the dial and headset jack have been mounted on a chassis which can be removed from the case, so that all parts

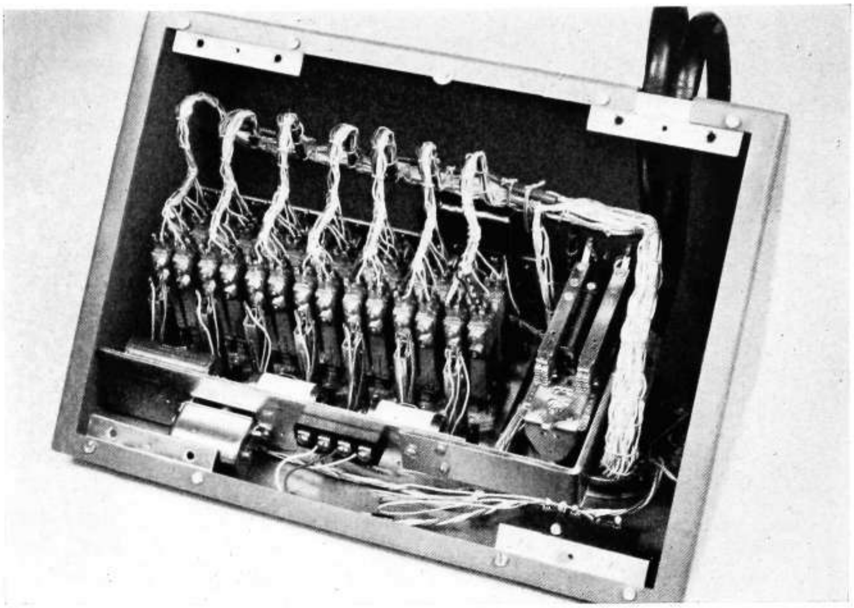


Fig. 2 X 8123

Multi-line telephone with base plate removed

are easily accessible. The leads from the multi-line telephone terminate on two 40-point plugs.

The seven keys have the following functions:

The key at the left (adjoining the dial) is used in its upper position as answering key for the individual line, and in its lower position as transfer key. The lamp above this key is a pilot lamp which lights when the test relay operates to a call on an incoming line. The lower lamp is a busy lamp for the transfer position of the key. It lights at all stations when any of the telephonists attempts to transfer a call to the master set when the latter is engaged.

The other six keys are answering keys for the multipled lines, and the lamps above and below them are the line calling lamps.

Should it be necessary to connect more than twelve lines to one position, the capacity of the multi-line telephone can be increased by means of an extension unit, *AEA 1122*, with connection facilites for fourteen lines. The extension unit can only be used in conjunction with a multi-line telephone, since its sole equipment consists of answering keys and calling lamps for multipled lines.

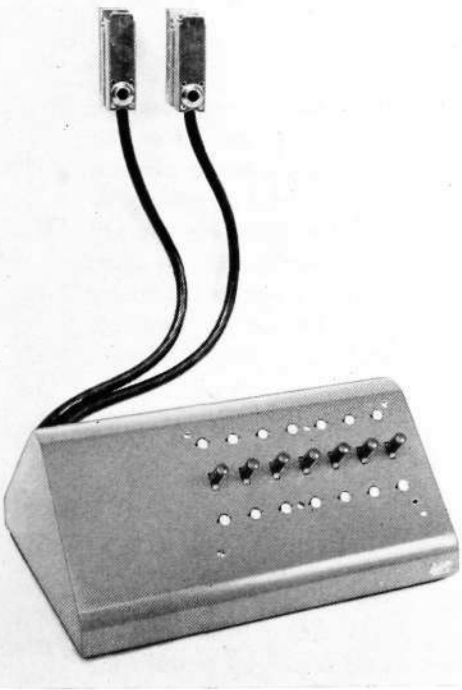


Fig. 3 X 2372

Extension unit AEA 1122

Relay Sets for the Multipled Lines

The multi-line telephone can be connected to any type of public exchange system, whether automatic or manual, C.B. or magneto, since it is called by a normal ringing signal.

The relay sets for the connected lines are of different types according to the type of line and to whether transfer facility is required or not.

The following relay sets are used for the multipled lines:

BCB 1634 containing equipment for two C.B. lines (automatic or manual) *without* transfer facility.

Fig. 4 X 2373

Line relay set rack

BCB 1635 containing equipment for one magneto line *without* transfer facility. When these relay sets are used, a ringing current generator such as a pole changer is also required for the clearing signal to the magneto exchange.

BCB 1637 will be required for each line in addition to the magnets relay set. *with* transfer facility.

If transfer facilities are required for magneto lines, one C.B. relay set *BCB 1637* will be required for each line in addition to the magneto relay set.

Ordinary telephone instruments can also be connected to the multi-line telephone. For connection of a magneto telephone the aforementioned magneto relay set is used unmodified, since calls from magneto telephones are made by ringing signals. For C.B. telephones there is a special relay set, *BCB 1652*, containing equipment for one line with transfer facility. The design of the relay set is such that the calling lamp on the multi-line telephone lights as soon as the handset of the C.B. instrument is raised.

All relay sets can be mounted on wall rack *BDE 80X01,* which accommodates seven relay sets. One position on the rack is taken up by a fuse relay set containing fuses and other common equipment for the other relay sets.

Operation of Multi-Line Telephone

An incoming call is signalled by the lighting of the calling line lamp at all stations to which the line is multipled. The call is answered by the first free operator throwing the line answering key towards the calling lamp. To avoid connection of a line to several stations simultaneously, should more than one telephonist attempt to answer the call, connection is not established until the test relay of the answering station has operated. At this station a red pilot lamp now lights, at the same time as the calling lamps of that line darken at all stations, and a speaking circuit is established between the answering operator and the calling subscriber.

If a call has been answered at a station equipped with transfer facility, and the operator finds that it should be transferred to the master set or that she must make an enquiry, she depresses the transfer key on her instrument. The line calling lamp on the master set then lights and flashes to distinguish transfer calls from ordinary calls. After depression of the line answering key on the master set the two stations are in connection, whereas the incoming line is placed on a holding circuit. If the call is to be taken over at the master set, the keys on the instrument which first answered the call are restored, and a speaking circuit is now established between the master set and the caller.

In the case of a simple enquiry to the master set without transfer of the call, the line is reconnected to the original station when the transfer key at the station is restored.

An incoming call on the individual line is signalled by the sounding of a buzzer and is answered by throwing the line answering key. If an outgoing call is to be made on that line, the answering key is first thrown, whereby the speaking equipment is connected to the line in the same way as when the handset of an ordinary telephone is raised. The call is then completed in the normal manner, depending on the type of exchange to which the line is connected.

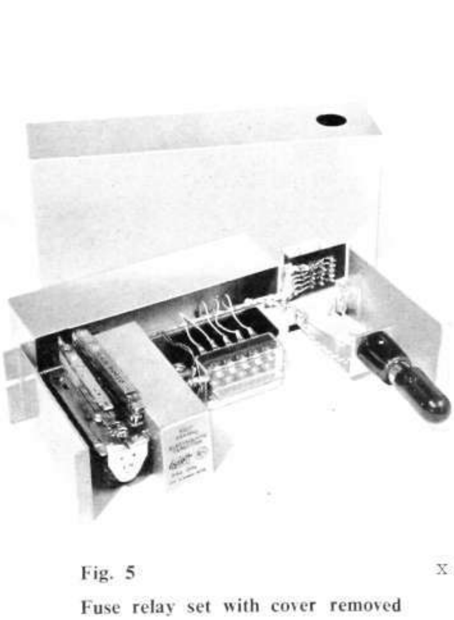


Fig. 5 X 2374

Fuse relay set with cover removed

Fig. 6 X 8124

The multi-line telephone installation at the SAS (Scandinavian Airlines System) booking office in Stockholm

Layout of Multi-Line Telephone System

A multi-line telephone system can be made up in many different ways according to specific requirements, number of instruments etc., so that only a few general hints can be given in the present context.

One of the questions to be decided when planning a multi-line telephone system is the number of operators' positions required. If traffic statistics are available, the calculation can be based upon them, but this is not usually the case. On the other hand, the required number of lines is usually known, and as a general rule it will be sufficient to install one or two operators' positions less than the number of lines in view of the multipling arrangements.

An installation scheme for a multi-line telephone system on separate desks is shown in fig. 7. In this proposal the cabling is drawn under the desks and a hole is made in the desk for the connecting leads. If the instruments are to be placed on a table along a wall, the cables can be attached to the wall and the connecting leads brought over the edge of the table instead of through a hole.

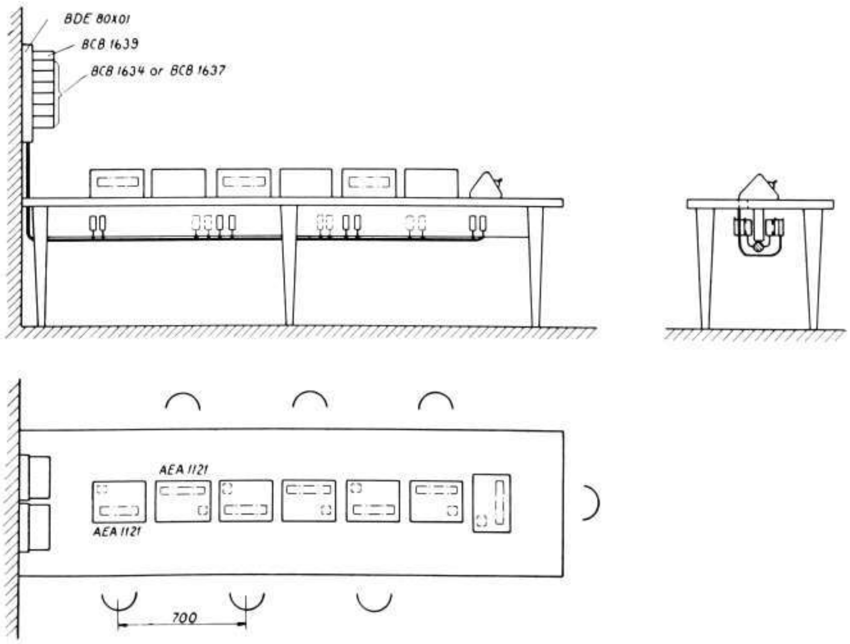


Fig. 7 X 8122

Installation scheme for a multi-line telephone system

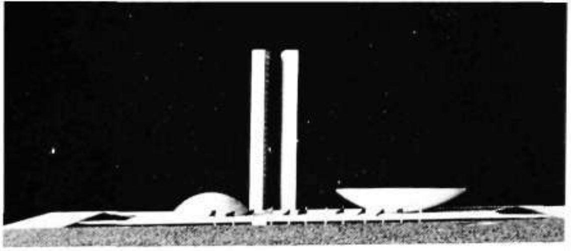
If a system comprises less than twelve lines, the lines can be multipled over all stations. If there are more than twelve lines, the system can be divided into groups, each for a maximum of twelve lines, the lines being graded between the groups. If the traffic is required to be concentrated to a few positions during slack periods, certain positions can be equipped with extension units so as to have access to all lines.

If master sets are to be installed in a system which is divided into groups, it is possible to have one master set per group or a master set common to the entire system. With one master set per group, the master set can receive enquiries and transferred calls only within that group. A common master set, on the other hand, can receive enquiries and transferred calls from all groups.

Power Plant

As already mentioned, the multi-line telephone operates on 24 V and functions satisfactorily between 22 an 28 V. According to the reliability of the mains supply, the power equipment may consist either of a battery eliminator or of a battery with charging unit. The current consumption varies both with the number of multi-line telephones in the system and with the number of connected lines, so that it is impossible to give exact figures, but it is generally calculated that about 2 A suffices for a plant containing up to eight stations and about 4 A for up to fifteen stations.

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



Model of the Brasilia administrative centre.

L M Ericsson Delivers Telephone Equipment for Brazil's New Capital

L M Ericsson will be contributing to one of the most daring town planning projects of all times. This is Operation Brasilia, which will give Brazil a brand new capital in the centre of that vast country. L M Ericsson has received an initial order for telephone exchange equipment, telephone instruments and line plant for the new city to a value of nearly 10 million kronor. The installations are to be completed by January 31, 1960. Telephone requirements in the new city are expected to increase very rapidly.

The idea of a new capital for Brazil is not new. It is set forth in the Brazilian constitution, drawn up over 70 years ago when Brazil became a republic. Brasilia, the building of which started last year, will be situated on the Central Plateau in the State of Goiás, 600 miles from the beautiful, but overpopulated, present capital of Rio de Janeiro.

Even if the idea of Brasilia is not a new one, everything in the city will be entirely new and different from anything yet conceived by town planners. The winner of the architectural competition for the new project was the Brazilian architect Lucio Costa, and, viewed from above, his city looks like a modern streamlined jet plane. And the city is being built at jet speed. Speed is essential: by 1980 Brazil's present population of 60 million is expected to have grown to 100 million.

The Government Buildings, Supreme Court and the Congress Building will form an administrative centre in the heart of the city. The President's Palace, designed by the famous Brazilian architect Oscar Niemeyer, was the first building to be completed. It is hoped that the transfer of the country's administration inland from Rio will lead to an increased understanding of the potentialities existing in the enormous natural resources of the Brazilian continent. The new capital will form a centre for putting these great resources to profitable use, and the government will there be in more intimate contact with the problems involved and be working in the healthier atmosphere of the highland climate.

Brasilia will have a beautiful situation. And every effort is being made to beautify the city, too, by the creation of parks and green spaces. An artificial lake, 15 sq.miles in area, will be an added attraction, while fulfilling a practical aim at the same time: the outflow will drive the generators of the city's power station.

The residential buildings will consist mainly of blocks of flats in a setting of green belts. Some areas will have groups of small houses. The shops will be set in ranks, with covered walks facing the pedestrian approaches. In addition to the green belts around the residential areas, the city will have large green spaces with zoological gardens and sports grounds. Communications will be helped by advanced forms of traffic systems, but the division between pedestrian and vehicle traffic systems will not be carried to extremes.

The telephone installations are to be built by L M Ericsson, comprising in the first stage a telephone exchange for 5000 lines working on the ultra-modern crossbar system, and 8 smaller exchanges working on the same system. L M Ericsson's Brazilian affiliates, Ericsson do Brasil, with a factory at São José dos Campos in the State of São Paulo, is to build the exchanges, supply the telephone instruments and construct the line plant. A number of Brazilian orders have recently been placed with L M Ericsson –in 1958 contracts were signed for telephone exchanges aggregating over 60,000 lines.

The main street of the rapidly growing capital will be 200 yds. wide.

(Right). Dr. Israel Pinheiro, chairman of NOVACAP, the economic association responsible for the building of the city, signing the contract with L M Ericsson. From left to right: Messrs. W. Kantif and S. O. Englund (president) of Ericsson do Brasil, Dr. Pinheiro, Dr. José Paulo Vianna, NOVACAP, and Mr. V. Muniz of Ericsson do Brasil.

The end of the cable is hauled ashore on the Swedish coast, floating on empty drums tied together in pairs.

New Cable Across the Sound Supplied and Laid by Sieverts Kabelverk

High tension cables have linked Hälsingborg in Sweden with Helsingör in Denmark since 1914. Two 50 kV solid type cables were installed in 1925 and 1929, and two 120 kV oil-filled cables in 1951 and 1954. All these cables are owned by I/S Kraftimport in Denmark. In order to step up the supplies of power from Sweden to Denmark, the Swedish State Power Board and the Sydkraft Company placed with Sieverts Kabelverk at the end of 1957 a joint order for a new oil-filled cable rated at 140 kV.

The laying of the cable, for which Sieverts Kabelverk was also responsible, was done with a floating drum. This procedure was adopted in the invasion of Normandy for the laying of PLUTO (Pipe Line Under The Ocean) across the English Channel, as also in Denmark for laying two oil-filled cables, and in Sweden for various pipe lines. The submarine cable was delivered to Hälsingborg from the Sundbyberg factory in eight lengths of about 750 yards each.

The entire cable route except a portion in the middle of the Sound, where the depth was greater than 80 ft., was examined by a frogman, who also televised the cable so that a surface crew could see that it lay properly on the sea-bottom.

The cable was dug down about 3 ft. at each coastline for protection especially against ice damage, and was also covered with bags of cement to a depth of at least 6 ft. on each side of the Sound.

Additions to Automatic Exchanges in Colombia

L M Ericsson recently signed two important contracts with Colombia. One is for the extension of the telephone exchanges in the capital of Bogotá by 14,000 lines, bringing the total capacity up to 100,000 lines. This contract is for 2.1 million dollars.

The other is for the extension of the telephone system in the port of Cartagena. The telephone exchanges are being equipped for an additional 1000 lines, the cable plant is being expanded, and new telephones delivered. This contract is for 660,000 dollars.

Following a lengthy stoppage of import licences for telephone equipment, the Colombian government has recently granted L M Ericsson licences to a value of 6 million dollars, which will permit the completion of a number of previously contracted installations.

The first L M Ericsson exchange in Colombia was opened at Ibagué in 1932 and served 1500 lines. Today there are twenty-six Ericsson exchanges with a total capacity of 165,000 lines. In 1957 alone equipment for 21,000 lines was installed in different parts of the country.

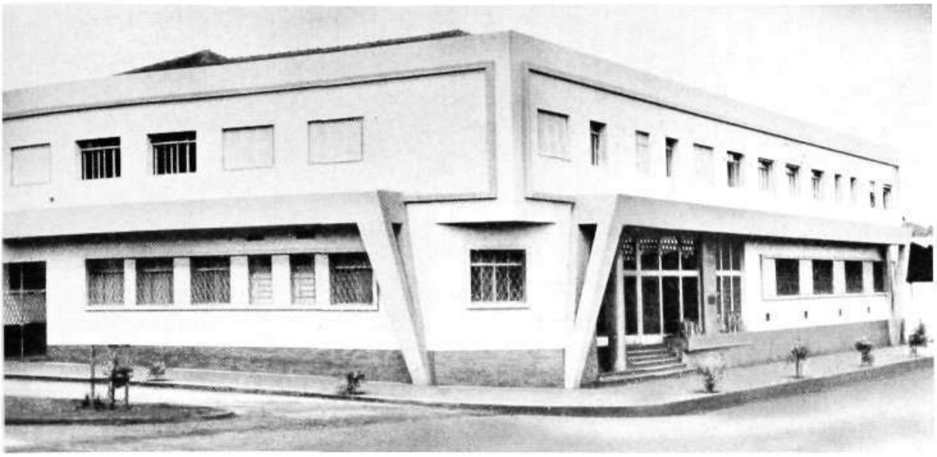
Ninety Finnish Exchanges to be Equipped with Crossbar

Ninety telephone exchanges in the Seinäjoki area are to be equipped with crossbar for later link-up with the all-automatic telephone network now being constructed in Finland.

The contract for these exchanges was signed in September when a Finnish delegation visited L M Ericsson in Stockholm.

In the course of the years L M Ericsson has supplied roughly half of the automatic exchange equipment in Finland, amounting to close on 200,000 lines.

The Finnish delegation consisted of Mr. Tiitu, director of Seinäjoki Telephone Company Heikell, and of Messrs. Reinola, Ollila, Taimisto, Huhtamäki, Väisälä and Loukola. L M Ericsson was represented by Mr. Ingmar Horelli, vice-president of O/Y L M Ericsson A/B.

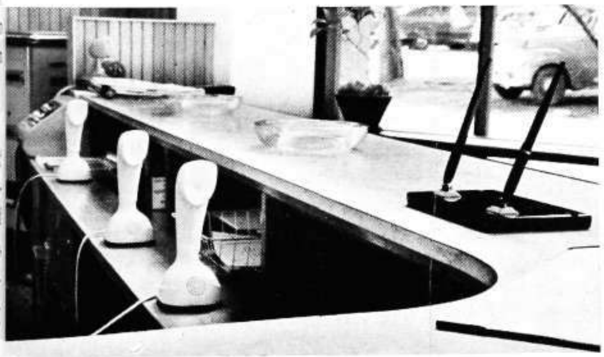


This fine building is the telephone exchange at Campo Grande in the State of Matto Grosso, Brazil. A three-coloured mosaic decorates the facade. The exchange is equipped with L M Ericsson's 500-line switches. Its ultimate capacity is 10,000 lines, of which 1,500 are so far in use.

The Kramer Tennis Circus has been in Stockholm and given a brilliant display. L M Ericsson felt that each player was well worth an Ericofon. The team are here seen inspecting their presents: from left Ken Rosewall of Australia, Pancho Segura from Ecuador, "King Pancho" Gonzales and Tony Trabert of USA.

At a recent exhibition of industrial products at Sacramento, California, Sweden was awarded no less than 12 gold medals out of 26 possible for outstanding design, functionality and practicability. Mr. Kenneth B. Fry, on the exhibition management, is seen presenting the gold medal awarded to L M Ericsson for the Ericofon. Mr. Erik Juréhn (right) of the Swedish Chamber of Commerce received the medal on L M Ericsson's behalf.

The telephone equipment for the new Jameson Hotel, the most modern in Salisbury, South Rhodesia, was supplied by L M Ericsson. It consists of a complete P.A.B.X. system type AHD 32. The hotel has 88 bedrooms, in each of which is an Ericofon. The total number of extensions, including service sets, is 110. The smooth functioning of the telephone plant has won great appreciation. The reception office (right) has three Ericofons. A call to the reception office goes to the first free instrument. If all three instruments are engaged, the call is transferred to the operator's set (in the background).



L M Ericsson, Midsommarkransen, was recently visited by Mr. O. Myers (left) of Bell's New York Laboratory and Mr. R. A. Fairbairn from Bell of Canada, Montreal.

In Memoriam

Camillo Protto
Hilding Ohlsson
Carl Ballhausen
Antoni Molmenti

The great expansion of Telefonaktiebolaget L M Ericsson on foreign markets from the 1920s onward brought into the company many men in responsible positions whose time is now passing.

During November and December the company lost in quick succession no less than four prominent members of its management. The obituaries on this page have been written by persons who not only had intimate contact with them at work but were bound to them by personal friendship.

Camillo Protto

On December 12, 1958, the Swedish Consul General, Camillo Protto, president of the Italian companies of the Ericsson Group, died in Milan. His loss will be greatly felt.

Camillo Protto was one of the Italian businessmen and technicians who helped to secure the telephone operating rights for L M Ericsson in southern Italy at the beginning of 1925. He was born on August 20, 1886. After passing through a commercial college he was first engaged in the textile industry, in which he advanced to the post of president of a Financial Institute for the North Italian wool industry. His financial and administrative experience was drawn upon at an early stage in SET, FATME, and SIELTE, which in 1930 were grouped together under the holding company SETEMER. In 1939 Protto became president of SETEMER and of the three subsidiary companies, being chairman of the respective boards and in reality in charge of their current business. He proved to be a leader of great stature and won respect and admiration both inside and outside the companies under him. Especially during the war and the years immediately succeeding, his work for the SETEMER group produced outstanding results. Among his achievements during recent years we remember especially the hard but successful negotiations concerning the transfer of the SET telephone operating company to the Italian State.

In addition to his work in the SETEMER group Protto held other leading positions in large Italian industrial concerns and was honoured two years ago with the exceptional distinction of Cavaliere del Lavoro (Knight of Industry). For his loyal work on behalf of Swedish interests, and the good will he so often displayed for our country, he was appointed Swedish Consul in Milan 1937 and was given the title of Consul General in 1955.

Protto was not only an unusually able businessman and leader of industry; he was also a man of great and varied learning with a lively interest in many fields of culture. His intelligence and uprightness won him appreciation in wide circles, and his personal qualities and warmth of heart made him greatly loved by all who had close contact with him.

Holger Ohlin

Hilding Ohlsson

The news from Buenos Aires of the death of Hilding Ohlsson came as a shock to many of us. Hilding Ohlsson was appointed chairman of the board of Cía Sudamericana de Teléfonos in 1939. Despite his heavy engagements in numerous responsible posts, he bestowed much time and disinterested attention on the various problems of this company.

Hilding Ohlsson had settled in Argentine in the 1920s, and the main work of his life was therefore devoted to that country. Yet he never lost contact with his homeland, which he visited every year.

Hilding Ohlsson was a man of true quality, always ready to extend a helping hand to persons not so well circumstanced as himself. He won innumerable friends both in Argentine and Sweden, who have now lost an honest and loyal friend.

Sven T Åberg

Carl Ballhausen

On November 10, 1958, Carl Ballhausen died at the age of 65. The head of one of Copenhagen's most reputed firms of solicitors, he was a very prominent and respected jurist.

Carl Ballhausen was on the board of L M Ericsson's Danish subsidiary since its formation in the early thirties, for many years as chairman. He was also chairman of the board of another L M Ericsson company, Dansk Signalindustri, and vice-chairman of Telefonfabrik Automatic in which L M Ericsson holds shares.

He worked for these companies with skill and a constantly lively interest, and actively furthered the interests of L M Ericsson in Denmark in other ways as well.

We who were favoured to know Carl Ballhausen will remember him as an uncommonly wise and charming person and a good, cheerful and loyal friend.

Cornelius Berglund

Antoni Molmenti

The president of Compañía Argentina de Teléfonos, Antoni Molmenti, died in Buenos Aires on November 30.

When the Ericsson Group acquired the local telephone company at Tucumán in 1928, Molmenti, who was head of the company, entered the service of L M Ericsson. With his wide knowledge of public service and his excellent connections with the authorities, he quickly became an invaluable asset to the Group. In 1935 he was appointed head of the company's telephone operations in north Argentine, being later transferred to the central administration in Buenos Aires as president of Cía Argentina de Teléfonos, which post he retained until his death.

Molmenti had a great charm of manner and the ability to win the confidence alike of his staff and of trade unions and official bodies, and he was able to advance the company's interests in many ways. He leaves behind him a gap which it will be difficult to fill, and which will be felt both by his colleagues and by his numerous friends. A truly faithful servant has left us.

C E Lindeberg

Automatization of International Traffic Continues: now U.K.—Holland

A telephone exchange for semi-automatic two-way traffic between the U.K. and Holland was opened at Rotterdam on November 17. The automatic switching and operators' equipment was supplied by L M Ericsson. The next stage in the automatization of international trunking will be the full-automatic connection of The Hague, Amsterdam and Rotterdam with Belgium and part of Western Germany.

New *Ericsson Technics*

Ericsson Technics No. 2, 1958, which has just appeared, contains the papers presented by representatives of L M Ericsson at "The Second International Teletraffic Congress" at The Hague from 7th to 11th July. This well organized congress had gathered some one hundred delegates from thirty telephone administrations and companies of fifteen countries. Some thirty addresses were delivered.

The first article in this issue of Technics is the paper by H. Y. Kraepelien, "The Influence of Telephone Rates on Local Traffic". A theory is presented based on the economic principle of elastic demand, and an abundant material is tested by statistical methods.

The following article, by G. Leunbach, is entitled "Factors Influencing the Demand for Telephone Service".

In "Statistical Supervision of Telephone Plant" G. Lind discusses methods of arriving at a proper maintenance strategy and an economically justified level of fault incidence in telephone operation.

S. G. Carlsson and A. Elldin, in "Solving Equations of State in Telephone Traffic Theory with Digital Computers", describe a method of solving equations of state containing a large number of unknowns in the shortest possible time by the use of digital computers. This method extends the range of applications for equations of state.

G. Kjellberg's paper, "On the Convergence of Successive Over-Relaxation Applied to a Class of Linear Systems of Equations with Complex Eigen-Values", which was not presented at the congress, deals with the linear equations of state used in the previous article. Conditions for optimal convergence are formulated.

In the final article, "Artificial Traffic Trials on a Two-Stage Link System Using a Digital Computer", B. Wallström presents a further case in which digital computers can serve the needs of telephony. The author has developed a method of measuring artificial traffic through a two-stage link system. From the results obtained he illustrates certain fundamental properties of link systems and studies the accuracy of some different methods of computation.

L M Ericsson P.A.X. to ASEA, Västerås

L M Ericsson is to supply a large P.A.X. to ASEA, Västerås, Sweden. It will be of crossbar type for 3,500 lines with facilities for additional extension.

Internal calls at ASEA have been found to represent some four-fifths of all conversations, and they will now be handled through the P.A.X., leaving the old branch switchboard to deal with external calls.

With the installation of the new P.A.X., a number of "robot" functions (see article in Ericsson Review No. 3, 1958) will become available to the ASEA staff. Automatic call-back from an engaged extension, and automatic interception with redirection to another extension or to a telephone answering machine, are two particular finesses. The P.A.X. is to be equipped for centralized dictation (Ericsson Review No. 1, 1958), and it will be possible to operate an efficient night watchman control system in conjunction with the P.A.X.

Management Appointments at North Electric Co.

Mr. William Tucker, Chairman and Chief Executive Officer of North Electric Company, Galion, Ohio, reports the following changes in the management of the Company and states that the addition of these gentlemen to the top management team is another step toward strengthening the executive group.

Mr. Lloyd Bender – promoted to the position of Senior Vice President and will assume responsibility for certain general management functions. Initially, Mr. Bender will be responsible for Industrial Relations, Government Contract Administration, Research and Development, and Cost Reduction.

Mr. H C Ryon, Vice President, Telephone Division – Mr. Ryon resigned as Sales Promotion Manager of Automatic Electric, the main manufacturing subsidiary of General Telephone Company to head up the reorganized and expanded telephone division of North Electric. Mr. Ryon was formerly associated with North Electric from 1931 to 1952.

Mr. E W Gray – promoted to Administrative Officer and is responsible for many of the duties performed by H Y Kræpelien who resigned as President of the Company. Mr. Gray's record with the Company has been excellent in the many capacities he has been requested to fill, most recently as Manager, Telephone Division.

Rear Admiral Fritz Gleim, (USN Ret.), Assistant to the President – Admiral Gleim graduated from the United States Naval Academy at Annapolis and completed studies for his Master's Degree at the University of California, Berkeley. Admiral Gleim's long association with Naval Communications culminated in a tour of duty as Commanding Officer of the Naval Communications Station, Norfolk, Virginia and Fifth Naval District Communications Officer. He retired from the Navy as Chief of Staff of the Fifth Naval District and brings to North Electric a broad background of administrative and executive abilities in the Communications field.

Mr. Joseph F Dolland, Director of Manufacturing – Mr. Dolland is a graduate of Iowa State College with a Bachelor of Arts Degree in Mathematics and Science and later obtained a Bachelor's Degree in Industrial Engineering, Chicago Engineering College, followed by one year's graduate work in Industrial Management and Business Administration at the Harvard Graduate School of Business. For three years prior to joining North Electric, Mr. Dolland was Vice President of the O A Sutton Corporation, Wichita, Kansas, in charge of Manufacturing.

Mr. Ralph Nottingham, Director of Quality Control – Mr. Nottingham is a graduate of Wayne University, Detroit, Michigan where he earned both his Bachelor's and Master's Degrees. Additional work for his Ph. D. was continued at Columbia University. He brings to North Electric administrative and technical experience necessary for the critical nature of current production for missile projects as well as advanced and specialized communications and electronic systems development and production.

(Left) L M Ericsson has once again awarded gold medals to persons with long service in the company. The presentations this year were made by Eric Boheman, vice-chairman of the board of the company and former Swedish Ambassador in Washington. Here he is with two of the gold medallists, Marianne Ågren (left) and Gerda Stenström, the latter oldest in years of service among the women medallists.

(Below) "Sweden's best telephone operator" is the title given to Miss Ruth Elg, who has worked at L M Ericsson's switchboard since 1908. Her voice is well-known to LM customers all over the world. Due to leave the company in 1959, she was recently awarded the firm's distinguished silver medal and at the same time received a gift of shares in the company.

LM Ericsson Delivers Five Automatic Exchanges to Brazil

Five automatic exchanges serving a total of 7,600 lines, and associated cable plant and telephone instruments, have been delivered to the so-called ABC municipalities in Brazil. The ABC municipalities are three progressive and densely populated communities on the outskirts of São Paulo, with very considerable industrial development.

The new exchanges are of crossbar type, this being the first large scale installation of crossbar in South America. The equipment was supplied from L M Ericsson's Brazilian factory. Orders for extensions amounting to 2,000 lines have been received.

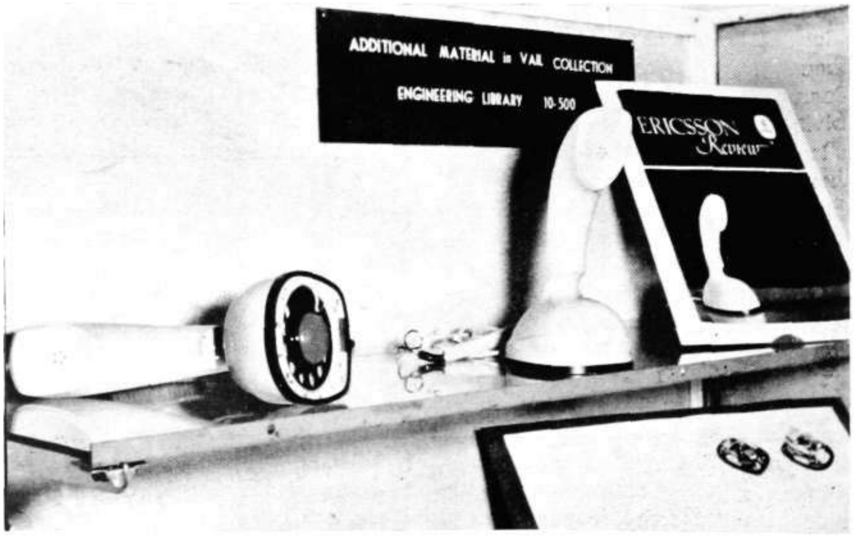
Ericofons for Increased Comfort of Patients

The Wesley Memorial Hospital of Chicago wishes its patients to have the greatest comfort. Each patient has been given a control panel from which windows can be opened and closed, the temperature can be regulated, lights switched on and off, a bell can be rung for the nurse, the bed can be raised and lowered, and the TV

switched on and off, and patients can converse without risk of spreading infection with visitors in the vestibule. To allow patients to telephone without having to sit up, they have been provided with Ericofons.

Massachusetts Institute of Technology Exhibits Ericofons

The Massachusetts Institute of Technology, Cambridge, Mass., is very delighted with its Ericofons. Professor Carlton E. Tucker of the Institute considered that pupils and visitors should also be given a glimpse of the instruments and arranged for them to be exhibited on the small stand to the right. Miss Pearl Lewis, librarian of the Institute, felt that Ericsson Review also deserved a place on the stand.



U.D.C. 654.937.2:621.395.66

HOLMQVIST, Å & STRIGÅRD, G: *Centralographs as Fault Recorders at Telephone Exchanges.* Ericsson Rev. *35*(1958): No. 4, pp. 108–114.

The CENTRALOGRAPH as a service observation instrument in automatic telephone exchanges was referred to in Ericsson Review No. 1, 1958. In L M Ericsson's automatic transit exchanges it is also used for the recording of faults discovered by markers and v.f. receivers.
The article deals with Centralograph applications in automatic exchanges of the Swedish Telecommunications Administration, where its use differs from that in the L M Ericsson normal supervision systems.

U.D.C. 621.395.44
621.395.5

FILIPSON, B: *L M Ericsson's 960-Circuit System for Coaxial Cables. III. Terminal Equipment.* Ericsson Rev. *35*(1958): No. 4, pp. 115–124.

L M Ericsson's terminal equipment for the 960-circuit system is described in this and a subsequent number of Ericsson Review. The article deals with the parts of the equipment which are directly concerned with the transmitted signal band.

U.D.C. 621.395.3–217
621.3.049.7
621.395.6–217

NEOVIUS, G: *Printed Circuits–A New Production Technique.* Ericsson Rev. *35*(1958): No. 4, pp. 125–127.

The new printed circuits ROA 211–214 have been designed for electronic apparatus used in telephone exchange relay sets. Printed circuits eliminate the need for many of the various fittings previously used for small components.

U.D.C. 621.395.26

DAHLGREN, A: *Multi-Line Telephone for Enquiry Services and Booking Offices.* Ericsson Rev. *35*(1958): No. 4, pp. 128–132.

Telefonaktiebolaget L M Ericsson has designed a multi-line telephone, that is a telephone with several multipled lines, for offices catering mainly for incoming traffic. The kinds of organization for which this telephone is specially suited are information services of different kinds, travel bureaux, booking offices etc.

The Ericsson Group

Associated and co-operating enterprises

• EUROPE •

Danmark

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

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España

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

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

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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

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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

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

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

A/S Industrikontroll *Oslo*, Teatergaten 12, tel: Centralbord 33 50 85, 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

Schweiz

Ericsson Telephone Sales Corp. AB, Stockholm, Zweigniederlassung Zürich *Zürich*, Postfach Zürich 32, tel: 32 51 84, tgm: telericsson

Suomi

O/Y L M Ericsson A/B *Helsinki*, Fabianinkatu 6, tel: A 8282, tgm: ericssons

Sverige

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

AB Alpha *Sundbyberg*, tel: 28 26 00, tgm: aktiealpha-stockholm

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

AB Ermi *Bromma 11*, tel: 26 26 00, 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*, Kungsgatan 33, tel: 22 31 00, tgm: ellem

Mexikanska Telefonaktiebolaget Ericsson *Stockholm 32*, tel: 19 00 00, tgm: mexikan

Sieverts Kabelverk AB *Sundbyberg*, tel 28 28 60, tgm: sievertsfabrik-stockholm

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

• 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

Liban

Telefonaktiebolaget L M Ericsson, Technical Office *Beyrouth*, Rue du Parlement, Immeuble Bisharat, tel: 33555, tgm: ellem

Türkiye

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: 22 81 02, tgm: ellemist

• AFRICA •

Union of South Africa

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

• AMERICA •

Argentina

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*

Brasil

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

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

Colombia

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

México

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

Perú

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: 24201, tgm: northphone-galionohio

Venezuela

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

Teléfonos Ericsson C. A. *Caracas*, Apartado 3548, tel: 54 31 21, 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 •

Belgique

Electricité et Mécanique Suédoises *Bruxelles*, 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

Island

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

Yougoslavie

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

Österreich

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

• 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

Hongkong

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

Liban

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

Syrie

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

Viêtnam

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

• AFRICA •

British East Africa

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

Congo Belge

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

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

Marruecos

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

Moçambique

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 & Nyasaland

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

• 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

República Dominicana

García & 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-guatemala

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, tgm: aseaburd

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