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EDITOR: SIGVARD EKLUND, DHS

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CONTENTS

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On cover: The administration building of Cía. Telefônica da Borda do Campo (CTBC) at Santo André, Brazil. CTBC was the first telephone administration in Brazil to introduce L M Ericsson's crossbar switching system on a major scale in 1962 on conversion to all automatic operation. CTBC today has 7 local exchanges in operation with a total capacity of 16,400 lines. Plans exist for extension of these exchanges by another 8000 lines.

Protection against Overvoltages on Telephone Lines

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UDC 621.316.933
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LME 7392 761

Special measures must be taken to protect outside plant, exchanges and subscribers' apparatus against overvoltages, especially in areas where there are open wire lines. The type and extent of the protective arrangements depends on the structure of the plant, the occurrence of disturbances and on the earthing conditions.

The author here presents an account of the protective system adopted by the Helsinki Telephone Company and of the improvements in the form of lower fault rate that have been achieved.

Overvoltages on telephone lines can be caused both by atmospheric discharges and by power lines, by induction or by direct contact. It is essential to protect both the telephone lines and the exchanges and subscribers' apparatus connected to them against damage caused by overvoltages, and the Helsinki Telephone Company has made thorough investigations of the possibilities of improving its protective arrangements.

The Helsinki Telephone Company covers an area of about 3700 km² in the south of Finland. About 100 km² of this district consists of purely urban area in which the cables run almost completely in conduit or are buried in the ground. The rural area covers 3540 km² with a subscriber density varying between 0.4 and 266 subscribers/km². In the latter area there are about 125,000 pair-kilometres of cable and about 6200 pair-kilometres of open wire, 40 per cent of the cable being overhead with an average capacity of 20 pairs. Of the total length of subscriber cable about 75 per cent is overhead. Some 45 per cent of the junction cables are overhead cables with an average capacity of 30 pairs.

The urban networks have operated reliably but in the rural networks there have often been disturbances and interruptions of service during thunderstorms.

Despite the northerly situation of Finland there are some 20–30 days of lightning per year. The specific earth resistance is also high, which adds to the fairly frequent faults in telephone equipments. As is known, the effective distance for atmospheric discharges increases with the specific earth resistance. It is also difficult to obtain sufficiently effective earthing of overvoltage protectors – protective earthing. The bedrock in the surroundings of Helsinki is primitive rock consisting of granite and gneiss. If the rock is intact its specific resistance is especially high, about 50,000 ohm-metres, but owing to water-filled cracks it varies locally between 10,000 and 50,000 ohm-metres. This bedrock is covered by moraine, the thickness of which varies between a few metres and some tens of metres. The moraine, which was formed during the Ice Age, has a very high specific resistance. There are also areas of clay in the neighbourhood of Helsinki which were earlier covered by the sea. The clay is sediment which has been washed up by the water.

These circumstances have necessitated special measures for earthing of overvoltage protectors. In our network these protectors are usually located at the junction between open wire and cable in order to protect the cable against the overvoltages which arise in the open wires as a result of atmospheric discharges and power networks. The specific resistance of the earth is measured, usually by the tetrode method (fig. 1). The measurements are made at a sufficient number of places to provide a clear and definite picture of the soil conductivity in the area. On the basis of these measurements the

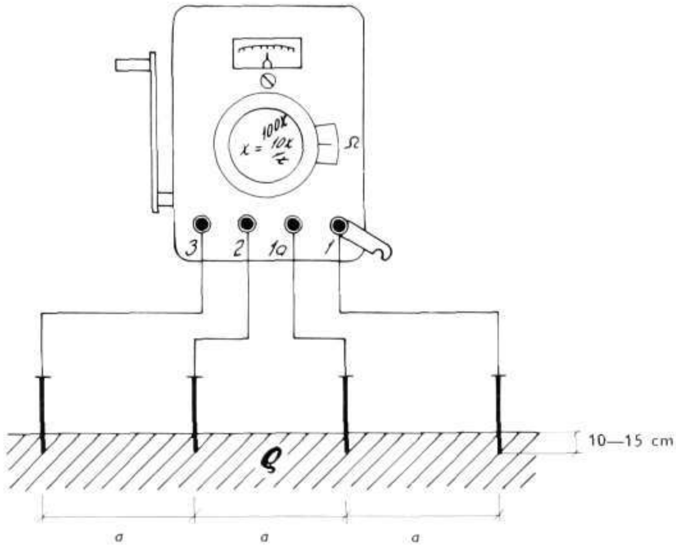

Fig. 1

Measurement of the specific resistance of the earth by the tetrode method

$$\rho = 2\pi aR$$

Example:

a m	"R" Ω	ρ Ωm
1	30	188
2	16	201
3	12	226
5	6.2	195
10	2.9	182

distribution point is located at the most suitable position from the earthing point of view. Earths are arranged either vertically or horizontally, and the earth resistance in summertime must be less than 20 ohms and in wintertime max. 60 ohms. Our specifications stipulate that the copper wire used for horizontal earths shall be min. 6 mm². For vertical earths we use 1–1½" copper-plated steel pipe through which a copper wire is drawn and terminated in a loop which is short-circuited. We also use copper-plated solid steel rod.

Under difficult earthing conditions Sanick gel may be used to reduce the earth resistance. From earths installed in our area we have come to the following results as regards the earth resistance:

Without Sanick gel		With Sanick gel	
50	ohms	45	ohms (90 %)
100	,,	78	,, (78 %)
200	,,	120	,, (60 %)
500	,,	210	,, (42 %)
1000	,,	300	,, (30 %)

In Finland the sheaths of buried, conduit and overhead cables, and the suspension wires of the latter, are interconnected throughout the whole network. The protective earth at distribution points is also connected to the cable sheaths. At the exchange the sheaths are connected to the common earth bar in the cable vault, to which the exchange earth is also connected. In our experience this avoids the danger of disturbances due to potential differences between different types of soil.

At the end of the fifties the Finnish power company adopted the principle of rigid earthing which, in the event of an accidental earth, gives rise to a greater magnitude of current than the earlier earthing method. The greater current induces greater voltages in the telephone lines, which in some cases means that the lines must be protected. At present it is considered that the limit should be 430 V, which means that the telephone line must be protected if the voltage induced into it from an accidental earth on a power line is higher than 430 V.

Protective System of the Helsinki Telephone Company

It has long been practice to use carbon arresters, i.e. a spark gap between two carbon electrodes, to protect the equipment at the terminal points of a telephone line against overvoltages. Carbon arresters have generally been combined with a fuse placed in front of the carbon arrester to protect it against too great quantities of electricity, which would destroy the electrodes. The disadvantage of this combination is that the life of the carbon electrode is short despite the protection afforded by the fuse, that with a carbon arrester one cannot guarantee protection against voltages below 800–1000 V, and finally that the line is broken every time the fuse blows. The latter problem is all the most serious since the subscribers concerned often have a long way to their nearest neighbour and are therefore greatly dependent on a reliable telephone service. The cost for the telephone administration per repairman's visit is also high in view of the long distances to the remote subscribers. It therefore pays to install equipment on the subscribers' lines which ensures satisfactory service, even if the equipment is fairly expensive.

Owing to the disadvantages of the carbon arrester it was necessary to replace it by a protector which withstands so large a quantity of electricity that no fuse is required, and which functions at lower voltages and so provides the necessary protection against overvoltages induced from accidental earths on power lines. In view of the considerable development that has taken place in rare gas tubes, these were adopted by the Helsinki Telephone Company about five years ago. The tubes, which are made by L M Ericsson, are designed to fit the holders previously used for carbon arresters. The previous fuses were also removed from the protector boxes and replaced by dummies.

The rare gas tube employed by us has a striking voltage of about 210 V r.m.s. in a.c. operation and below 1000 V for a wave form of 1 : 50. Since the tube is preionized, the time lag is less than in an air gap and below 0.3 μs at a wave front of 5 kV/μs. It withstands very high momentary currents, e.g. 1000 A for 1600 μs. At a load of longer duration the tube is short-circuited by a bimetallic mechanism, whereby the power developed in the tube is reduced and its discharge capacity increased. Thus shortcircuiting occurs, for example, at a current of 10 A within one second. After the overvoltage has disappeared the bimetallic contact opens and the rare gas tube again functions normally.

The Finnish Telephone Administrations have made it general practice in the last two decades to protect their outside plant and telephone equipments only at points of the outer network where the open wire lines change to cable. They have also departed from the practice of placing protective equipment on the exchange M.D.F. This makes for an important saving of space.

Of the present 140 exchanges in our area 20 are completely served by cables and therefore have no overvoltage protectors. The remaining 120 exchanges are predominantly located in the countryside. The distribution points in 75 of these areas so far have been equipped with overvoltage protectors consisting of rare gas tubes and with fuses replaced by dummies. The earthing of these overvoltage protectors has been done as already described. On subscribers' premises where the drop wire consists of lead-sheathed cable, the only protective measure has been to earth the sheath, allowing a maximum earth resistance of 300 ohms. In one of our exchange areas, in the spring of 1962, we introduced on trial single-pair fuse boxes mounted on poles at the subscribers' premises, equipped with rare gas tubes and dummies. In these cases the earth resistance is max. 20 ohms.

On examining the results achieved by these measures it is found that the following number of lightning faults have occurred in our network: 1829 in 1960, 1275 in 1961, 688 in 1962, and 596 in 1963. It will be seen from figs. 2, 3 and 4 how these faults are distributed among the exchange areas during the years 1961, 1962 and 1963.

If we now look at the statistics from 1961, for example, we see that the number of lightning faults in that year was 240 for cable faults and 1035 for other faults. Of the cable faults 155 occurred on lead-in cables, 81 on primary or secondary overhead cables, and 4 on primary or secondary buried cables.

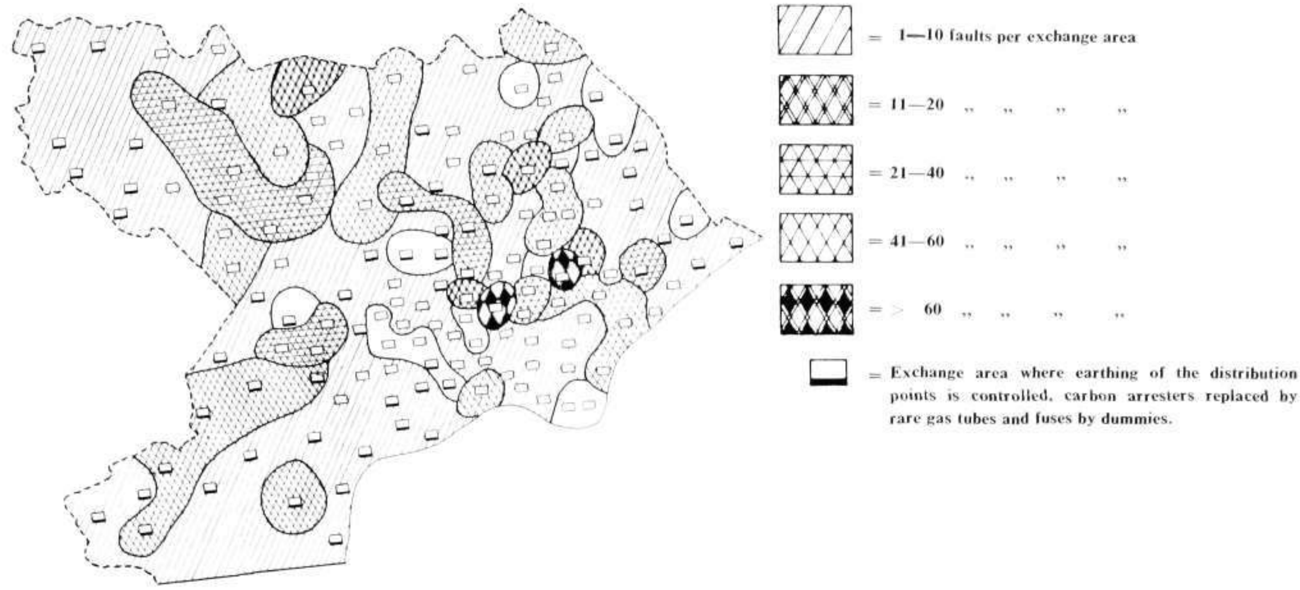

Fig. 2. Number of lightning faults in 1961

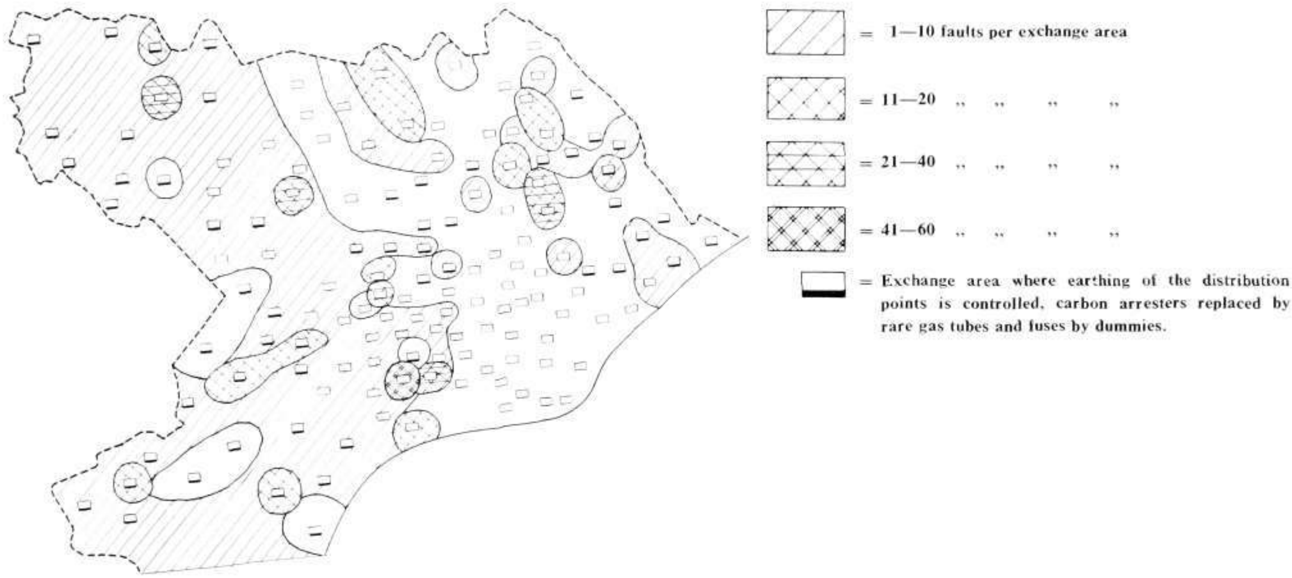

Fig. 3. Number of lightning faults in 1962

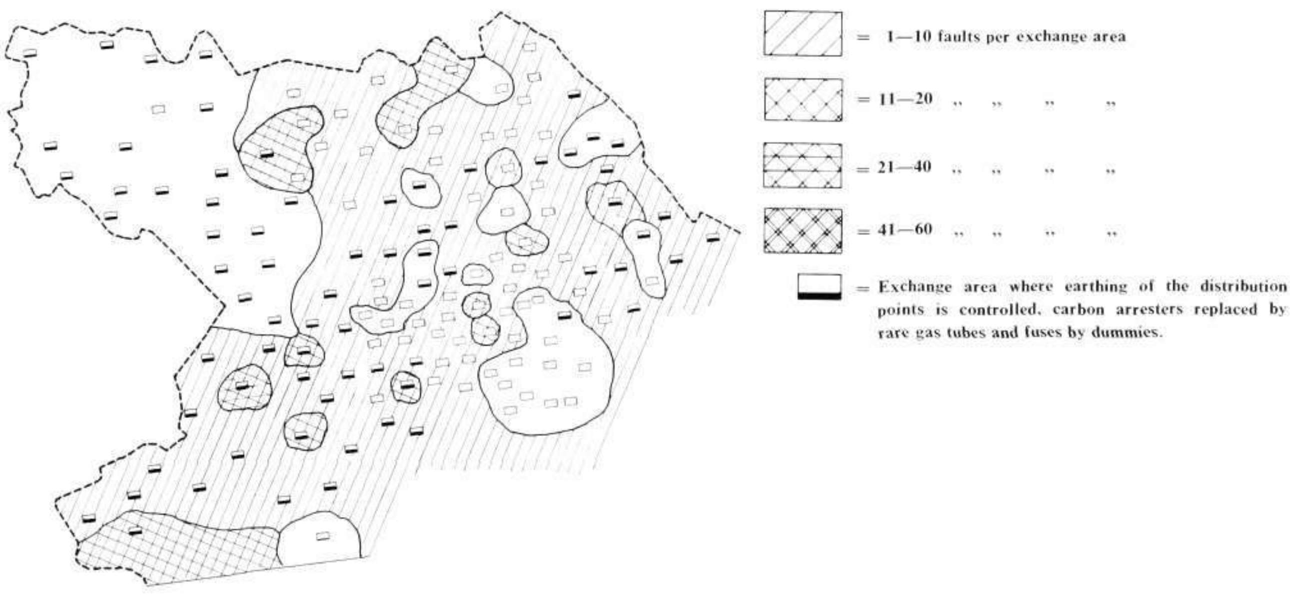

Fig. 4. Number of lightning faults in 1963

The remaining faults occurred when fuses had blown and the carbons had been damaged. This happened in areas which had not been modernized through the introduction of rare gas tubes, dummies and controlled earths.

Since our network comprises a total of 684 km of buried cable and 1985 km of overhead cable, the fault rate is thus 0.58 per 100 km of buried cable and 4.08 per 100 km of overhead cable.

Results

Comparing the results with those from previous years, a clear improvement is observed, as is evident from the table below showing the lightning fault statistics from 1960–1963 in the Lapinkylä area. At the same rate as proper earths have been introduced and rare gas tubes and dummies have been provided at the distribution points, the situation has decidedly improved. Especially it may be said that the buried cable situation is satisfactory. This is not because buried cable as such is better protected against lightning overvoltages than overhead cables. The better resistance of buried cable is due to its larger size and armouring, so that the sheath has a better safety factor.

It will be observed that the greatest number of faults were on the lead-in cables to subscribers' premises. These cables are small and the sheath safety factor therefore poor, and they are accordingly very sensitive to overvoltages. They have, moreover, been connected to bare wire lines without overvoltage protection. This has resulted in flashover to the lead sheath. From our experience the majority of these overvoltages have entered the subscribers' cables from the bare wires.

To gain more experience, in the spring of 1962, as already mentioned, we built one of our exchange areas (Haavisto) in such a way that the subscriber lead-in points were also protected by rare gas tubes and dummies and with an earth resistance of max. 20 ohms. The results during last summer came fully up to our expectations. In future we shall protect also these transition points by rare gas tubes and dummies.

Finally it may be said that one is often guilty of neglect in respect of telephone earths since we not enough is known about the significance of earths as protection and as disturbance-eliminating factor. It must be pointed out that, once an earth has been satisfactorily arranged, it cannot be left to its fate. Earths and overvoltage protectors must be kept under observation and measurements must be made at regular intervals in order that the necessary action may be taken in good time.

The cost of earthing arrangements varies between 40 and 140 Finnish marks (US $ 12–40) each. Then, of course, there is the difference in price between a rare gas tube and a carbon arrester plus fuse. The cost as a whole, however, is small if it is considered that the measures for radical improvement of protection and earthing have resulted in a great reduction of the number of lightning faults.

Lightning faults in Lapinkylä group area 1960—1963

The Lapinkylä group area comprises the following exchanges: Evitskog, Huhmari, Kylmälä, Lapinkylä, Näsby, Siuntio and Veikkola.

Year	Termination points in exchange area without controlled earths	Termination points in exchange area with controlled earths and rare gas tubes	Line faults		Exchange faults		Total	
			per annum	per termination per annum	per annum	per termination per annum	per annum	per termination per annum
1960	701	—	306	0.44	42	0.06	348	0.50
1961	341	402	82	0.11	19	0.03	101	0.14
1962	—	798	43	0.05	77	0.10	120	0.15
1963	—	865	64	0.07	43	0.05	107	0.12

The Automatic Telephone Network in Curaçao

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UDC 621.395.74
621.395.34
LME 808 830

In this article the author presents a survey of the growth of the Curaçao automatic telephone network from the opening of the first exchange 25 years ago up to the present day.

Curaçao, the largest island in the Netherlands Antilles, is situated in the Caribbean Sea about 40 miles off the coast of Venezuela (fig. 1). It is 170 sq. miles in area and has 132,000 inhabitants. Its capital is Willemstad.

The climate is tropical. The average temperature is 27.5° C but the constant north-east trade-wind prevents this temperature from being specially troublesome.

The economic conditions are dominated by the fact that the island has one of the largest natural harbours in the world and a large oil refinery belonging to the Shell group. Trade and tourism are also important factors in the economic life of the island.

Constitutionally the Netherlands Antilles, to which Curaçao belongs, are an independent part of the Kingdom of the Netherlands.

The need for a telephone service on Curaçao was felt as early as in 1892 and on January 23, 1892, the first licence to build a telephone network was granted. The result was not particularly successful either financially or technically. One cause of this was the constant change of licensee.

These changes of ownership, of course, did not favour developments, and after pressure had been brought to bear especially by trading and industrial circles the company was placed under public ownership on January 22,

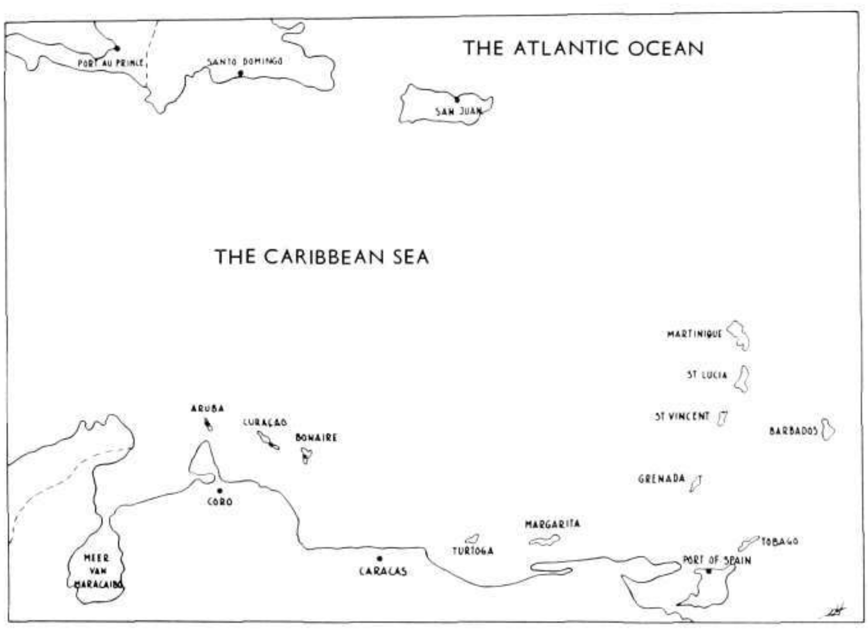


Fig. 1
Curaçao's geographical situation

Fig. 2
Curaçao's telephone network
● Local exchange
◗ Satellit exchange

1927. The existing equipment was modernized and replaced by a manual magneto system of L M Ericsson make. This system comprised 3 operators' positions each serving 100 lines, which were later extended to 5 positions for altogether 500 lines. The line plant, which for the most part consisted of overhead wires, was also renewed.

Although this modernization brought a clear improvement over earlier conditions, it was soon realized that an automatic exchange would be preferable to the manual system. In 1937 funds were granted for the acquisition of an automatic exchange. After mature consideration and study of the situation the government ordered from L M Ericsson an automatic exchange for 1500 lines. The equipment was installed in premises belonging to "Telefoondienst" under the supervision of an Ericsson expert. The building was situated in the Punda district, at that time the most important part of Willemstad (fig. 2).

This first automatic exchange was opened by the governor on July 3, 1939, just 25 years ago. The exchange was equipped with 500-line switches (see trunking diagram in fig. 3). It had a 4-digit numbering scheme (1000–2499, extendable to 7999). There were also a number of group selector levels reserved for special services (00–05), and two group selector levels for automatic traffic with the Emmastad exchange owned by a Shell subsidiary, Curaçaosche Petroleum Industrie Maatschappij. Digit 9 was used as area code for traffic with this exchange, which was of Strowger type.

Fully automatic traffic was now possible between these two exchanges. The Punda subscribers, after dialling 9, had to await a new tone and then dial the subscriber's number. The Punda register was thereby bypassed and the dial pulses were forwarded to the Emmastad exchange. Calls from Emmastad to Punda passed through normal line relays in Punda. In principle the same procedure is followed today.

On economic grounds equipment for only 1200 subscribers was installed despite the 1500-line capacity of the Punda exchange. The registers were equipped with rotary selectors. The automatic exchange had great advantages, the number of subscribers quickly rose, as also did the traffic intensity. The tariff system employed at that time—stepwise increasing tariff—also contributed to the rise of traffic intensity, i.e. the number of calls had little effect on the cost to subscribers. During the first years of World War II there were difficulties in procuring new equipment. The number of link circuits could not be increased and there were often traffic stoppages. The waiting time for dial tone was sometimes 20 seconds or more. As an emergency measure the conversation time during peak traffic periods was limited, the operators breaking off the call if it went on too long. This solution was far from practical since it could be employed only during a short period and with little result.

To cover the large need for telephone connections in the important residential area of Mahaai, a *PABX* plant of type *OL 45* was employed as public exchange in 1942, again an emergency measure. All-automatic traffic was now possible to and from the Punda exchange. For this purpose a number of outlets from the 03 level of the group selector in Punda had been connected as internal numbers of the *PABX* at Mahaai. There were 8 junctions with Mahaai.

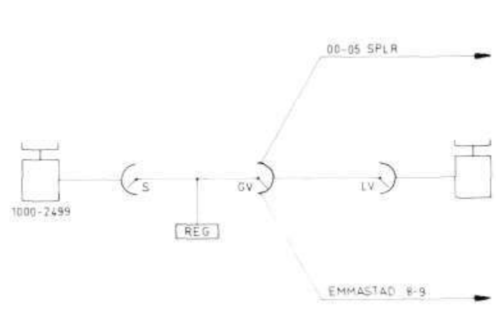


Fig. 3
Trunking diagram of Punda exchange when opened on July 3, 1939
Capacity 3 × 500 lines

S Line finder
GV Group selector
LV Final selector
REG Register
SPLR Special lines

Apart from Mahaai there was also a small manual exchange at the remote Dokterstuin, with only one junction to Punda. The Dokterstuin exchange was operated by the police.

After the war the necessary expansion of the Curaçao network could be started. At the Punda exchange new selectors and new registers were installed to eliminate the traffic stoppages during busy hours. The *PABX* at Mahaai was replaced by an ordinary automatic exchange. A new exchange was built at Otrabanda west of St. Anna Bay.

The Otrabanda exchange filled a great need. Before its installation the subscribers in that district were connected to the Punda exchange via a submarine cable across St. Anna Bay. This cable, however, was very vulnerable. Several times a year it was damaged by anchors from incoming ocean vessels, which isolated the subscribers in Otrabanda. This problem was solved, at least as regards local traffic, after the opening of the Otrabanda exchange. The junction traffic to Punda and Mahaai, however, still passed through this submarine cable.

The Mahaai exchange had a capacity of 500 lines, which was extended to 1000 lines in 1950 (5000–5999), and Otrabanda 1000 lines (3000–3999). Both exchanges could be regarded as detached groups from the Punda exchange. The trunking scheme from 1952 is shown in fig. 4. It was a complicated scheme and the junction lines were used very uneconomically. Every group of 500 numbers required its own junctions to the other exchanges, which in turn had their own incoming final selectors (*LIV*). Quite soon

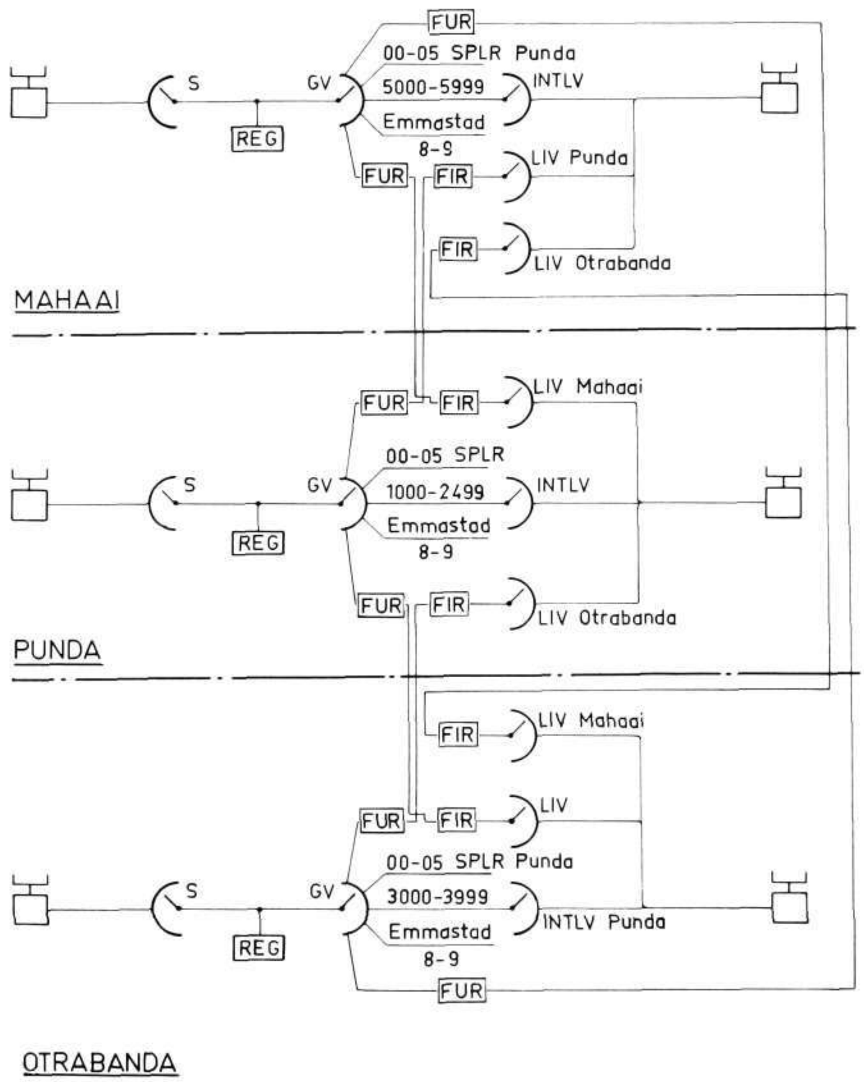


Fig. 4
Trunking diagram of Curaçao network in 1952 (without incoming group selectors)

S Line finder
GV Group selector
LIV Incoming final selector
INTLV Internal final selector
REG Register
SPLR Special lines
FIR Incoming junction
FUR Outgoing junction

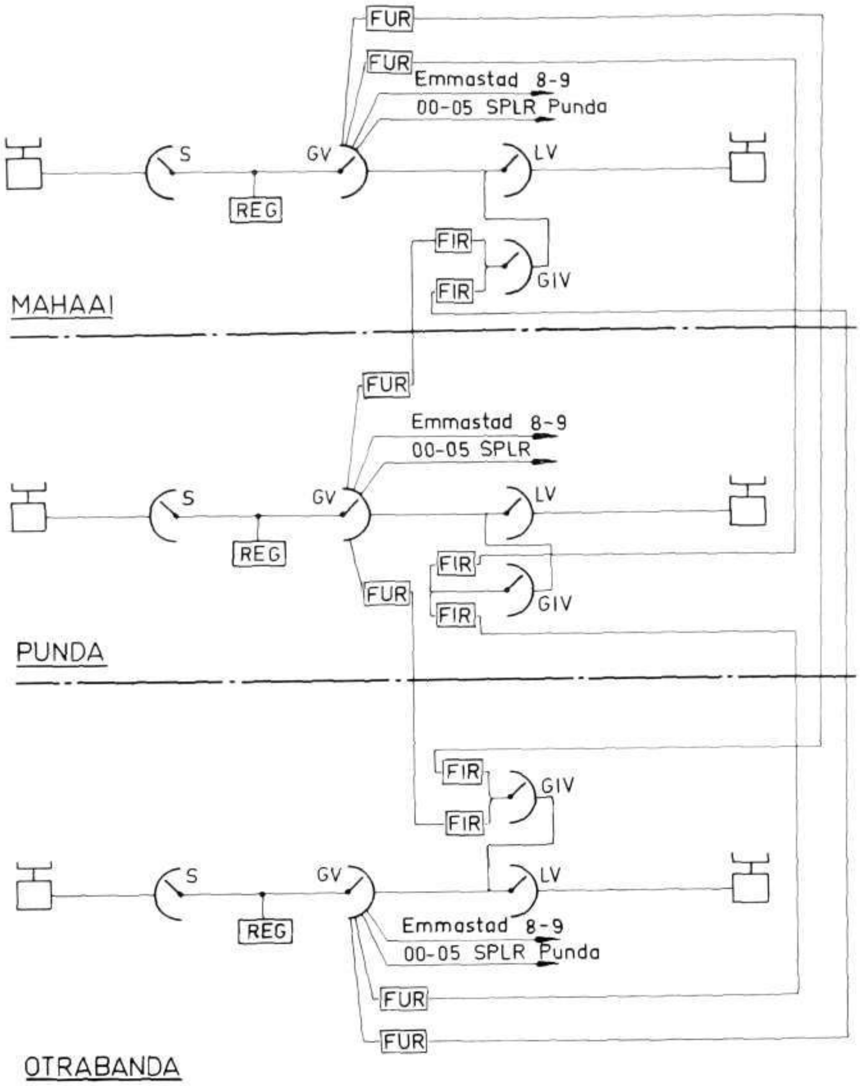


Fig. 5

Trunking diagram of Curaçao telephone network around 1954 (with incoming group selectors)

S	Line finder
GV	Group selector
GIV	Incoming group selector
LV	Final selector
REG	Register
SPLR	Special lines
FIR	Incoming junction
FUR	Outgoing junction

therefore—during the years 1953 and 1954—another course was adopted. All incoming traffic was directed via special incoming group selectors. This simplified the trunking scheme, as will be seen from fig. 5. The line capacity in 1952 was 3500 and the number of subscribers 3275.

But in the long run not even this solution was adequate for the growing need of subscriber connections and for the growing traffic. As a result of the flourishing economic situation new residential areas were built which required new telephone connections. After the opening of the Punda exchange the number of connections within the existing network had trebled and the traffic quadrupled (figs. 6 and 7). In order to meet this growing need for the future as well, it was necessary to alter the entire plan of the network. Around 1953 this question was brought up for examination. This first requirement was that the new plan should permit easy adaptation to the need for telephone connections both in the near and distant future. The peculiar geographical structure of Curaçao was an important factor. Two trading centres, Punda and Otrabanda, had to be taken into account. These two centres constitute the town of Willemstad with a surrounding zone of residential areas around the Schottegat and sparsely populated outer areas. It was also required that existing exchanges should be incorporated into the new plan without any great difficulty. It was decided to have a system of district exchanges interconnected through a lattice-shaped network. Satellite exchanges could be con-

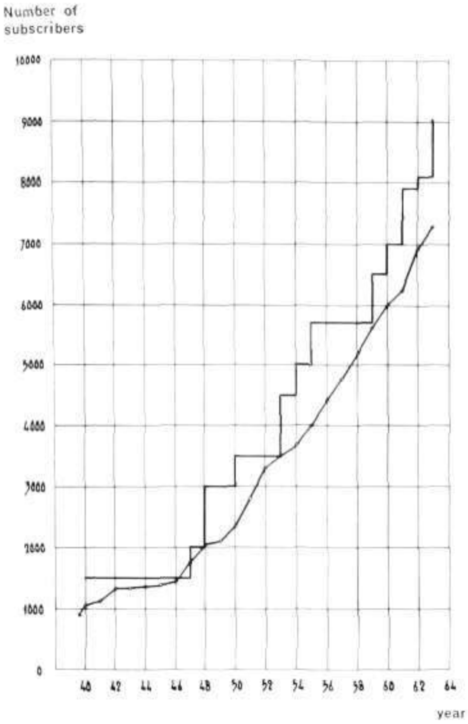


Fig. 6
Line capacity and number of subscribers (at the end of the year end)

——— Line capacity
o—o—o Number of subscribers

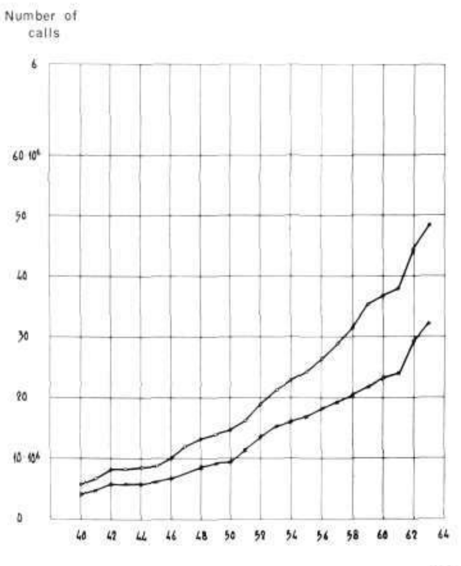


Fig. 7
Increase in number of register and final selector calls

o—o—o Register calls
x—x—x Final selector calls

Fig. 8
Telephone density, i. e. number of subscribers per 100 inhabitans

nected to these district exchanges as required. This plan made it necessary to change to a 5-digit numbering scheme. The Punda, Mahaai and Otrabanda exchanges had to be adapted to this scheme and a fourth exchange was planned at Rio Canario. A satellite exchange was later to be built at the Hato airfield connecting with the Rio Canario exchange.

The first step in putting this plan into effect was to replace the mechanical registers at Punda by crossbar registers in 1953. A new 500-line exchange was built in the Rio Canario residential area. The registers at Otrabanda and Mahaai were adapted for the new scheme, the necessary junction apparatus was installed and the junction network extended.

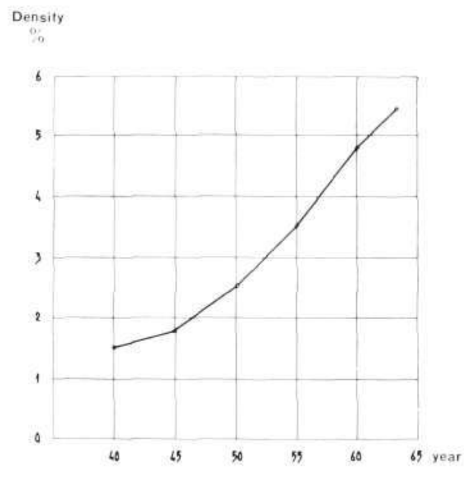
On June 5, 1955, *the 5-digit numbering* scheme was *introduced*. At the same time the Rio Canario and Hato exchanges were put into operation. The new plan had thus become a reality.

Through this alteration of the network structure the principles of the future Curaçao network had now been established. New extensions could easily be made and new requirements met for many years ahead. The installed capacity on June 5, 1955, was 5700 lines and the number of subscribers around 3800.

The registers at Punda and Otrabanda were equipped with a special switching facility. As already mentioned, these exchanges were linked by the cable across St. Anna Bay. This cable was very vulnerable. A switch had therefore been installed on the registers at Punda and Ortrabanda with which the traffic could be redirected from Punta to Otrabanda, or vice versa, via Rio Canario when a fault occurred.

In the following years the network increased steadily in capacity and telephone density (figs. 6, 7 and 8). The need for connections in the outer areas also increased. An exchange was therefore installed at St. Rosa (a satellite to Mahaai) in 1959. In 1961 came the Dokterstuin and Brievengat exchanges (both satellites of Rio Canario). The Dokterstuin exchange replaced the previous manual exchange. After the installation of this exchange (on February 27, 1961) the entire Curaçao network was now automatic.

Since the distance between the Dokterstuin and Rio Canario exchanges is about 15 miles, it was necessary to introduce special measures for signalling between them. An elevated signal voltage of 36 V was therefore used at the Dokterstuin exchange.



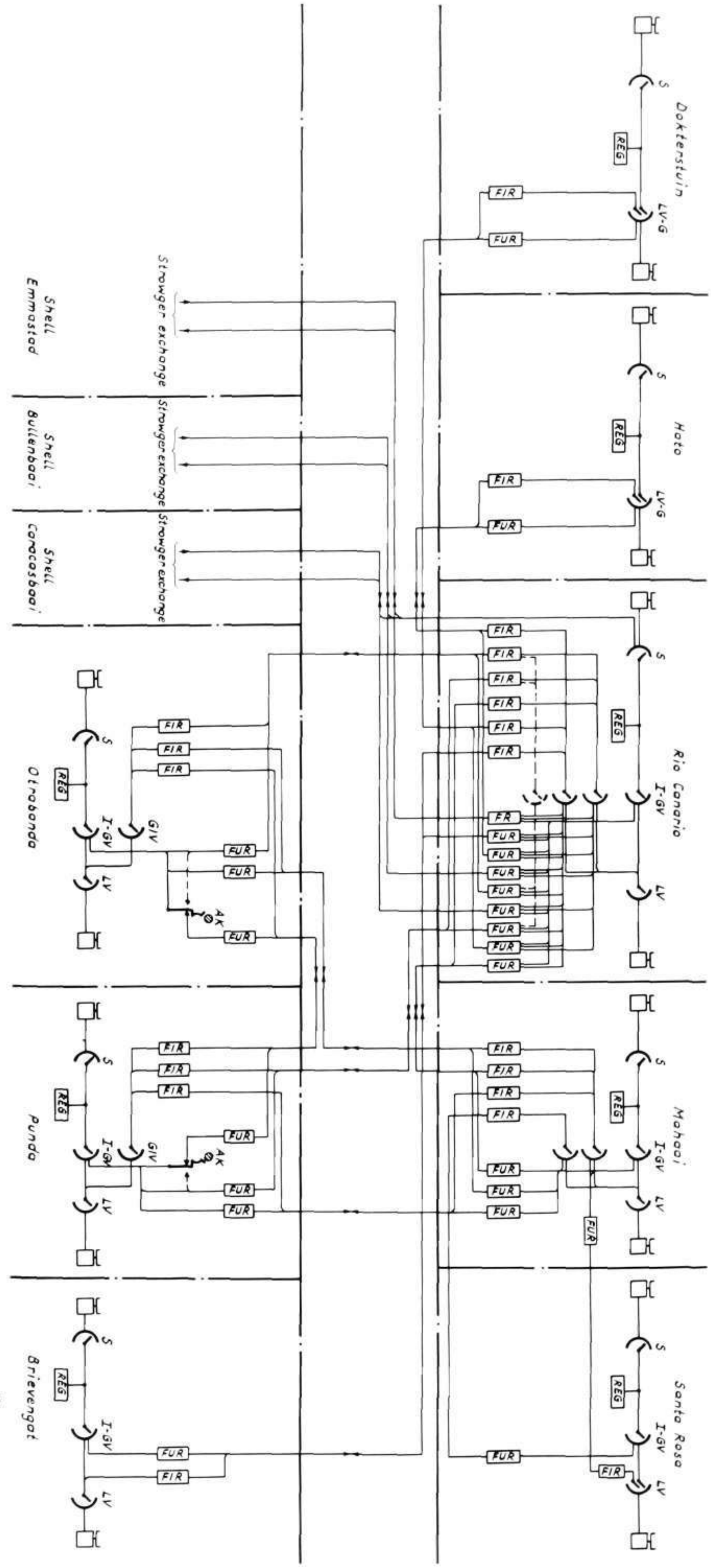


Fig. 9

Trunking diagram of Curaçao network in 1964

S Line finder
LV Final selector
LV-G Final and group selector
I-GV First group selector
AK Register switch
REG Register
FIR Incoming junction
FUR Outgoing junction

The installation of new and the extension of already existing exchanges, and equipment alterations, had so far always been done under the supervision of an expert from L M Ericsson. Since 1956 this work has been entirely entrusted to the island's own personnel. The first complete exchange installed by its personnel was St. Rosa in 1959.

On July 3, 1964, 25 years after the opening of the first automatic exchange, the total capacity was 9100 lines with 7650 subscribers on 4 district and 4 satellite exchanges. The trunking scheme is shown in fig. 9.

Naturally the cable network as well has been greatly extended during the past 25 years. In recent years particular attention has been paid to the use of underground cable to the greatest possible extent.

To keep the attenuation in the network within reasonable limits, the longest junction circuits have been equipped with negative impedance repeaters. These repeaters have a very favourable effect. One example is the long distance circuit between Otrabanda and Mahaai. Without these repeaters the attenuation at 300, 800 and 3000 c/s was 4.6, 7.5 and 15.5 db, respectively. After the installation of repeater equipment the attenuation was reduced to 3.0, 2.5 and 4.7 db, respectively.

All connections between Curaçao and other islands in the Antilles consist of radio links. The traffic with Aruba and Bonaire is operated on a semi-automatic basis. Investigations are at present being made concerning the possibility of full automatic traffic between the islands. Direct radio-telephone connection exists also with New York, Amsterdam, Caracas, Paramaribo (Surinam) and Barbados.

Finally it may be said that in the past 25 years the choice of the Ericsson *AGF*-system has proved a good choice. Even the oldest equipment is still working fully satisfactorily. The maintenance required is very slight, especially in consideration of the tropical climate.

Relay Interlocking with Push-button Control and Train Describer System at Stockholm Central Station

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UDC 656.257
LME 869

This article presents the main features of a new interlocking plant at Stockholm Central Station based on entirely new principles. Among the new features are a train describer system and a keyboard for setting up train routes.

At the end of April 1964 the first part of a new relay interlocking plant at Stockholm Central Station was put into service. When fully installed the plant will be about six times as large as at present and will then control some 100 main-line signals, 250 position-light shunt signals, 225 electrically operated points, 850 train routes and 525 shunting routes. The number of train and shunting movements per day will be about 2000. The controlled area is rather more than 15 kilometres long in a north–south direction.

The signals within the area have so far been controlled from four power-operated lever frames which, after 30 years of hard service, need to be replaced. They will be successively dismantled as each new part of the plant becomes ready for service. The new plant is expected to be completely installed by 1966. It will save manpower and allow more effective traffic routing and a better survey of the traffic situation.

The control office is situated at Stockholm Central Station. The office is on a level with and adjacent to the platform system, so that quick and convenient communications exists between the office, which also serves as train despatcher's room, and the trains and platforms. The arrangement of the control room is shown in fig. 1.

External Plant

In respect of external equipment the plant is constructed in the conventional manner with track circuits, point machines and signals of normal design. A. C. track circuits are used within the central area, while more remote track circuits, which are generally longer, are fed with D. C.

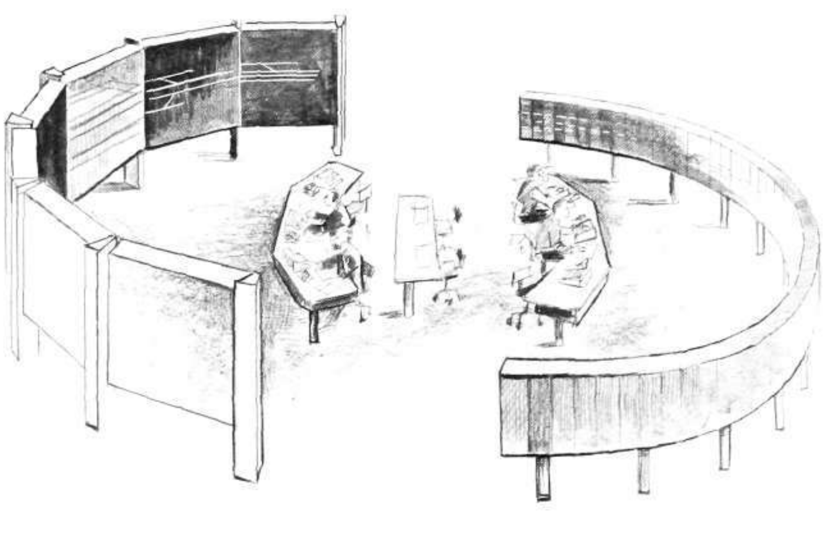

Fig. 1
A drawing showing how the control room will be arranged in future.

In addition to the local interlocking (left), the first part of which has now been commisioned, the room will also house a CTC office (right). The CTC office will remote-control some 70 stations just outside the interlocking area.

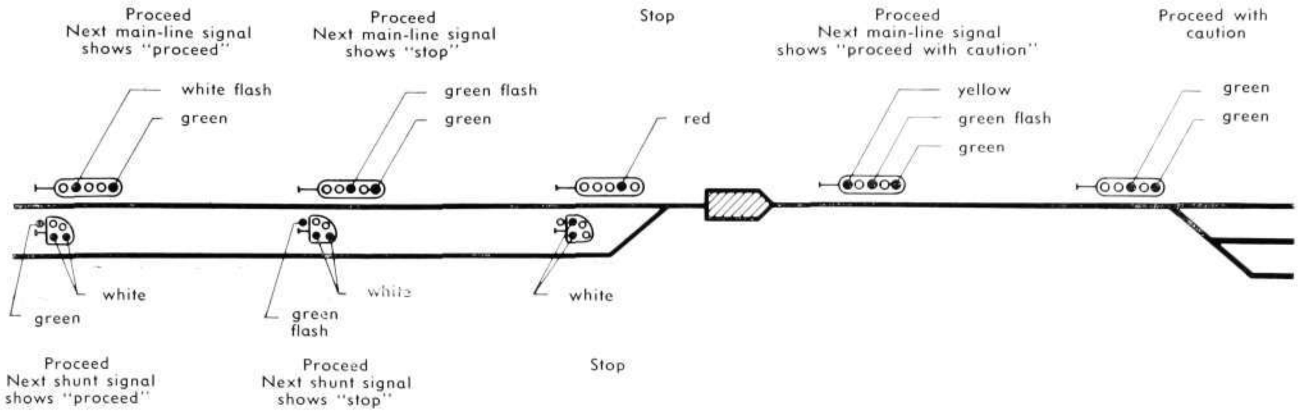

Fig 2

Five-light main-line signals are used on tracks where the speed may not exceed 40 km h, and on other tracks shunt signals supplemented by a green aspect.

In addition to the proceed aspect the signals also show the aspect of the signal ahead.

Fig. 3

Position-light shunt signal with four white apertures and one green

Train movements on tracks on which speeds of 40 km/hour are allowed will be controlled by main-line signals, other train movements by position-light shunt signals with green light (fig. 2).

Each main-line signal is preceded by a distant signal. In the shunt signals the green light serves also as distant signal for the subsequent main-line or shunt signal (fig. 3).

The platform tracks have special departure signals for passenger trains.

All main-line and shunt signals are operated from the control office, whereas the departure signals are operated by the train guards from switches on the platform. The departure signals are dependent on the other signals and can show the departure aspect only if the corresponding exit signal shows proceed.

Points and derailers, which are to be operated from the control office, have electrical mechanisms. Certain points have local switches. These points can be locally operated by the shunting personnel on permission from the control office. All points can also be manually operated with a crank in the event of power failure or other fault.

Points and derailers which are seldom operated are designed solely for local manual operation and are locked in position by electric locks.

Internal Plant

The main parts of the internal equipment are the control apparatus and the illuminated track diagram in the control office (fig. 4). The necessary relays and power supply equipment are placed in relay rooms under the control office.

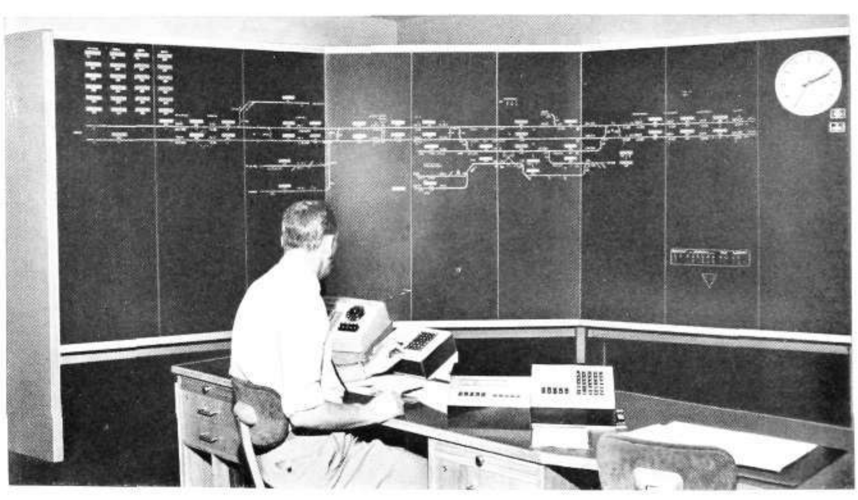

Fig. 4

The control office at Stockholm Central Station

In the background is the indication panel with the track system for the part of the plant at present in use.

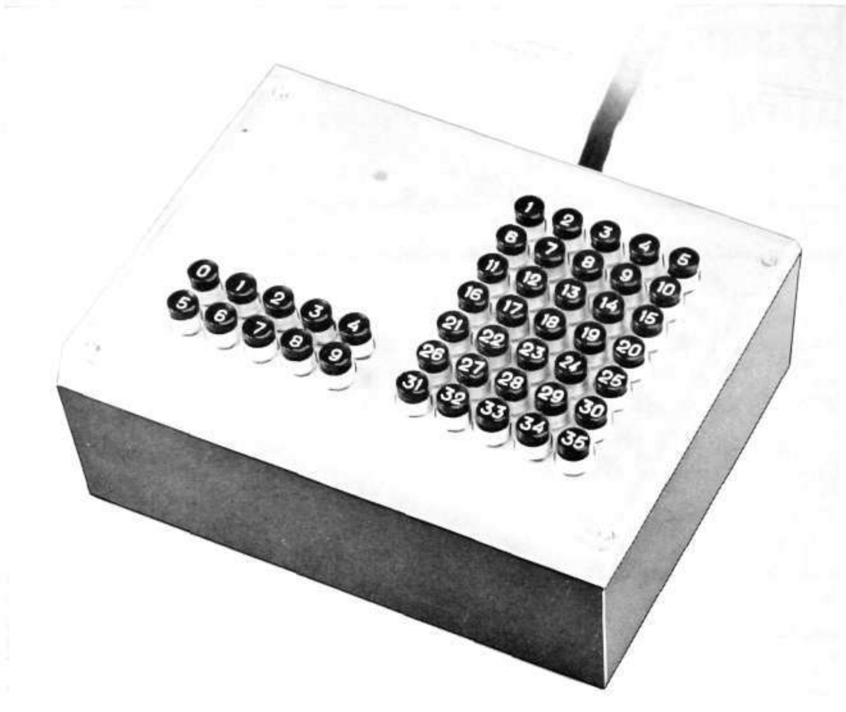

Fig. 5
Keyboard for establishment of train routes

The plant is operated from three keyboards (fig. 5), each of which controls nine sections of the plant in whole or in part. At low traffic periods, therefore, the entire plant can be controlled from a single keyboard. Each keyboard contains 45 keys of which the ten in the bottom left-hand row are numbered 0–9. These are used for selection of signals, points, derailers and track circuits etc., all of which have three-digit numbers between 201 and 999. The 200 lowest numbers are reserved for control of Älvsjö Station south of Stockholm Central Station. The remaining keys on the right are numbered 1–35 and are used for establishment of routes and for switching of points and signals etc.

A route is established by keying the numbers of the signals at the start and end of the route and then pressing an execute button for the route.

The illuminated track diagram is about 1.5 × 10.5 m (fig. 6). The track system is shown on plexiglas sheets. Under the sheets are lamps which lighten or darken in response to the various indications.

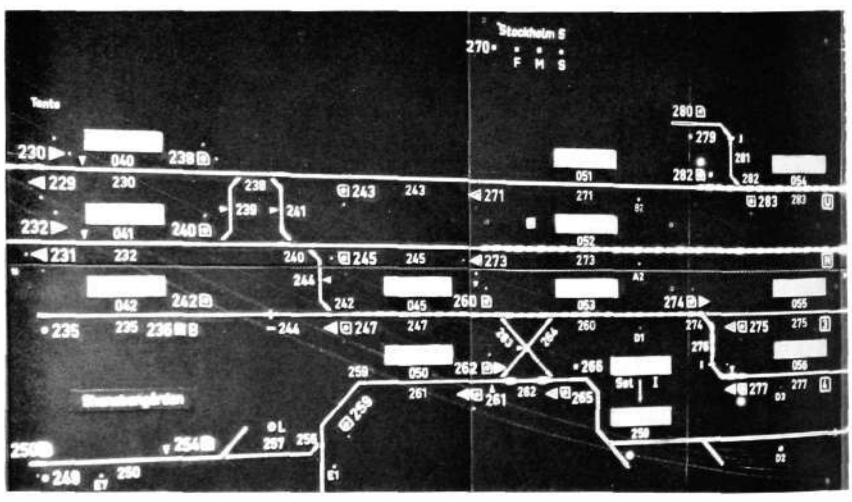

Fig. 6
Detail of indication panel

The track system with text etc. is engraved on black plexiglas, the track system in grey and text in white. The symbols for track circuits are orange-coloured.

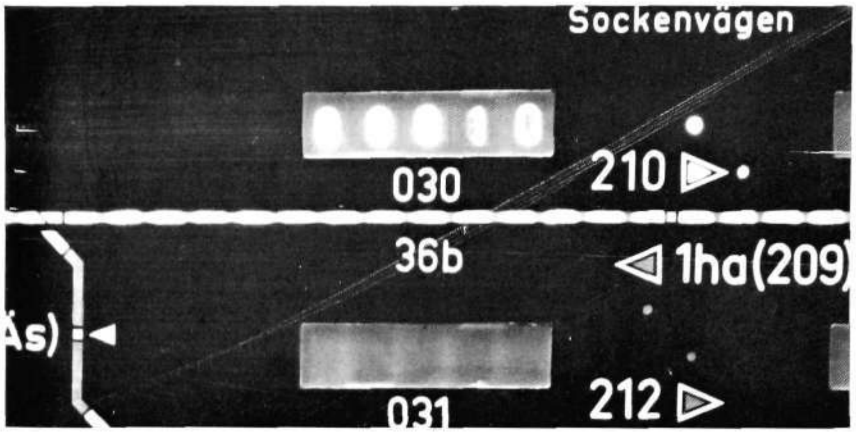

Fig. 7
Train descriptions are set-up in rectangular display units. The picture shows description 00010 in display unit 030.

The indications are displayed in various symbols according to the nature of the indication. The same aperture may show indications in different colours and in steady or flashing light. The indication lamps are normally extinguished and light only when the attention of the control office personnel needs to be summoned or as an acknowledgement of an executed control.

The operation of the plant is facilitated by a train describer system which keeps the control office personnel informed of the descriptions of trains within or approaching the area. The descriptions are set up in rectangular display units over each track or part of a track on the track diagram. When a train is on a track, its description is set up in the relevant display position (fig. 7) and then follows the train as long as it is within the signal-controlled area.

The train describer system is operated from a separate keyboard (fig. 8) from which the descriptions of trains leaving the area are keyed into the system. This keyboard has ten keys numbered 0–9. To set up a train description, the operator first keys the three-digit number of the relevant display unit and then the train description. Destination and description can be checked in the verifying display unit on the keyboard. After this check the description is transferred to the track diagram with the start key *S*. Wrongly keyed numbers can be cancelled both as regards destination and train description.

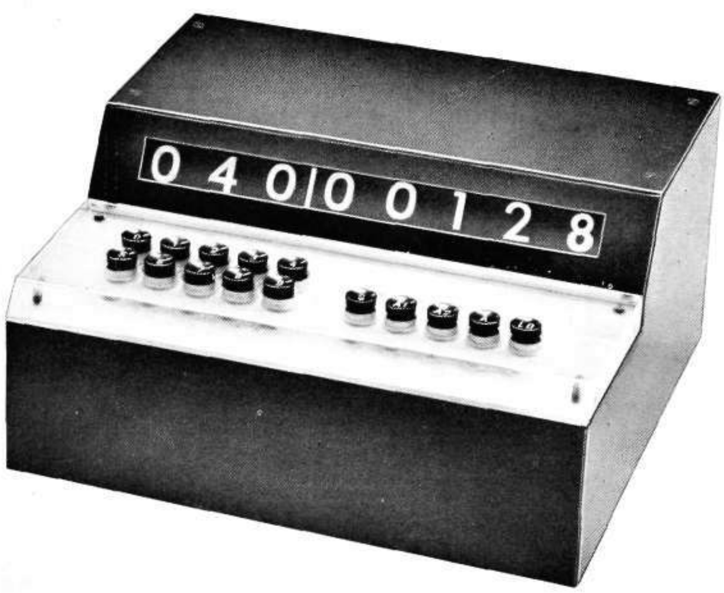

Fig. 8
Keyboard for train describer system

Descriptions of trains entering the area are automatically transmitted to the control office from adjacent stations. They are displayed first in a position corresponding to the transmitting station and are thereafter moved down to the area display positions when the train enters the controlled area. The "remote" display positions are seen at the top left of the track diagram (fig. 4).

The descriptions for departing trains are transferred in the same way under remote control to adjacent stations.

The relay equipment consists of safety relays which ensure the safety of train movements. Telecommunication relays are used in the train describer system and also for repetition of keyset signals and other functions of a non-safety character in the actual signal plant. The telecommunication relays are mounted in relay sets of plug-in type (fig. 9). For the power supply of the plant there are rectifiers for the relays and converters for the A.C. track circuits. A standby unit is automatically switched-on in the event of a fault in the normal supply.

Concluding Remarks

Experience hitherto of the part of the plant that has been in operation has been thoroughly satisfactory both as regards the safety and control and the train describer systems. This bodes well for the future when the plant is fully installed and its many advantages in respect of saving of manpower and improved traffic capacity and supervision can come into their full right.

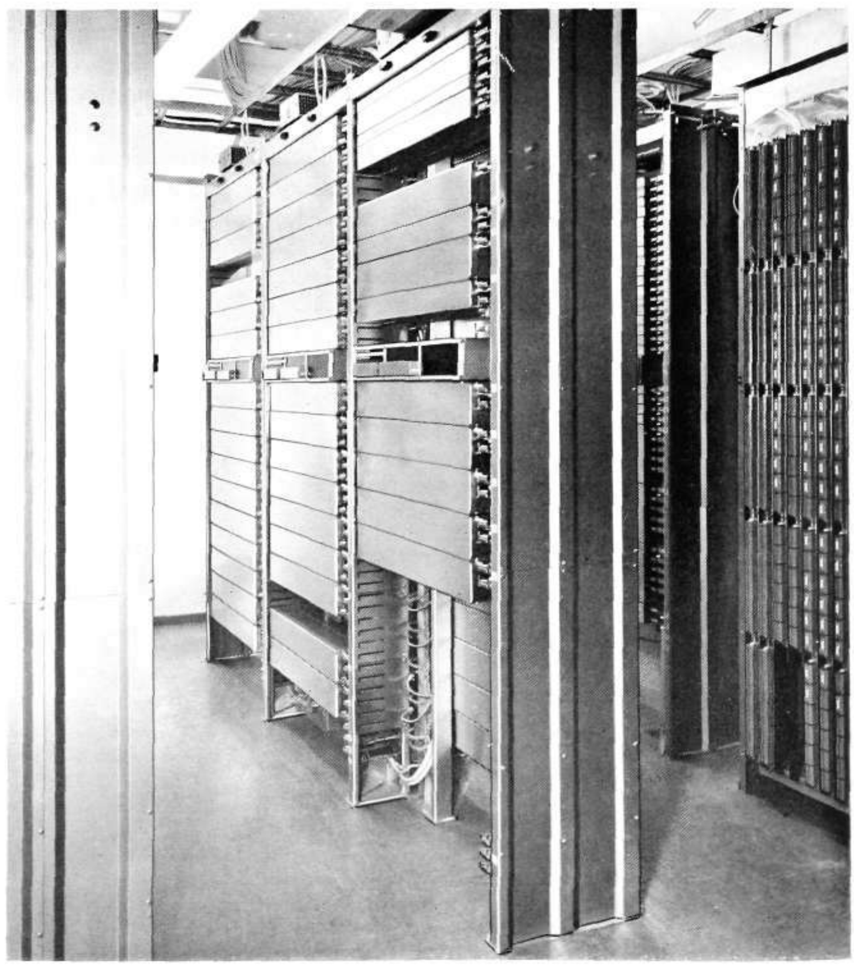

Fig. 9
Telecommunication relay rack

RITT Method of Instruction

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UDC 371.3:681.84
LME 0339

Instruction units for systematic operation and experience learning are now used by several manufacturing firms and schools in Sweden. This method, called the RITT method (Rational Instruction and Training with recorded Tapes), in conjunction with specially designed apparatus, is a rational and efficient training aid, not only in industry but also in many other fields for teaching manual skills, instruction in the use of tools, machines, instruments etc., and as "check lists" for complicated manufacturing processes and the like.

The article presents an account of the method, its applications, advantages and the results achieved.

The RITT method originated at L M Ericsson nearly five years ago when the company had a pressing training situation on hand and attempted to meet it by recording working instructions with the Ericorder tape recorder which was then made within the group. The first results were not particularly promising, but the idea was worked upon further. Today we have a well established method of instruction, founded on theoretical and practical experience, for the main aspects of which patents have been filed. The apparatus has also been adapted to the instruction method, the original tape recorder having been entirely redesigned into an instruction unit suited for the particular purpose, with a separate recording equipment. An Ericsson subsidiary, Instruktionsteknik AB, is now in charge of the marketing of the method and apparatus.

The Method

If the problems are to be seriously attacked and satisfactory results are to be obtained, very extensive and qualified work is required on the preparation of the tape recorded instructions. The following brief description will give an idea of how this work is done and how the instruction is used.

The working routine is first studied on site. If there is any earlier MTM* analysis or film available, it is fairly easy to analyse the routine. Once the method study has been completed and the routine has been established, a manuscript is prepared. To start with, the pupil must be taught how the place of work is to be organized and what tools and other equipment are required. Thereafter the actual routine is described in a technically and pedagogically correct manner. This detailed description of the working process teaches the pupil how the work is done in accordance with the stipulated method, but it gives him no training in quickness.

To enable the pupil to increase his pace of work, the instruction is now repeated a number of times but within successively shorter periods. This is done by systematically omitting certain words on each occasion without affecting the clearness of the instruction.

In the recording of the manuscript it is essential to accurately time the pauses in the recording corresponding to the times needed to perform the various operations.

Before the instruction is put to use, it must be thoroughly tested in practice. This can be done both at the manuscript stage and after the manuscript has been recorded. The complete instruction is then used as follows:

* Method-time-measurement

Fig. 1
Instruction unit KTB 2351 with control box

An instructor takes the pupil in charge and explains the functioning of the apparatus. Both of them then put on headsets and the instructor carries out the job in accordance with the instruction, the pupil looking on and listening in the earphones. In this way the pupil obtains a clear picture of the work both through his auditory and visual faculties. When the instruction has been run through, the instructor and pupil change places and the pupil does the job while the instructor checks that he is following the instruction. If the pupil is not clear about any operation the apparatus is stopped, the tape is wound back and the operation is repeated.

Fig. 2
Headset RLD 9811 with transistor receiver for magnetic loop

Apparatus

A special Instruction Unit has been developed at L M Ericsson. To withstand the stresses of industrial environments it is robustly constructed, and the latest type is also tropicalized.

The unit is designed for magnetic tape in a cartridge. The cartridge is easily inserted and removed. It is also effectively protected against dust and dirt.

In order that the instruction unit shall be easy to operate, and perhaps especially to prevent alteration of the recorded instruction, the unit is designed for playing back only. It has a separate wire-connected control box with keys for playback, fast wind and rewind, stop and repeat. A pulse device stops the rewound tape automatically at different stages of the instruction, the stop being preselected during recording of the routine. This technique enables the pupil to quickly find any desired part of the instruction for repetition of a particular operation. If only a phrase or a few words of the instruction are to be repeated, he presses the repeat key. The tape is then wound back about 10 seconds and the instruction thereafter continues automatically.

Fig. 3
Instructor and pupil run through an instruction on relay adjustment

The unit has sockets for two headsets, one for the instructor and one for the pupil. It has no loudspeaker, however, since this would disturb others in the vicinity and would not require the same concentration when listening.

A magnetic loop system may also be employed. A loop which generates a magnetic field is set up round the working position and connected to the instruction unit. The pupil uses a pair of earphones with a transistor receiver. In this way he can listen to the instruction while having full freedom of movement within the area inside the loop.

A special recorder is used for recording of instructions. For copying of a complete instruction an instruction unit is connected to the recorder.

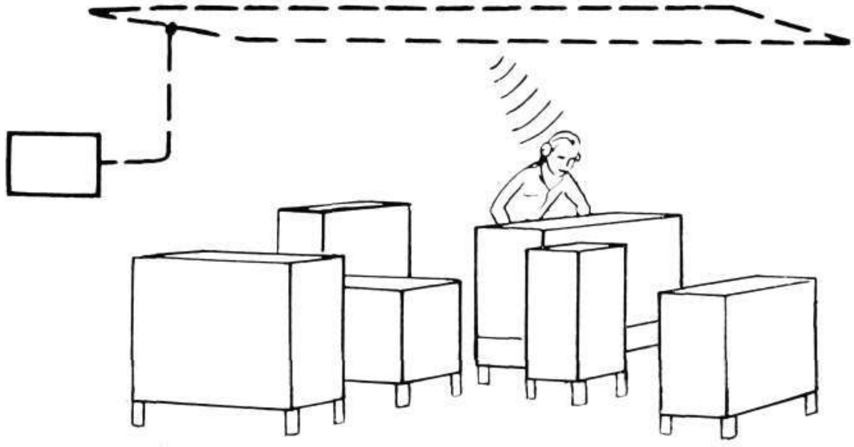


Fig. 4
Sketch of magnetic loop system

Advantages of the RITT Method

The advantages of magnetic tape instruction by the RITT method may be summarized under the following points:

- ☐ Several elements in the design of the recorded instruction and of the instruction unit are calculated to make the learning process effective, i.e. step-by-step presentation, reinforcement, the pupil can work at his own pace and "ask" the tape a question at any time, increased concentration, simultaneous engagement of auditory and visual senses. Although the relative effects of these various elements have not yet been completely ascertained, all practical experience hitherto points to an appreciable reduction in the time of learning. This not only reduces the cost of instruction but means that operatives become productive more quickly and, when working on a piecework system, they more quickly come up to the intended rate of pay. Secondary effects are the smaller turnover of personnel and reduced costs of recruitment.

- ☐ The instruction unit does not render a human instructor unnecessary but relieves him of much work, and his work is of a more qualified kind. He can more easily form an opinion concerning the suitability of a pupil for a particular job and can devote more time to really difficult operations etc.

  All pupils obtain equally good instruction and there is less reason for friction between instructor and pupil.

- ☐ The instruction is identical on every occasion and is only changed if the operational method is changed. The tape can serve as a book of reference. It is filed as long as the job continues, is an effective aid for checking working methods and provides an objective basis for piece rate negotiations. Safety regulations can be learnt at the same time as the working methods.

- ☐ The pupil has direct contact with the person who devised the working method. This creates a better guarantee of obtaining the qualified personnel required for a particular operation. The calculated gains from any working method can be realized to the full and rejects are reduced.

  The preparation of an instruction tape is therefore a natural sequel to MTM work.

- ☐ The taped instruction greatly simplifies the teaching of foreign personnel since it can be prepared in their own language.

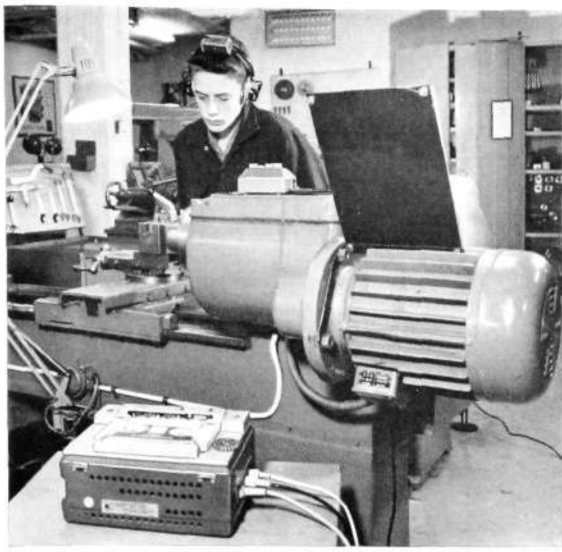
  It also facilitates the instruction of handicapped persons, for instance the blind, as well as people who cannot read.

- ☐ These improvements in the method of instruction mean that expensive machinery can be more effectively used and looked after.

- ☐ When certain operations are transferred to other factories, there is an assurance that the work will be done properly. Obviously, when selling know-how, this will be of more value if it includes taped instructions.

Practical Experience

Training by the RITT method is in progress at a large number of Swedish companies and institutions. Among them may be mentioned ASEA, SKF, Volvo, Åtvidaberg, the Öresund Shipyard, Svenska Stålpressning AB (pressed steel products) and Tretorn (rubber products). Other training applications are for nursing, prison warders, vocational schools, and within sales and service companies such as Scania-Bilar (motor cars) and Hasselblads Fotografiska AB (photographic equipment).



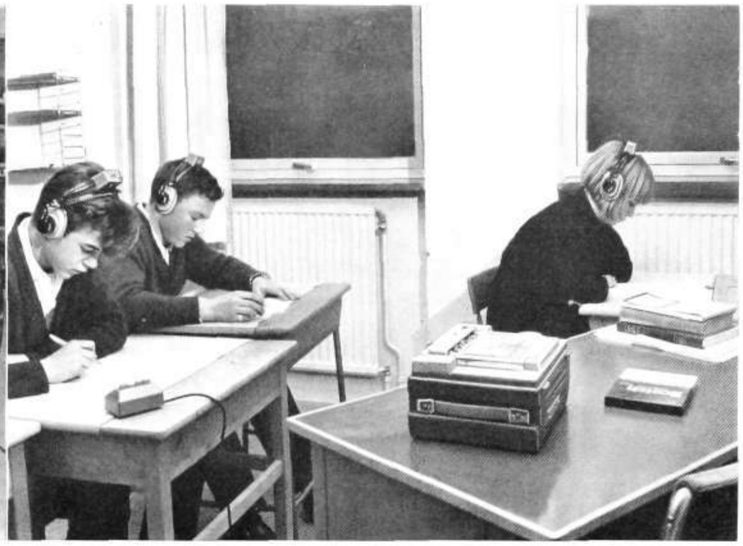


Fig. 5

Training on a school lathe and language teaching

Exact times and results of training are usually lacking by conventional methods. Nor is there time nor the opportunity in industry to carry out statistically reliable comparative studies. Nevertheless the following statements made at a conference on August 20, 1962, organized by ASTI (The Swedish Work Study Technical Institute, Stockholm) provide clear evidence of the important advantages to be gained through the use of the method.

L Sandberg, Work Study Engineer, Volvo:

We have used tape recorded instructions for teaching machine operators, especially for work on the assembly line. We have found that the time of learning has been reduced to about one-third of that required earlier.

L Mattsson, Production Manager, Hasselblads:

Our work comprises the developing of coloured film. During the height of this last season we taught about 30 employees with tape recorders. The great advantage of the method has been that the time of learning of the primary process was reduced to half of that earlier required.

B Andrén, Work Study Department, SKF:

We have prepared some 10 instructions which have been used for training about 100 employees. We found that the method has many advantages and it is our intention to greatly increase its use.

B Myhrvold, Manager, Nordiska Tvätten (Laundry):

We have used the method for instructing women in the ironing of shirts and we have found it far superior to the method we previously employed.

The following may be quoted from an investigation at L M Ericsson's Söderhamn Factory. Training time on soldering of 500-line switches was reduced from 12 to 6 weeks per employee when using the RITT method, and on winding of coils from 14 to 10 weeks.

A very large number of people have been trained at L M Ericsson since the method was first brought into use. Foreign labour have been trained by instructions in Finnish, Greek and Italian. Finally it may be mentioned that jobs transferred to L M Ericsson's factories in Spain and Australia have been accompanied by working instructions in Spanish and English.

L M Ericsson Exchanges Cut into Service 1964

CITY EXCHANGES

Public exchanges with 500-line selectors AGF

Town	Exchange		Number of lines
Bolivia			
La Paz	Centro	(extension)	1000
Brazil			
Goiânia Area	Campinas	(extension)	2000
”	Centro	(extension)	2000
Colombia			
Medellín area	Bosque	(extension)	2000
”	Buenos Aires	(extension)	2000
”	Poblado	(extension)	1000
Ecuador			
Guayaquil	Centro	(extension)	500
”	Sur	(extension)	500
Quito	Mariscal Sucre	(extension)	500
Ethiopia			
Addis Ababa	Central	(extension)	500
”	Filwoha	(extension)	500
Finland			
Pieksämäki		(extension)	250
Seinäjoki		(extension)	500
Tammisaari/Ekenäs		(extension)	500
Tampere/Tammerfors		(extension)	1000
Italy			
North Italy			
Legnago		(extension)	300
Mogliano		(extension)	100
San Bonifacio		(extension)	100
Schio		(extension)	500
Strà		(extension)	140
Valdagno		(extension)	300
Verona	Centro	(extension)	500
”	Borgo-Trento	(extension)	500
Vicenza		(extension)	1000
South Italy			
Alcamo		(extension)	1000
Avellino		(extension)	1000
Caltagirone		(extension)	1000
Canicatti		(extension)	500
Caserta		(extension)	500
Castellammare di Stabia		(extension)	1500
Catania	Nesima	(extension)	1000
”	Ognina	(extension)	3000
Formia		(extension)	200

Town	Exchange		Number of lines
Giarre Riposto		(extension)	500
Lecce		(extension)	1000
Mazara del Vallo		(extension)	800
Messina	Nord	(extension)	500
Modica		(extension)	500
Napoli/Naples	Museo	(extension)	2000
”	Nolana	(extension)	1500
Palermo	Calatafimi	(extension)	2500
”	Libertà	(extension)	3500
Reggio Calabria		(extension)	500
Salerno	Centro	(extension)	1500
”	Pastena		2000
Siracusa		(extension)	1000
Torre del Greco		(extension)	800
Lebanon			
Beyrouth	Chiah	(extension)	1000
”	Furn-el-Chebak	(extension)	1500
Mexico			
Jalapa		(extension)	500
Mexico DF	Apartado	(extension)	1000
”	Morales	(extension)	500
”	Piedad	(extension)	1500
”	Portales	(extension)	1000
”	Roma	(extension)	3000
”	Sabino	(extension)	500
”	San Angel	(extension)	500
”	Saro	(extension)	1000
”	Tacubaya	(extension)	500
”	Valle	(extension)	2000
Uruapan		(extension)	1000
Netherlands' West Indies			
Curaçao	Mahaai	(extension)	500
Norway			
Hisøy			500
Porsgrunn		(extension)	500
Skien		(extension)	1500
Panama			
Colón		(extension)	500
Panama City	Panama 4	(extension)	500
”	Panama 5	(extension)	1000
Sweden			
Borås		(extension)	500
Enköping		(extension)	1000
Eskilstuna		(extension)	2500
Falköping		(extension)	500

Town	Exchange	Number of lines
Gothenburg		
Centre area	Masthugget (extension)	2000
"	Vasa (extension)	2000
Suburban area	Askim (extension)	1000
"	Biskopsgården (extension)	1000
"	Frölunda (extension)	2000
Halmstad	(extension)	2000
Hälsingborg	(extension)	500
Jakobsberg	(extension)	1000
Karlstad	(extension)	2500
Klippan	(extension)	500
Kristianstad	(extension)	500
Köping	(extension)	1000
Linköping	(extension)	1500
Lund	(extension)	500
Norrköping	(extension)	1500
Norrtälje	(extension)	500
Stockholm		
Centre area	Group stations (extension)	2000
"	Högalid (extension)	2500
"	Kungsholmen (extension)	2000
Suburban area	Enskede (extension)	500
"	Farsta (extension)	1500
"	Handen (extension)	1000
"	Hanviken (extension)	1000
"	Huddinge (extension)	2000
"	Lännersta (extension)	1000
"	Mälarhöjden (extension)	3000
"	Norrviken (extension)	500
"	Råsunda (extension)	3000

Town	Exchange	Number of lines
Suburban area	Saltsjöbaden (extension)	500
"	Storängen (extension)	1000
"	Sundbyberg (extension)	2500
"	Tullinge (extension)	500
"	Årsta (extension)	3000
"	Ängby (extension)	1500
"	Örby (extension)	500
Trollhättan	(extension)	500
Uddevalla	(extension)	1500
Västervik	(extension)	1000
Västerås	(extension)	1000
Åmål	(extension)	500
Örebro	(extension)	500
Turkey		
Adana	(extension)	2000
Ankara	Bahçelievler (extension)	2000
"	Merkez Santral (extension)	3000
"	Yenişehir (extension)	4000
Iskenderun	(extension)	1500
Izmir	Bornova (extension)	100
"	Buca (extension)	100
"	Karşiyaka (extension)	1000
"	Merkez Santral (extension)	2000
Mersin	(extension)	2000
Venezuela		
Mérida	(extension)	700
	Total	**144390**

Public exchanges with crossbar switches

Town	Exchange	Number of lines
Argentine		
Salta		8000
Australia[1]		
New South-Wales		
Ballina		800
Blacktown		1000
Civic		2000
Cooma		2000
Corrimal		2800
Deakin		3000
Goulbourn		3400
Mudgee		1400
Sydney	Bankstown	1000
"	Burwood	1000
"	Cronulla	4000
"	Dural	600
"	Edgecliff	1000
"	Epping	1000
"	Guildford	600
"	Harbord	1000
"	Haymarket (extension)	1000
"	Hurstville	1000
"	Kingsgrove	800
"	Kogarah	600

Town	Exchange	Number of lines
Sydney	Lakemba	1000
"	Liverpool	1400
"	Miranda	1400
"	North Ryde	600
"	Peakhurst	1000
"	Potts Point	800
"	Pymble	1000
"	Sefton	3000
"	Willoughby	800
Woy Woy		1000
Queensland		
Brisbane	Aspley	2400
"	Chapel Hill (extension)	200
"	Chermside	1400
"	Currumbin	1000
"	Mitchelton	800
Brisbane	Nundah	1600
"	Salisbury	400
"	Toowong	800
Bundamba		900
Cairns		1000
Gympie		1800
Ipswich		3800
Mt. Gravatt		1400

[1] The equipment for these exchanges has been manufactured in Australia on L M Ericsson-license.

Town	Exchange		Number of lines
South Australia			
Adelaide	Brighton		1000
"	Edwardstown		1000
"	Flinders		5400
"	Modbury	(extension)	1000
"	Nightcliff		600
"	Paradise	(extension)	2000
"	St. Mary's		1000
"	Woodville		1000
Tasmania			
Hobart	Bellerive		800
"	Lindisfarne		400
Launceston	St. John		1000
Western Australia			
Perth	Morley		1800
"	Scarborough	(extension)	400
"	Tuart Hill		2400
"	Wembley		2000
Victoria			
Melbourne	Blackburn		2000
"	Bulleen		3000
"	Burwood		1000
"	Clayton		2000
"	Fawkner		2000
"	Jordanville		1000
"	Newport		3000
"	Northcote		1000
"	North Melbourne		1000
"	Springvale		1000
"	Tally Ho		2000
"	West Essendon	(extension)	400
Montrose			1000
Brazil			
Barbacena		(extension)	600
Brasilia		(extension)	4000
Presidente Prudente			2000
Santo André Area	Mauá	(extension)	200
Chad[2]			
Fort Lamy		(extension)	400
Colombia			
Bogotá DE	Chic	(extension)	4000
Medellin area	Bello	(extension)	600
"	Envigado		2000
"	Iguana		3000
Denmark			
FkTAS			
Odense		(extension)	2000
Rudkøbing		(extension)	1000
Svendborg			6000
JTAS			
Aalborg		(extension)	2000
Aarhus	Nord	(extension)	1000
"	Syd	(extension)	1000
"	Vest	(extension)	1000
Esbjerg		(extension)	1000
Grenaa		(extension)	400
Grindsted			1600
Hobro		(extension)	200
Holstebro			4000
Ikast		(extension)	400
Kolding			9000
Lemvig			1600

Town	Exchange		Number of lines
Nykøping Mors			2000
Odder		(extension)	200
Randers		(extension)	1000
Struer		(extension)	400
Varde		(exteusion)	400
KTAS			
Albertslund			3000
Alleröd			3000
Espergærde		(extension)	1000
Helsingør		(extension)	1000
Hillerød			6000
Copenhagen	Ballerup	(extension)	1000
"	Borups Allé	(extension)	3000
"	Brøndbyøster	(extension)	1000
"	Farum	(extension)	1000
"	Herlev	(extension)	3000
"	Holte		4000
"	Hvidovre	(extension)	1000
"	Kastrup	(extension)	1000
"	Lille Værløse	(extension)	1200
"	Lyngby	(extension)	3000
"	Nærum	(extension)	1000
"	Nora	(extension)	4000
"	Nørregade	(extension)	12000
"	Rødovre	(extension)	2000
"	Sundbyøster	(extension)	5000
"	Søborg	(extension)	1000
"	Taastrup	(extension)	1000
"	Valby	(extension)	1000
"	Vallensbæk	(extension)	1000
Korsør			3000
Nykøbing F		(extension)	1000
Slagelse		(extension)	1000
Egypt (UAR)			
Assiut			3000
Benha			1000
Cairo	Abbassia	(extension)	5000
"	Opera	(extension)	10000
Minia			3000
Ethiopia			
Asmara			3000
Finland			
Helsinki/Helsingfors	Gräsa	(extension)	400
"	Haaga/Haga	(extension)	600
"	Heikinlaakso/Henriksdal	(extension)	160
"	Herttoniemi/Hertonäs	(extension)	600
"	Kaarela/Kårböle	(extension)	1000
"	Kallvik		1000
"	Kilo		1000
"	Käpylä/Kottby	(extension)	600
"	Leppävaara/Alberga	(extension)	600
"	Meilahti/Mejlans	(extension)	1000
"	Oulunkylä/Åggelby	(extension)	600
"	Pakila/Baggböle	(extension)	400

[2] This equipment, System CP 400 is deliverad by Société des Téléphones Ericsson, Colombes or their licensees.

Town	Exchange		Number of lines
Helsinki/Helsingfors	Pihlajamäki/Rönnbacka	(extension)	400
”	Puotila/Botby	(extension)	3000
”	Sörnäinen/Sörnäs	(extension)	2000
”	Tapiola/Hagalund		2000
”	Viherlaakso/Gröndal		1600
Oulu/Uleåborg	Tuira	(extension)	1000
Pietarsaari/Jakobstad		(extension)	1000
Pori/Björneborg	Koivisto		2000
Tampere/Tammerfors	Epilä	(extension)	200
”	Messukylä	(extension)	200
Turku/Åbo		(extension)	3000
Vaasa/Vasa	Roparnäs		1000
France[2]			
Annemasse			3200
Bergerac			2000
Bourg en Bresse			3200
Brennilis			200
Castres			2400
Chalons sur Saone			4000
Dreux			2000
Niederbronn			400
Poissy			4000
Royan			3200
Saint-Tropez			2000
Troyes			8000
Gabon[2]			
Libreville		(extension)	400
Iceland			
Akranes			1400
Indonesia			
Padang			3000
Ireland			
Dublin	Malahide		800
”	Nutley	(extension)	1000
Italy			
North Italy			
Padova		(extension)	5200
Treviso		(extension)	400
Venezia/Venice	Mestre	(extension)	2200
Verona	Borgo-Roma	(extension)	1000
South Italy			
Acerra			600
Acireale			3400
Afragola			800
Angri		(extension)	100
Aversa		(extension)	200
Bagheria		(extension)	400
Bitonto			1000
Capri			2200
Castellana Grotte			700
Castelvetrano		(extension)	800
Catania	Barriera		2800
Corato			1000

Town	Exchange		Number of lines
Enna			2200
Fondi		(extension)	200
Lentini		(extension)	500
Misilmeri			600
Monopoli		(extension)	200
Napoli/Naples	Casoria		800
” ”	Miano		5000
” ”	Poggioreale	(extension)	1200
” ”	Ponticelli		1600
” ”	San Giovanni	(extension)	1000
Nocera Inferiore		(extension)	600
Nola		(extension)	600
Palermo	Stadio		6000
Paternò		(extension)	400
Pomigliano		(extension)	200
Positano			400
Procida			700
Putignano		(extension)	200
Ruvo di Puglia		(extension)	600
Taormina		(extension)	200
Trapani		(extension)	1600
Vico Equense		(extension)	200
Cameroons[2]			
Yaoundé		(extension)	400
Congo[2]			
Pointe-Noire		(extension)	400
Lebanon			
Hammana			600
Jounieh			1200
Mexico			
La Paz			800
México DF	Santa Clara	(extension)	1000
”	Santa Fé		800
”	Satélite		2000
”	Tlalnepantla	(extension)	600
Netherlands			
Barendrecht		(extension)	400
Maassluis		(extension)	800
Rotterdam	Hoogvliet (Pernis)	(extension)	2000
”	Schiebroek II		5000
Niger[2]			
Agadès			100
Niamey		(extension)	400
Norway			
Mo i Rana			2000
Molde			2500
Mosjøen			2000
Portugal			
Province of Macau	Macau		1000
Sweden			
Motala		(extension)	800
Nyköping		(extension)	1000
Skövde		(extension)	1000
Visby		(extension)	800

[2] This equipment, system CP 400 was delivered by Société des Téléphones Ericsson, Colombes or their licensees.

Town	Exchange	Number of lines
Thailand		
Bangkok	Chaiyapruek	5000
Lampang		1000
Nakorn Sawan		1000
Pitsanuloke		1000
Ubol		1000
Tunisia		
Sousse		2400
Sfax		4000
Turkey		
Afyon		1000
USA[3]		
Winter Garden, Florida	(extension)	250
Winter Park, Florida	(extension)	2500
Perry, Georgia	(extension)	400
North Madison, Indiana	(extension)	200
Chillicothe, Ohio	(extension)	500
Galion, Ohio	(extension)	300
Mansfield, Ohio	(extension)	1000
Steward Road, Ohio		1000
Hood River, Oregon	(extension)	100
Yugoslavia[4]		
Beograd	Dunav	2000
"	Karaburma	1000
Niš	(extension)	1000
Novi Sad	(extension)	400
Titograd		1000
Zadar	(extension)	600
Zagreb	Centar	6000
	Total	**430510**

[3] These exchanges, System NX-1 were delivered by North Electric Co., Galion, Ohio.

[4] The equipment for these exchanges has been manufactured on L M Ericsson-license by the Yugoslavian factory Nikola Tesla, Zagreb.

RURAL EXCHANGES

	Number	Number of lines incl. extensions
Public rural exchanges with crossbar switches, system ARK, ART, NX-2 cut into service 1964.		
Australia[1]	96	12780
Canada	—	400
Denmark	9	4100
Ecuador	1	100
Finland	57	5850
Greenland	1	400
Iceland	1	200
Ireland	12	2220
Italy	14	2600
Lebanon	1	200
Mexico	6	360
Netherlands	—	400
Norway	15	1530
Sweden	—	4200
Thailand	2	800
USA[2]	12	5310
Yugoslavia[3]	29	5100
Total	**256**	**46570**

TRANSIT EXCHANGES

	Number of junctions
Transit exchanges with crossbar switches, system ARF, ARK, ARM, ART or with 500-line selectors, system AGF	
Canada	200
Colombia	800
Denmark	10800
Egypt (UAR)	2300
Finland	2960
Iceland	120
Ireland	160
Italy	2200
Lebanon	300
Mexico	1120
Netherlands	2000
Norway	460
Sweden	8205
Yugoslavia	6700
Total	**38325**

[1] The equipment for these exchanges has been manufactured on L M Ericsson-license.

[2] These exchanges, system NX-2, were delivered by North Electric Co., Galion, Ohio.

[3] The equipment for these exchanges has been manufactured on L M Ericsson-license by the Yugoslavian factory Nikola Tesla, Zagreb.

NEWS *from* *All Quarters of the World*

1964 — Record Year for LM Ericsson Public Automatic Systems

A preliminary survey now exists of the inflow of orders for and commissioning of public telephone exchanges by the Ericsson group during the past year.

More than 600,000 local automatic lines were installed, of which nearly 500,000 connected to crossbar exchanges. Several new records were set up in, among other countries, Australia and Denmark, where over 114,000 and 106,000 local lines, respectively, were installed during the year. As regards our transit systems, large scale installations have taken place in Denmark, Egypt (UAR), Finland and Yugoslavia. Transit exchanges with a total multiple capacity of 38,000 lines have been cut over during 1964.

Orders on hand at January 1, 1965, amounted in round figures to 1.9 million local lines, an increase of about 22 % during 1964. As mentioned in this and earlier numbers of Ericsson Review, large orders have been received both from new and old markets. Among the former may be noted large contracts with Costa Rica, El Salvador, Saudi Arabia, Spain and Malaysia, and important orders have come also from old-established markets such as Colombia, Mexico, Finland and Ireland.

Signing of the Venezuela contract. (Seated from left) Mr. N. Kjellander, Compañia Anónima Ericsson, Sr. A. Rodriguez-Tamayo, Managing Director of Compañia Anónima Nacional de Teléfonos de Venezuela, Sr. E. Tovar Cova, Telecom., and Sr. A. Ramirez-Torres, Chairman of Compañia Anónima Nacional de Teléfonos de Venezuela.

Large L M Ericsson Orders from Venezuela and Spain

L M Ericsson has received a large order from Venezuela for telephone equipment to a value of 25 million kronor. This equipment will be used for the radical modernization and expansion of Venezuela's telecommunications as part of the current five-year plan.

The order comprises 29 automatic trunk exchanges distributed throughout the country, an automatic international exchange, and manual exchanges. After the completion of L M Ericsson's undertakings the entire Venezuelan trunk network will have been converted to subscriber dialling.

The tender specifications were extremely detailed and complied fully with the rules of the World Bank. The order was won by L M Ericsson in competition with the principal telephone manufacturers of the world.

This contract is of great significance for L M Ericsson's future business with Venezuela and the choice of Ericsson system may be expected to influence future negotiations for similar equipment.

Among the Latin American countries which have earlier ordered equipment of the same type are Brazil, Colombia, Costa Rica, Ecuador, Mexico, El Salvador and Panama.

Spain has placed a large order with L M Ericsson for equipment for telex exchanges. The contract is worth some 20 million kronor apart from installation costs.

The equipment will be used for modernization and expansion of the Spanish telex network including the Balearic and Canary Islands.

The contract covers the delivery and installation of 65 terminal exchanges and 6 transit exchanges, all of the Ericsson crossbar system for telex, and associated v.f. telegraphy equipments and carrier systems for overhead lines. The transit exchanges for Madrid, Barcelona and Bilbao will provide facilities for all-automatic traffic with the remainder of Europe.

Opening of New LM Ericsson Exchanges

ALGERIA. A new crossbar switch exchange CP 400 for the government building in Algiers was officially opened at the end of 1964 by President Ben Bella. Among those present were the Vice President of the Council, Mohammed Said, the PTT Minister, M. Zaibek, the Minister of Social Affairs, M. Nekkache, the Head of the Long Distance Division, M. Hassani, the ambassadors of the Soviet Union, Korea and Albania, M. Gaude of the French Embassy, the Managing Director and Vice President of STE, Messrs. Duprez and Rosselin, the Director of the STE agency in Algiers, M. Cottavoz, and technicians from the Telephone Administration. The Head of the Inland Telecommunications Division, M. Snoussi, showed the visitors round the new installation and gave an account of the more important characteristics of the CP 400 system.

INDONESIA. A new crossbar exchange has recently been opened at Padang, Sumatra. It is housed in a new telephone building and has an initial capacity of 3000 lines. This exchange is one of the series of new exchanges for the conversion of the Sumatra network to automatic operation.

NIGERIA. A new crossbar exchange has been opened in Lagos in the government "Independence Building". This exchange is of type CP 400 and was delivered in 1964 by STE, Paris. It has a capacity of 4500 extensions, 45 outgoing and as many incoming exchange lines.

LEBANON. An ARM exchange was officially opened at Tripoli in December 1964 by the PTT Minister, Antoine Sehanoui, in the presence of the Governor of Lebanon, Bachir Al Awar, the Director of Telephony, A. Chémali, two former PTT Ministers and a number of representatives of the Administration, and of the church and local government. With the opening of this ARM exchange the 8000 Tripoli subscribers have automatic connection with 65,000 subscribers in the Beyrouth district. The cutover was completed according to programme and the equipment is working extremely well.

President Ben Bella and (left) M. Hassani speaking to the operators during the inauguration of the new crossbar exchange.

TURKEY. The first crossbar exchange in Turkey, at Afyon, Anatolia, was opened in August last year. The cutover, comprising 1000 lines of system ARF 102, attracted considerable interest both from the local population and the administration. The exchange is housed in a new building which also contains administrative offices and replaces an older automatic exchange of Rotary type. In conjunction with this installation a brief information course on L M Ericsson's crossbar system was held at Ankara, which met with a lively interest among the personnel of the head administration. Another 1000 AGF lines have recently been ordered for extension of the Ankara exchange Yenişehir.

The new crossbar exchange at Padang is housed in a building of rather unusual appearance.

Relay Interlocking on Geographical Circuit Principle at Swedish Railways

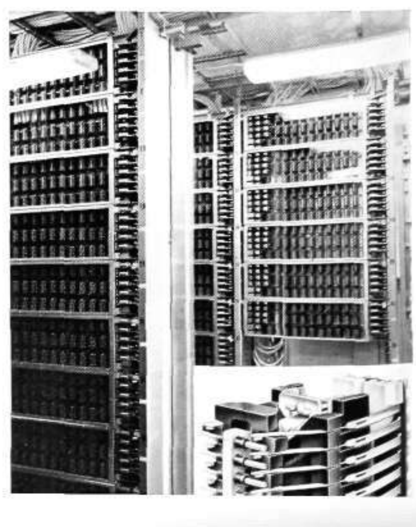
In November 1964 the Swedish Railways commissioned a relay interlocking of an entirely new type. Safety relays and non-safety relays are combined in relay sets with one set for each point, signal, etc. There are altogether seven types of relay sets, the smallest of which contain 2 safety relays and 8 non-safety relays, and the largest 32 and 13, respectively. The relay sets are interconnected with 40-conductor cables.

The relay sets and interrack cables are tested in the factory. They take very little time to install. On a change in the track system or signal system the relay interlocking can be easily altered or added to by transfer of existing relay sets or the addition of new sets.

The safety relay is the new JRF relay with 8 contacts. The relays are assembled in BCH relay sets mounted on BDH racks.

The new signalling plant comprises about 80 points and 70 signals and thus employs some 150 relay sets. Relay sets, racks and cables were supplied by L M Ericsson, which has also received orders from the Swedish Railways for another 1200 relay sets for a second relay interlocking of the same type.

BDH rack with BCH relay sets for centrally switched points. (Inset) a safety relay JRF.



The Director General of P. N. Postel, S. H. Simatupang, lays the foundation stone for a new telephone exchange building at Pakanbaru, Sumatra, in Indonesia. The initial installation will comprise 1000 lines of Ericsson's ARF system. Interested spectators at the ceremony were (in the background, from left) the head of the Pakanbaru telephone exchange, Djarwoto Moeljodiwirjo, the head of the West Sumatra and Riau telecommunications districts, R. Soenarjo Martosendjojo, and the Governor, Brigadier General Hadji Kaharuddin Nasution.

In November last year Ericsson do Brasil took part in an exhibition at Museu de Arte Moderna at Rio de Janeiro. Some 350,000 persons visited the exhibition, at which the Ericsson stand was one of the most attractive features. The inauguration was attended by Miss Universe (inset, right), who is here seen trying out an Ericofon.

NYSSA, New York Society of Security Analysts, is an association whose members deal in, administer and act as consultants in questions concerning securities. The association has regular meetings at its offices in New York, to which business executives are invited to speak about their companies and to answer questions from members.

It is mostly American companies that are represented at NYSSA meetings. On April 1 this year, however, L M Ericsson was invited–the first meeting in three years at which a foreign company was represented. The fact that it was 89 years to the day since Lars Magnus Ericsson started his operations may perhaps be considered as pure chance. There is at present a very great interest in L M Ericsson in the United States, as evidenced by the fact that 5 per cent of its shares are held there.

The photograph shows the L M Ericsson President, Mr. Björn Lundvall, on the rostrum. On the right of Mr. Lundvall is the President of North Electric, Bill Graham, and on his right L M Ericsson's Vice President in the USA, Nils Sterner.

French Order for 23 Million Kronor

The Group's French subsidiary, Société des Téléphones Ericsson (STE), has recently received its largest order hitherto, from the PTT, the French telephone administration. This order, for telephone exchange equipment of type SOCOTEL for new rural exchanges, is worth 23 million kronor after deduction of the 20 per cent French surplus value tax. The delivery period is 22 months and the PTT will install the equipment.

SOCOTEL equipment is most closely allied to the ARK system and was designed in cooperation between French telephone manufacturers and the PTT on the basis of STE's crossbar system CP 400.

STE received a similar order from PTT in the spring of 1964, on that occasion for equipment worth 16.4 million kronor.

Medals for Ericsson Veterans

Some 300 of the Ericsson staff assembled at the 1964 Gold Medal festivities held at the Stockholm Town Hall in the middle of December. Altogether 68 Ericsson employees had attained their "golden age" and had come to receive their medals and monetary gratuities. This was the twenty-first Gold Medal Celebration and, since 1944, 1014 Ericsson employees have now received gold medals.

Two of the oldest gold medallists, Rune Wahlstedt of the head factory, and Miss Gertrud Zetterström, Gröndal factory.

Erik A. Englund in Memoriam

Erik Adolf Englund died on January 21 at the age of 85.

EA—as he was known to his friends—was taken on as lines engineer in 1900 by the Stockholms Allmänna Telefon AB (ST). In 1901 he was sent to Russia to assist with the installation work undertaken by ST in Moscow. This plant was later followed by installations at, among other places, Charkov, Kiev, Archangel. EA remained in Russia until 1917 and transferred to L M Ericsson in conjunction with the take-over of the ST installations by the Swedish Telecommunications Administration. During the twenties, however, he re-established relations with the Soviet Union and the Baltic States. One result was that L M Ericsson's 500 switch system was introduced in Moscow and Rostov.

In conjunction with the outside plant installations in Russia new materials and methods had to be developed and EA's achievements in this field left their mark on Swedish outside plant engineering for several decades to come.

At the end of the First World War the world was crying out for telephones and an experienced lines engineer need not be without employment. Outside plant projects in Italy, Greece, Turkey, Portugal and, later, Latin America, as also railway cable installations in Sweden, were planned, contracted and executed under EA's leadership. Once again it became necessary to modernize materials and improve methods and EA's, at once, imaginative and practical turn of mind—a rather unusual combination—produced results which stand to this day.

Gunnar Åberg

Ericsson Technics

Ericsson Technics No. 1, 1965, has recently appeared. This number contains two dissertations, one for the degree of doctor of technology and one for the degree of licentiate of technology, both in the subject "Communication Networks and Systems" at the Royal Institute of Technology, Stockholm.

Curt Ahlberg, in his dissertation "On the Dynamic Behaviour of Electromagnetic Relays", presented a new theory for the operate and release motion of the relay armature. Motion time, speed and acceleration are analysed. The effect of the mass on the motion is explained. The self-governing capacity of the armature, which did not appear in earlier presentations of armature motion, is illustrated, and means of utilizing it for reducing the acceleration peaks in the motion are demonstrated. Armature and contact vibrations are thereby reduced and the speed of operation can be accelerated.

José Gerstl Valenzuela, in his dissertation "Study of Certain Types of Cyclic Gradings for Random Hunting", has made a contribution to the constant efforts to improve the detailed design of telephone systems, which should assist in deciding on the most suitable methods for executing gradings in respect both of efficiency in traffic handling and of ease in introducing alterations and extending existing systems.

The author studies a given type of grading with random hunting, used in the ARF 10 system among others. By means of equations of state he obtains a previously unknown expression for the distribution of the number of busy devices in the devices of a grouping which are accessible from an inlet group.

The results have a great significance also for the calculation of congestion in link systems with grouping. They were presented at the Fourth International Teletraffic Congress in London in July 1964.

Father of T I M becomes Doctor of Technology

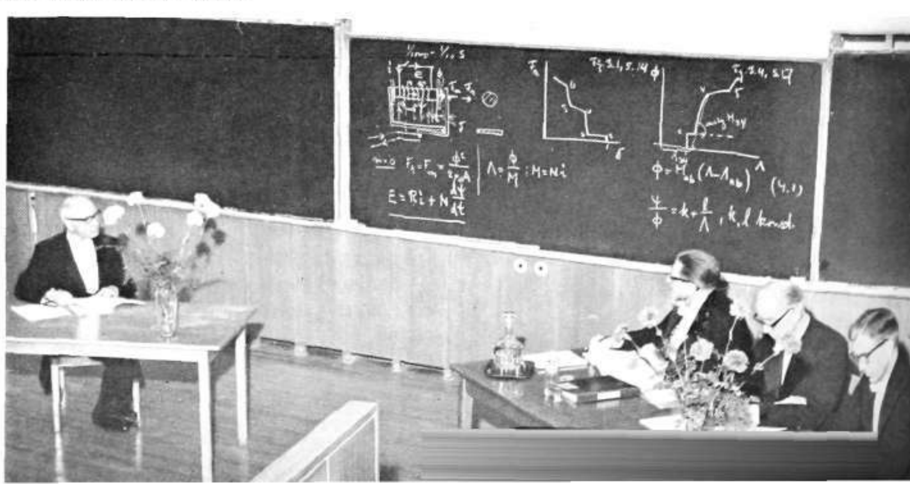
The first electromagnet was constructed in 1825 and the first relay in 1839. It might therefore be supposed that everything worth knowing about these components in modern automatic telephony had been known for a long time past. Detailed phenomena of the apparently simple operation and release of the armature have therefore been considered unworthy of notice. Insofar as the armature motion has attracted any interest at all, researchers have been content with stereotyped notions of an accelerating motion which is suddenly stopped and is associated with armature and contact vibrations, which in turn shorten its life and limit its usability to relatively low frequency applications.

A new theory advanced by Curt Ahlberg throws new light on the armature motion. It shows that a relay has an armature reaction which regulates the speed of motion in full analogy with the armature reaction in a DC motor, and that the speed is by no means always accelerated but under certain conditions may even be retarded.

The new theory was presented in a dissertation defended at the Royal Institute of Technology in Stockholm on March 25, 1965. The principal examiner was Stig Ekelöf, Professor of Theoretical Electricity at the Chalmers Institute of Technology. The second and third critics were Sam Enger, L M Ericsson Signalaktiebolag, and Olof Bager, Telefonaktiebolaget L M Ericsson.

Curt Ahlberg graduated from the Stockholm Institute of Technology in 1925 and was taken on by L M Ericsson in 1926. The Swedish photoelectric time announcer, TIM, was produced under his leadership in the company's research and development department. He has also worked in the telesignalling section of L M Ericsson Signalaktiebolag and was transferred to the technical management of the parent company as consultant in 1962.

From the public discussion of Curt Ahlberg's thesis. (From left) Curt Ahlberg, Professor Stig Ekelöf, Sam Enger and Olof Bager.



UDC 621.316.933
621.395.73
LME 7392 761

ERNA, H.: *Protection against Overvoltages on Telephone Lines.* Eriksson Rev. *42*(1965): 1, pp. 2—6.

Special measures must be taken to protect outside plant, exchanges and subscribers' apparatus against overvoltages, especially in areas where there are open wire lines. The type and extent of the protective arrangements depends on the structure of the plant, the occurrence of disturbances and on the earthing conditions.

The author here presents an account of the protective system adopted by the Helsinki Telephone Company and of the improvements in the form of lower fault rate that have been achieved.

UDC 621.395.74
621.395.34
LME 808 830

VAN BRUGGEN, A. G. C.: *The Automatic Telephone Network in Curaçao.* Ericsson Rev. *42*(1965): 1, pp. 7—13.

In this article the author presents a survey of the growth of the Curaçao automatic telephone network from the opening of the first exchange 25 years ago up to the present day.

UDC 656.257
LME 869

LEJDSTRÖM, B.: *Relay Interlocking with Puch-button Control and Train Describer System at Stockholm Central Station.* Ericsson Rev. *42*(1965): 1, pp. 14—18.

This article presents the main features of a new interlocking plant at Stockholm Central Station based on entirely new principles. Among the new features are a train describer system and a keyboard for setting up train routes.

UDC 371.3:681.84
LME 0339

EHNBORG, Å.: *RITT Method of Instruction.* Ericsson Rev. *42*(1965): 1, pp. 19—23.

Instruction units for systematic operation and experience learning are now used by several manufacturing firms and schools in Sweden. This method, called the RITT method (Rational Instruction and Training with recorded Tapes), in conjunction with specially designed apparatus, is a rational and efficient training aid, not only in industry but also in many other fields for teaching manual skills, instruction in the use of tools, machines, instruments etc., and as "check lists" for complicated manufacturing processes and the like.

The article presents an account of the method, its applications, advantages and the results achieved.

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CONTENTS

On cover: L M Ericsson's factory at Broadmeadows, Australia. These quick-fingered ladies are working on cable forms for telephone relay sets and registers.

Equalizers for Telephone Channels

W. WIDL, TELEFONAKTIEBOLAGET LM ERICSSON, STOCKHOLM

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The existing telephone networks belonging to telecommunications administrations have been established with a view to permitting satisfactory speech connections between subscribers. However, the introduction of data transmission places new requirements on the network transmission characteristics. These can be fulfilled by introducing supplementary equipment in the circuits used for data transmission. The equipment developed by the L M Ericsson Telephone Company for this purpose is described in this article.

The increased demand for rapid transmission of information in coded form between data equipment at different points, makes it necessary for administrations to provide data transmission lines which in length correspond to, for example, trunk circuits in a telephone network. A satisfactory telephone circuit is, however, not necessarily a satisfactory connection for transmission of data. Telephone circuits have been planned and constructed so that they satisfy reasonable requirements by the telephone subscriber as far as the faithfulness of reproduction of the shades of information contained in the human speech is concerned. The data equipment naturally lacks the ability of evaluating subtle tones, but demands in return a perfect transmission of the signal shapes which carry out the transfer of information.

These different requirements from the transmission technique point of view become evident in that in speech transmission, the main requirement is that there shall not be too great a difference in attenuation at different frequencies within the speech band (variation of equivalent). If the various frequencies arrive with a few milliseconds time difference (the difference in transmission time depending on the variation of group delay and the phase distortion respectively), an average ear will not notice this.

The state of affairs is different in the case of data communication. Both attenuation distortion and phase distortion interfere when sending pulses, but as a rule it is phase distortion which limits the use of a telephone circuit for data transmission.

When it is a question of long and arbitrarily chosen circuits for data transmission, administrations are therefore faced with the following question. Is a completely new network to be built, or is it possible and economical by special measures to make the existing telephone circuits usable for data transmission?

In general, the answer depends on the order of data speeds used for transmission of information. Investigations thus show that the general telephone network, as a rule, is suitable for transmission of 600 bits/sec. or in certain cases 1200 bits/sec. without special arrangements. For higher data speeds the phase and attenuation distortions occurring in modern carrier and loaded cable circuits can often be compensated in a satisfactory manner by using so-called equalizers connected in series with the line. If these are designed on a modular principle, as described in this article, this permits simplified storage and a simplified application, thereby making the equalizing method economically advantageous.

Channel Equalization

Distortionless transmission of pulses requires the attenuation in the transmission band to be constant [$A(f) = A_0$] and the phase shift in the band to be linear with frequency [$B(f) = k \cdot f$] as shown in fig. 1. The channel phase shift can also be expressed as the group delay τ_g [$\tau_g = \mathrm{d}B(f)/\mathrm{d}f$]. Distortionless transmission requires the group delay to be constant throughout the transmitted band.

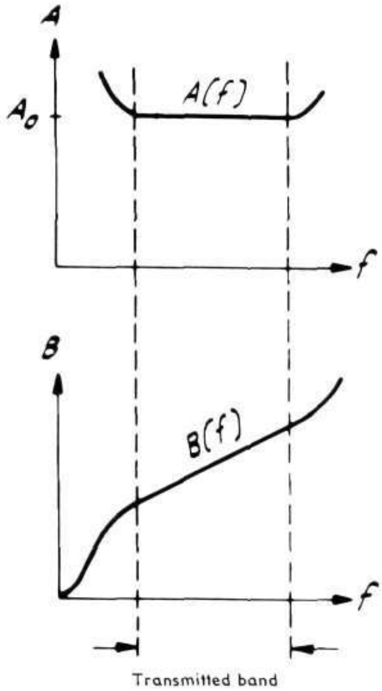

Fig. 1
Distortionless transmission channel
A **Attenuation**
B **Phase shift**

When connecting a distorting channel and an equalizer in series, a transmission medium is obtained which only in the ideal case fulfills the given requirements for completely distortionless transmission. Fig. 2 illustrates the equalization of a loaded line within a frequency band $0–f_g$ c/s. When equalizing, the loss of the equalizer is added to the line attenuation and the equalizer phase shift is added to that of the line. The equalized line therefore has greater loss in the passband, greater phase shift and group delay than before equalization.

When equalizing, it is in practice not possible, among other things for economic reasons, to realize the desired ideal [$A(f) = A_0$, $B(f) = k \cdot f$]. The deviation from the ideal case (residual error) leads to a remanent pulse distortion even after equalization, resulting in increased sensitivity to external interference. A transmitted pulse becomes distorted due to the magnitude and shape of the residual error. Mathematically, the residual error causes a series of pulse echoes which are superimposed on each other. When equalizing, the residual error usually occurs in the form of waves of different amplitudes and wavelengths. For baseband signals (having spectral components between 0 and a cut-off frequency f_g) and single sideband modulated signals (having spectral components between the carriers f_c and $f_c + f_g$) the following rules of thumb apply in the case of a sinusoidal residual error:

- ☐ A sinusoidal residual error in *attenuation* results in two pulse echoes located symmetrically with regard to the transmitted pulse i.e. a symmetrical transmitted pulse does not become asymmetrical but becomes wider (fig. 3 a).
- ☐ A sinusoidal residual error in the *phase characteristic* results in two antimetric pulse echoes relative to the transmitted pulse, i. e. a symmetrical transmitted pulse becomes asymmetric and wider (fig. 3 b).
- ☐ A sinusoidal residual error of *short* period gives rise to echoes situated relatively far away from the transmitted pulse (fig. 3 c).
- ☐ A sinusoidal residual error of *long* period gives rise to echoes situated relatively close to the transmitted pulse (fig. 3 d).
- ☐ The magnitude of the echoes is proportional to the amplitude of the sinusoidal residual error (fig. 3 e).

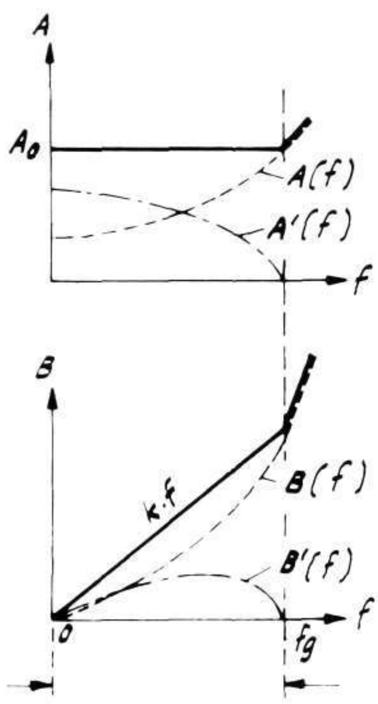

Fig. 2
Equalized loaded line
A(f) **Attenuation**, *B(f)* **Phase shift** — of loaded line
A'(f) **Attenuation**, *B'(f)* **Phase shift** — of equalized loaded line
A_0 **Attenuation**, $k \cdot f$ **Phase shift** — of the equalized loaded line in the transmission band

A sinusoidal residual error produces a single pair of echoes. When approximating arbitrary residual error graphs however, by applying Fourier analysis, a number of pulse echoes are obtained which contribute to the pulse distortion. When transmitting double sideband modulated signals, the influence of the residual error can be calculated after expressing them in terms of the equivalent baseband signals.

The residual error which can be tolerated, and therefore the necessary equalization, mainly depends on the shape of the transmitted signal and thereby on its spectral distribution. It is usual to assume a constant spectral distribution

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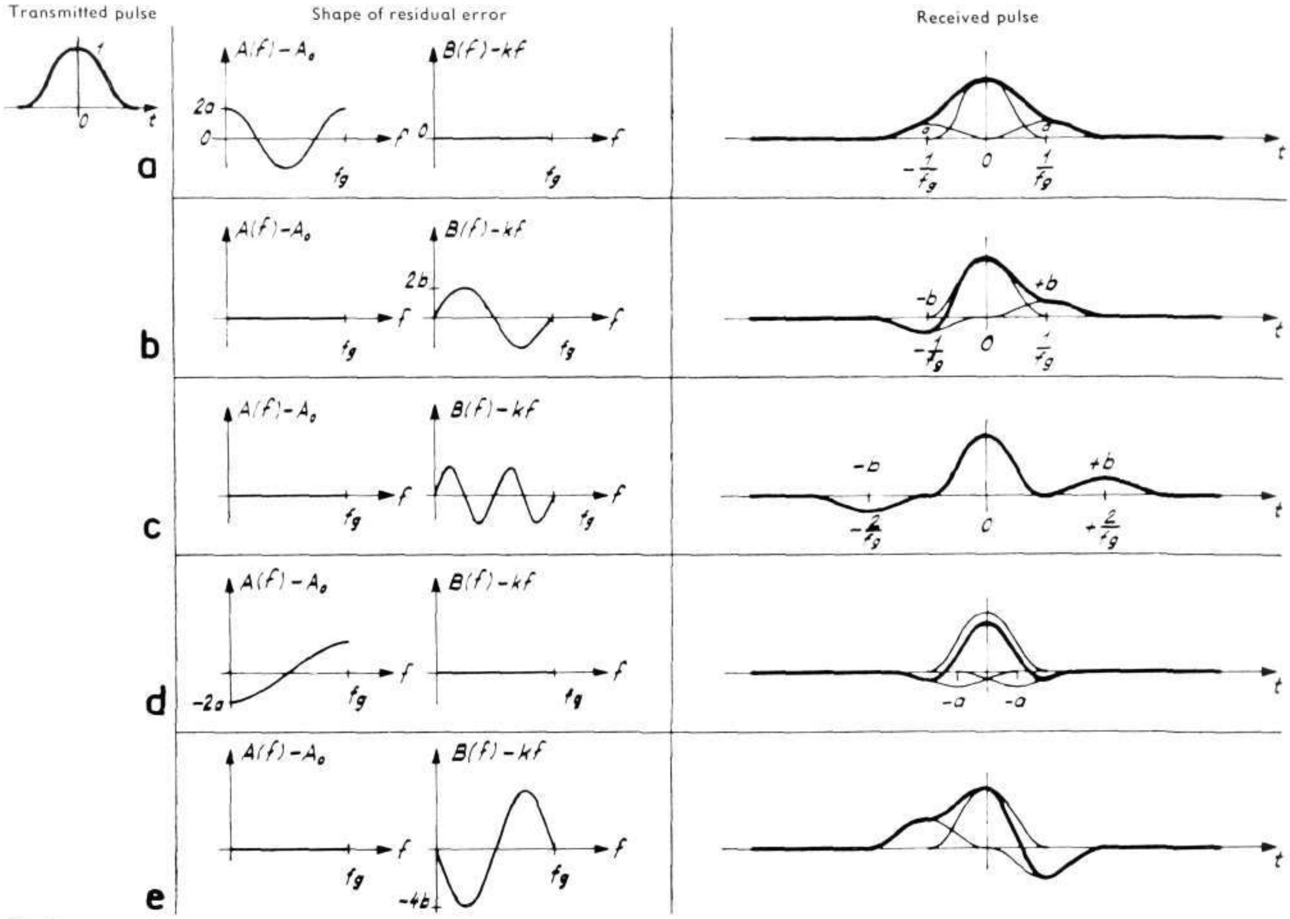

Fig. 3
Pulse distortion due to sinusoidal residual error
f_g Cut-off frequency of transmitted band

throughout the band to simplify the application of equalizers. It is also desirable to state a simple specification of the permissible residual error, preferably independent of the waveform of the residual error.

Phase and attenuation residual errors can be specified by their r.m.s. or peak values. Theoretical investigations show that the first alternative describes most favourably the relationship between the shape of the residual error and its influence on the transmitted signal. On the other hand, practical treatment leads to the necessity of calculating a graph by the method of least squares, a procedure which often means graphical integration. When equalizing telephone channels, residual error graphs are however often encountered where they can without great disadvantage be characterized by the peak value of the residual error. This appreciably simplifies the calculation. Instead of the peak value of the phase residual error the peak value of the group delay residual error can be given, thereby further simplifying the setting of the tolerances. The group delay residual error is the deviation from a constant: the phase residual error, on the other hand, is the deviation from a straight line of positive gradient with respect to frequency. To illustrate the difference between different tolerance settings, a phase residual error graph for an equalized carrier circuit is shown in fig. 4, together with the associated graph of group delay residual error obtained by differentiating the phase residual error graph. It will be seen that the residual error for τ_g is large at the edges of the band and decreases toward its centre.

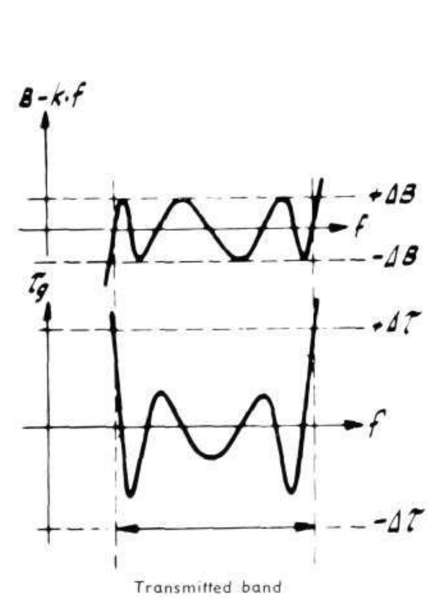

Fig. 4
Equalized carrier circuit
$B-k\cdot f$ Phase circuit
τ_g Variation of group delay

Technical Data for Equalizers

In the equalizers developed by L M Ericsson, passive, four-terminal networks consisting of capacitors, inductors and resistors are used. Three types

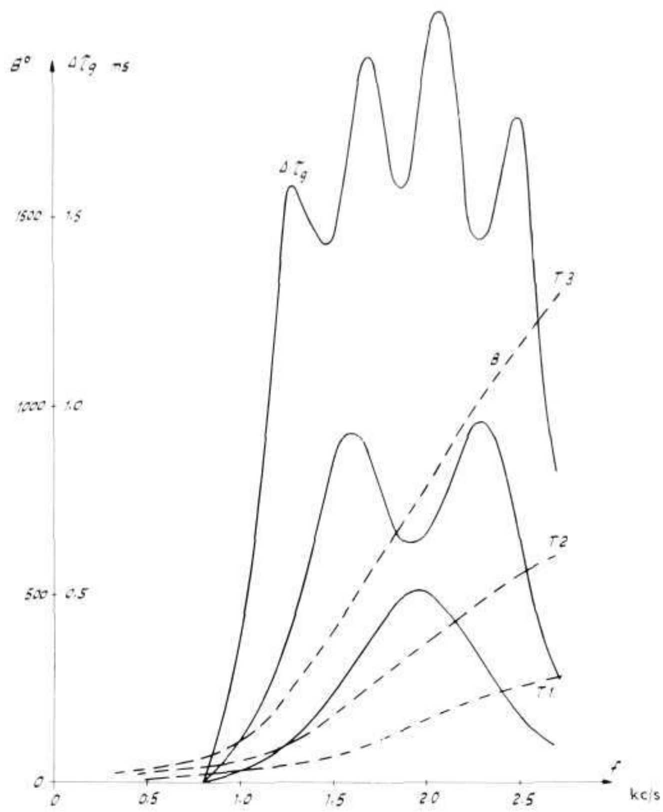

Fig. 5
Phase equalizing networks ZHD 10120—10121 for carrier circuits
B Phase shift
$\Delta\tau_g$ Group delay

of network have been designed for use in equalization of loaded circuits and carrier circuits and are as follows:

- phase equalizing networks for carrier circuits
- phase equalizing networks for loaded circuits
- attenuation equalizing networks for loaded circuits

The networks can be connected together like "building bricks" for equalization of a large number of different combinations of channels.

As already mentioned in the introduction, when sending pulses over distorting telephone networks, it is found that phase distortion causes more interference than attenuation distortion. For many circuits it is therefore sufficient to have phase equalization alone. Phase equalizing networks in addition have an inherent attenuation characteristic which in certain parts of the transmitted band counteract the variation of attenuation with frequency of the line.

☐ Phase equalizing networks for carrier circuits are used for equalizing a telephone circuit consisting of CCITT carrier circuits in tandem. The networks consist of one or more all-pass sections, the resonant frequencies of

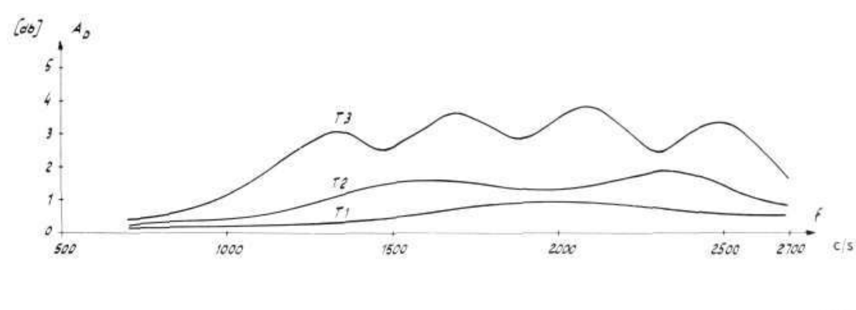

Fig. 6
Phase equalizing networks ZHD 10120—10121 for carrier circuits
A_D Equivalent

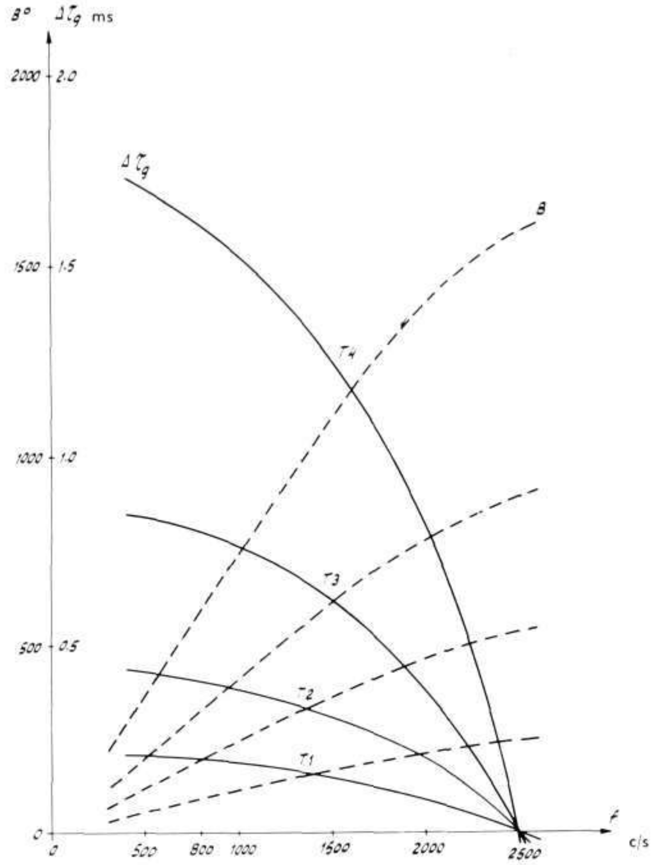

Fig. 7
Phase equalizing networks ZHD 10113—10115 for loaded lines
B Phase shift
$\Delta\tau_g$ Group delay

which lie distributed along the frequency axis so that an approximately sinusoidal residual error is obtained. Fig. 5 shows the phase shift and group delay characteristics of the equalizing networks and fig. 6 shows their variation of attenuation with frequency.

☐ Phase equalizing networks for loaded circuits are used for equalizing telephone circuits composed of loaded cables. To match the networks to the most usual loadings, a standard group delay graph has been agreed upon as a result of a large number of measurements. This mean graph is mainly based upon a loading of 132/55 mH — 1600 m, but it agrees very well for most standard loadings. The equalizing networks are designed for equalizing loading circuits having a group delay response corresponding to the mean standard graph. The networks are characterized by the variation of group delay occurring between 800 c/s and 2500 c/s. Networks have been designed to compensate for a variation of group delay of 0.2, 0.4, 0.8 and 1.6 ms. Fig. 7 shows the phase shift and group delay characteristics of the phase equalizing networks, and fig. 8 shows their variation of attenuation with frequency.

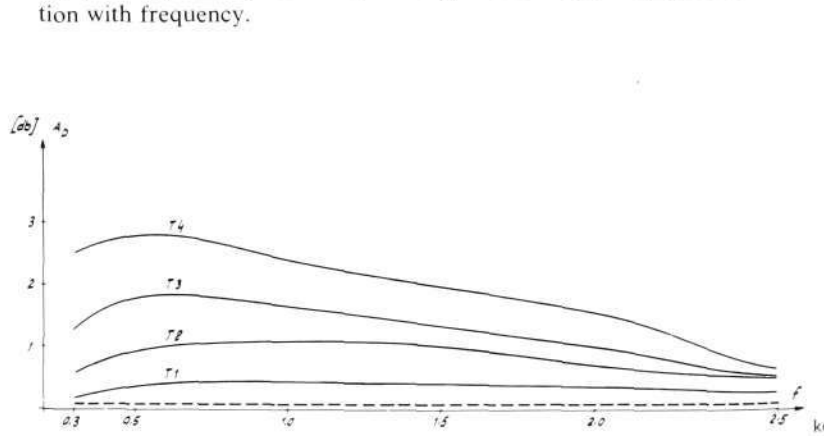

Fig. 8
Phase equalizing networks ZHD 10113—10115 for loaded lines
A_D Equivalent
— — — Transformer ZHD 10112

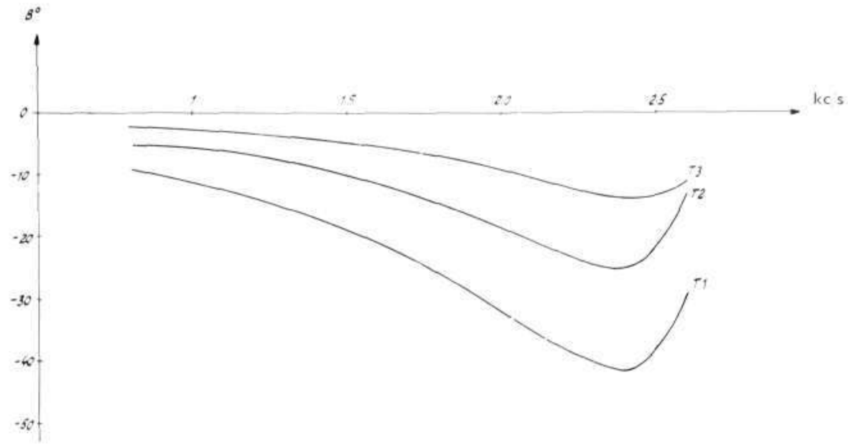

Fig. 9
Attenuation equalizing networks ZHD 10127 for loaded lines
B Phase shift

☐ Attenuation equalizing networks for loaded circuits are designed for equalizing circuits having variations of attenuation of 6, 8 and 12 db respectively in the frequency band 800 c/s to 2600 c/s. The phase and attenuation characteristics of the networks are shown in figs. 9 and 10.

The equalizing networks have been designed to have an unbalanced impedance of 3.6 kohms, and matching to a balanced 600 ohms line is made by means of matching transformers at input and output. The technical data for the equalizing networks are given in table 1 and for the matching units in table 2.

The parameters of the equalizers can be determined by measurement of the distortion of the transmitted channel in the frequency or domain by measurement of the channel pulse echo in the time. Using the same methods, the equalized channels can be checked to determine the shape of the residual errors or their influence on the transmitted signals.

The mechanical design of the units is in accordance with L M Ericsson's standard method for transmission equipment. The units used for channel equalization (equalizing units, transformer units and dummy units) are placed in a shelf for mounting in a 19 inch rack or in a transportable container. Each shelf will hold 12 units.

To obtain great flexibility in use, the different units can be combined in various ways. The shelf has therefore been wired so that by strapping in a

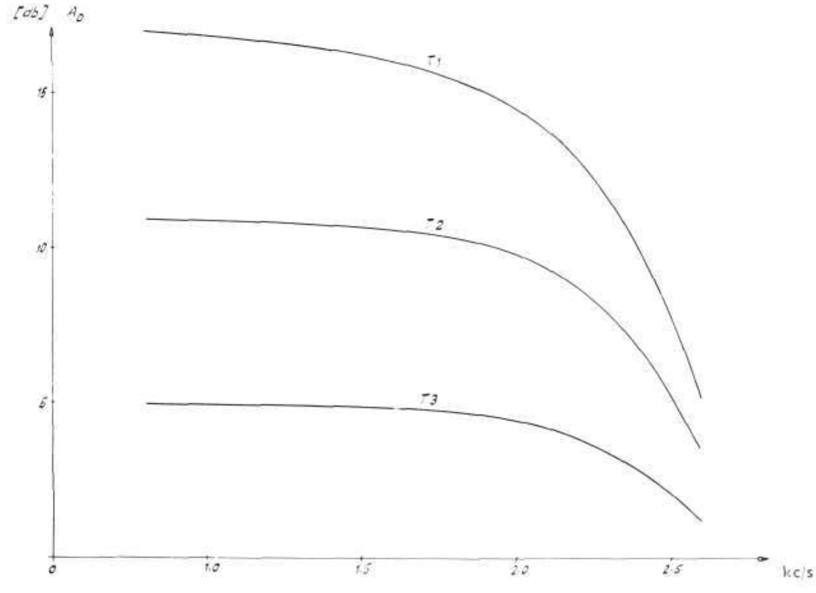

Fig. 10
Attenuation equalizing networks ZHD 10127 for loaded lines
A_D Equivalent

Table 1

Equalizer	Code: unit, network	Parameter	Frequency Range	Attenuation in pass band	Remarks
Phase equalization Carrier circuits	ZHD 10120, type 1 (T 1) ZHD 10120, type 2 (T 2) ZHD 10121, type 3 (T 3)	1 carrier channel 2 carrier channels 4 carrier channels	800—2700 c/s 800—2700 c/s 800—2700 c/s	< 2 db < 3 db < 5 db	Residual error for CCITT channel < |± 15°| (figs. 5 and 6)
Phase equalization Loaded circuits	ZHD 10113, type 1 (T 1) ZHD 10113, type 2 (T 2) ZHD 10114, type 3 (T 3) ZHD 10115, type 4 (T 4)	0.2 ms 0.4 ms 0.8 ms 1.6 ms } delay distortion between 800 and 2500 c/s	300—2600 c/s 300—2600 c/s 300—2600 c/s 300—2600 c/s	< 1 db < 2 db < 3 db < 4 db	figs. 7 and 8
Attenuation equalization Loaded circuits	ZHD 10127, type 1 (T 1) ZHD 10127, type 2 (T 2) ZHD 10127, type 3(T 3)	12 db 8 db 4 db } variation of attenuation	800—2600 c/s 800—2600 c/s 800—2600 c/s	17 ± 0.6 db 11 ± 0.6 db 5 ± 0.6 db } at 800 c/s	Phase distortion between 800 and 2500 c/s < |± 15°| (figs. 9 and 10)

Table 2

Matching unit	Code	Remarks
Transformer unit	ZHD 10112	Matching between balanced channel 600 ohms and unbalanced equalizer 3600 ohms return loss with equalizer > 15 db
Dummy unit	ZHZ 11322	replaces equalizer in certain network combinations

terminal block at the side of the shelf, network combinations consisting of a varying number of equalizing units can be obtained. The following combinations can be mentioned as typical examples:

- 1 transformer unit + 1 equalizing unit
- 1 transformer unit + 2 equalizing units + 1 dummy unit
- 1 transformer unit + 3 equalizing units
- 1 transformer unit + 4 equalizing units + 1 dummy unit
- 1 transformer unit + 5 equalizing units

Different combinations can be obtained in the same shelf. Certain equalizing units contain several different types of network and by means of strapping on the front of the equipment, the required types of network can be connected.

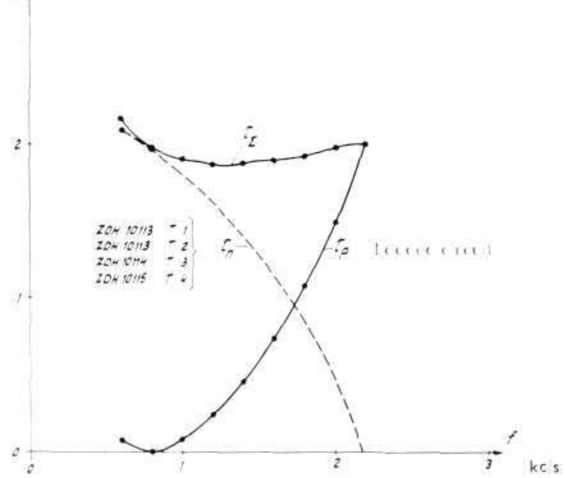

Fig. 11.
Equalization of loaded line
τ_p Group delay of loaded circuit 183 km, 132/55 mH—1600 m
τ_n Group delay of equalizers in tandem
τ_Σ Group delay of equalized loaded circuit

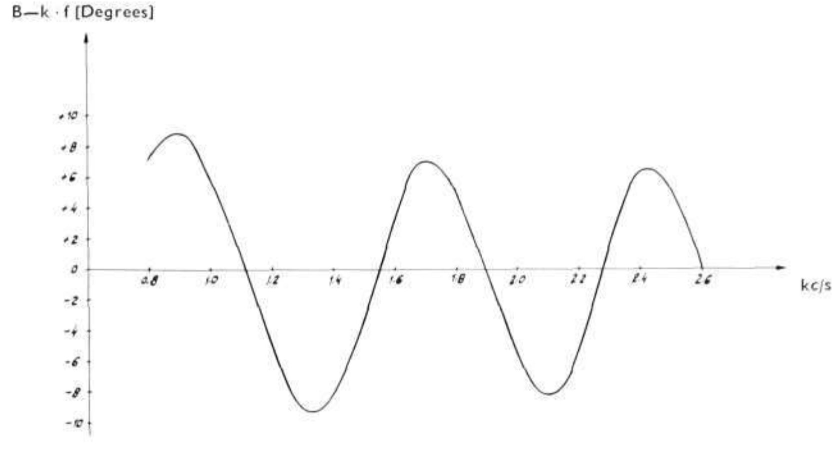

Fig. 12
Equalization of two carrier channels in tandem
$B - k \cdot f$ **Phase distortion**

Applications of Equalizers

As an example, the equalization of a 183 km long line with loading 132/55 mH — 1600 m is shown in fig. 11. In the frequency range 600–2200 c/s the group delay residual error after equalization is within $\pm$ 0.16 ms.

Finally, fig. 12 shows the phase residual error occurring when equalizing carrier channels in tandem. The residual error between 800 c/s and 2600 c/s is limited to less than $|+9^\circ|$.

Equalization of several different data transmission channels has shown that a relatively rough equalization increases the quality of the channel appreciably.

The construction of the equalizing network in accordance with the "modular principle" facilitates and shortens the work involved in channel equalization.

L M Ericsson Laser for Rangefinding

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UDC 621.317.39
621.375.9
LME 7292

L M Ericsson has been engaged on development work within the field of laser for some time past. A first result of this work is the laser rangefinder made at the Military Electronics Division of L M Ericsson. In its present design the rangefinder can without difficulty be carried and operated by one man. After minor modifications it can, of course, also be permanently installed, for example in an aircraft or tank. Among the civil uses of the rangefinder may be mentioned the measurement of cloud altitude for meteorological and air-traffic requirements, and in land survey. Among military applications are accurate rangefinding for different kinds of fire control, e.g. for artillery and coast artillery units. The rangefinder can also be used in tanks and naval vessels, and as rangefinding element in the sights of ground attack aircraft.

Principles of Laser

Before describing the design of the rangefinder it may be worth while to say a few words about the principle on which laser radiation can be produced and about the characteristics of the laser generating elements for different purposes.

The word LASER is an abbreviation of "Light Amplification by Stimulated Emission of Radiation".

In order to explain its physical import, we must consider the various states of energy which the electrons in an atom may assume. Some of the electrons in an atom may appear in different discrete orbits around the atomic nucleus, the particular orbit being determined by the energy of the electron. When the electron jumps from one orbit to another, this is accompanied either by absorption or emission of energy in the form of radiation. The frequency of this radiation is determined by the relation $\nu \cdot h = E$, where ν = the frequency of the radiation, h = Planck's constant and E = the change of energy level when the electron changes from one orbit to another.

Fig. 1
L M Ericsson laser in action

The electron changes from an orbit with a lower energy level to an orbit with higher energy level if it is supplied with energy $E = \nu \cdot h$ (a photon) in the form of radiation with the frequency ν. Often, however, the higher energy levels are unstable, and the electron will tend to return spontaneously to a lower energy level. This tendency can be considerably increased if a photon of frequency ν corresponding to the transition between the two energy levels hits the atom. Therefore, if a photon of the right frequency hits an atom which has already been excited to a high level, a kind of resonance occurs, and two photons instead of the incident single photon will be emitted from the atom. This phenomenon is called stimulated emission and can under suitable conditions be used to amplify an electromagnetic wave.

The earliest application of this principle of amplification was the maser. MASER is an abbreviation of Microwave Amplification by Stimulated Emission of Radiation. The resemblances between maser and laser are so great that many consider that laser should properly be called Optical Maser.

The type of laser with which we are concerned is an oscillator employing this principle of amplification. In the oscillator the atoms are excited to a higher energy level either by illumination of the active laser material with light from, for example, a flashbulb* or by passing an electric current through it. When an electron in the material thereafter changes to a lower energy level, radiation is generated which in turns stimulates an adjacent atom, and so on, so amplifying the radiation. The characteristic feature of the laser is that this process can be so arranged that the radiation becomes monochromatic, i.e. of practically a single frequency, and coherent, i.e. the phase of the outgoing wave is unambiguously determined by time and position coordinates. Thus laser light, in contrast to ordinary light, possesses properties which in these respects resemble those of the radiation which we have long been able to generate at microwave frequencies.

The principles of how the laser action can be achieved were elucidated during the 1950's by, among others, A.L.Schawlow and C.H.Townes who, in 1956, suggested that the active laser material be placed between parallel mirrors at a suitable distance from one another. In 1960 laser action was demonstrated in practice by researchers at Hughes Aircraft Company, and since then a large number of different laser systems have been built.

Laser action can be obtained both in gaseous and in solid media and one may distinguish between three main types of laser which have hitherto been put to practical use, namely *gas lasers* in which a gas mixture is excited by means, for example, of an electric discharge, *crystal lasers*** in which the active medium consists of a crystal containing suitable excitable ions which are supplied with energy from a flashbulb, and finally *laser diodes* in which the laser action arises in a P-N junction when an electric current passes through the diode.

By using substances of different composition in the active laser material the laser radiation can be given varying properties in respect, for example, of the wavelength of the radiation, and laser radiation has been produced at a large number of wavelengths from the ultraviolet to the infrared range.

Gas lasers and diode lasers are still used, mostly for generating continuous radiation or pulses with high repetition frequency and low pulse power, whereas crystal lasers may be used for generating pulses of short duration and high power. It is the latter type of lasers which are normally employed in rangefinders, usually with a ruby crystal (aluminium oxide doped with chromium) as active laser material. This is because, with the pulsed ruby laser, one can generate short light pulses with a high pulse power, so that a good range resolution can be achieved simultaneously with a comparatively large maximum range. With the ruby laser one can produce pulses of duration less than 100 nanosec (10^{-7} sec) and a pulse power of several MW.

The rangefinder designed by L M Ericsson is built up around a laser of this type, and in the sequel we shall limit the discussion to the ruby laser. In this laser the atoms are excited to a higher energy level with the aid of a flashbulb from which the ruby crystal absorbs light within the green wavelength range. The light which is then emitted on the return of the atoms to a lower energy level lies within the visible red wavelength range.

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* The frequency of the light absorbed by the laser material does not normally coincide with that of the emitted laser light. This is so because more than two energy levels in the atom are used. The electrons are first excited to a higher energy level with short life, thereafter changing to a more stable level (metastable level), and the laser light is not generated until the electrons change from the latter level to the basic state. The transition between the two excited levels is usually not accompanied by emission of light but results solely in heating of the laser material.

** In exceptional cases the material need not be crystalline. An example of this is the neodymium laser in which the active laser material consists of glass doped with neodymium.

To obtain a coherent laser radiation the emitted laser light must be reflected back into the ruby crystal by means of mirrors. The generation of a well-defined laser pulse is effected by regulating the quantity of light reflected back into the laser crystal, e.g. by changing the angle between the two reflecting surfaces. When the reflecting surfaces are parallel, the energy of the reflected light is greatest and at that moment a large number of atoms return to a lower energy level under emission of coherent laser radiation. Since the space between the two mirror surfaces can be compared to a microwave cavity, one says that one varies the Q-value and the method is called "Q-switching".

The ruby crystal is usually given the form of a rod of length considerably greater than its diameter. The mirrors are placed at the ends of the rod perpendicular to the longitudinal axis and one mirror is made slightly transparent for laser light. The other mirror may be movable (it may consist, for example, of a rotating prism), so that the two mirror surfaces can be brought into parallelism at the moment when the ruby crystal has been supplied with sufficient energy from the flashbulb. When the mirror surfaces are parallel (maximal Q-value) the laser pulse is emitted.

Rangefinding with Pulsed Ruby Laser

Since the power of the ruby laser is high and the duration of the pulse short, the pulsed ruby laser allows considerable range resolution.

Furthermore, since the light is coherent and monochromatic, it can be concentrated by means of suitable optics within a very small angular range, which both allows a considerable angular resolution and also increases further the energy of light with which an object can be illuminated. This makes it possible to measure the range to small objects at comparatively large distances. To measure the range to an object, one simply transmits a laser pulse which illuminates the object, and after reflection from the object the pulse is picked up by a receiver. By measuring the time elapsing from transmission of the laser pulse until the reflected pulse has been received, one obtains a measure of the range. In practice the time measurement is done by making the outgoing laser pulse start an electric "clock" which is stopped when the reflected pulse is picked up by the receiver. A counter connected to the "clock" can then directly indicate a numerical value of the range. If one wishes, one can also present the video signal from the optical receiver on an oscilloscope.

The receiver may consist, for example, of a photomultiplier with associated optics and amplifier so assembled that the axis of the receiver optics is parallel to that of the laser.

Since the width of the laser beam (lobe width) is very small (between 0.2 and 2 milliradians), considerable accuracy is required in aligning the rangefinder on the target and a sight is therefore usually included in the optical system. The alignment is therefore normally done in daylight, but this hardly disturbs the receiver since the optical bandwidth is very small. Owing to the high concentration of energy in the emitted laser pulse, special measures must be taken to protect the personnel using the rangefinder against eye injury. Since the flashbulb is fed with high voltage, special protective circuits must also be introduced to avoid high voltage accidents.

Problems and Limiting Factors

In the design of a laser rangefinder a compromise must be made between opposing demands and limiting factors.

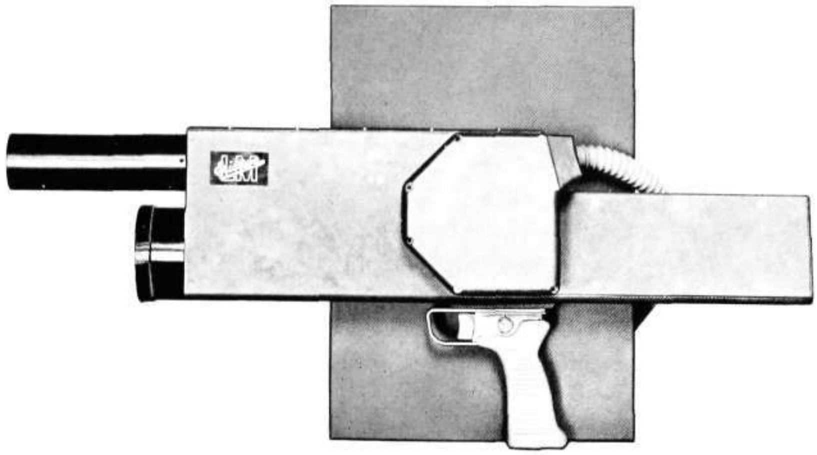

Fig. 2
External design of laser rangefinder

In a certain application one may imagine, for example, that a high pulse repetition frequency is desired, i.e. the ability to carry out a large number of measurements in a short time. The pulse repetition frequency, however, is limited by the heating of the ruby crystal, which results in a reduced pulse output. A high pulse repetition frequency, therefore, results in a reduced maximum range unless the cooling of the ruby crystal is improved correspondingly. In another application one may be interested, instead, in as large as possible a maximum range. The maximum range is determined by the magnitude of the reflected energy from the target in relation to the sensitivity of the receiver. One can increase the received energy, for example by reducing the lobe widths of the laser beam and receiver optics, but this may result in impracticable demands on the accuracy of angular alignment.

Atmospheric variations cause great variations in the maximum range since absorption and spread of the laser beam are greatly affected by the content of water vapour and water drops in the atmosphere.

Smoke and particles of soot in the atmosphere also limit the optical range and may lead to errors in measurements since they give rise to strong reflexes which may be confused with the reflex from the target. There are, however, ways of avoiding this.*

If the laser rangefinder is to be made portable and handled by one man, the need for low weight involves various limitations. The capacity of batteries and power units for charging the capacitor bank which feeds the flashbulb cannot then have so high a capacity as one would desire, and this leads to a low measuring frequency (pulse repetition frequency). The possibilities of effective cooling of the ruby crystal and flashbulb are likewise reduced by the requirement of low weight. If the environmental requirements are severe, the choice of components is strictly limited.

Objectives

In the development of laser equipment the goal has been to create a flexible basic equipment which, with small modifications, can be used for many applications.

The first application chosen was to build a portable equipment (fig. 2) for ranges of 5—15 km depending on type of target, weather, etc.

* Small objects not visually observed before firing the rangefinder may also give rise to reflexes, and so to unexpected range indications. In some cases, however, this may be an advantage.

In some cases the requirements were reasonably moderate. Certain modifications have already been prepared or can be introduced after minor changes. The maximum permissible total weight is about 25 kg, but it is already possible to come down to about 20 kg. This is almost entirely a question of the choice of power supply.

A measuring frequency of 2—3 measurements per minute was considered adequate for the equipment, principally to avoid undue strain on the batteries. The cooling arrangements allow an increase of the measuring frequency to a maximum permissible total weight is about 25 kg, but it is already possible to come down to about 20 kg. This is almost entirely a question of the choice of power supply.

Great care has been devoted to making the equipment simple in use. It is started up by trigger action. Laying and rangefinding are done as with a rifle by aiming and pulling the trigger. The sight is integrated with the receiver optics, which eliminates problems of adjustment.

Protection of personnel against eye injury due to reflexes from nearby objects has been included, and automatic switching circuits to protect against high voltages have been built into the equipment.

The lobe width has not been made extremely small since in many applications lobe widths below 1 mrad must be considered unnecessary. The lobe width can, however, be reduced by replacement of the transmitter optics, which is a simple modification. A further reduction of the lobe width can be achieved by altering the dimensions of the ruby rod. As regards the receiver optics there are two alternative lens systems. Which of these systems is chosen depends on the weight distribution desired in the gun section. Use with, as well as without, a support may be desired.

The optical filter bandwidth has been made relatively large so that the equipment is less dependent on temperature. This is because the laser wavelength changes according to the temperature of the ruby crystal.

The accuracy of the range presentation is ±5 m since this may be considered sufficient in most cases. The binary counter, however, is designed for a range accuracy of ±2.5 m.

Expensive components, such as the photomultiplier in the receiver, can be replaced to comply with varying environmental requirements.

Design Features and Operation

Fig. 3 shows the block schematic of the rangefinder and the sight image obtained. The figures within brackets in the sequel refer to this schematic.

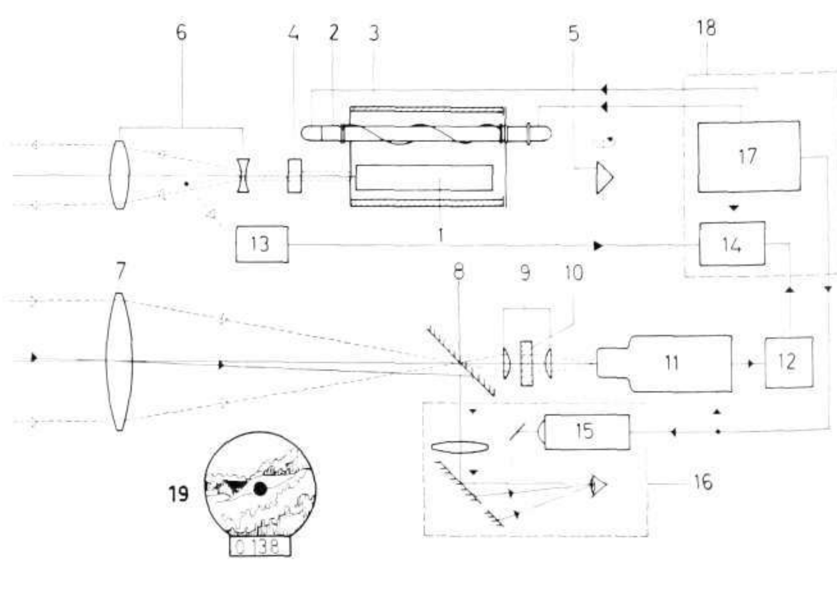

Fig. 3
Block schematic

1 Ruby rod
2 Flashlight
3 Reflector
4 Fixed mirror
5 Rotating prism
6 Lens system, transmitter
7 Receiver lens
8 Diaphragm and sight mirror
9 Lenses
10 Bandpass filter
11 Photomultiplier
12 Transistor amplifier
13 Photodiode
14 Binary counter
15 Mechanical counter
16 Sight
17 Power supply
18 Pack
19 Sight image (1380 m)

Laser Transmitter

The ruby (1) is supplied with light energy from a flashlight (2) via the elliptical reflector (3). The light is given a reciprocating movement in the longitudinal direction of the ruby rod by reflection in a fixed mirror (4) and a rotating prism (5) which functions as a Q-switch. The mirror is of multi-coated type with approx. 5 % light transparency. The flashlight is synchronized with the rotation of the prism so that the prism assumes the correct position only when a sufficient energy has been supplied to the ruby. In this position a laser pulse is transmitted through the transparent mirror to the transmitter optics. Ruby rod and flashlight are cooled by a fan.

The aperture angle of the transmitted laser beam is reduced by a lens system (6) consisting of a negative and positive lens.

Receiver

After reflection against the target a small part of the transmitted laser pulse impinges upon the receiver lens (7), passes a diaphragm (8) and a bandpass filter (10) for the laser wavelength concerned. The two lenses (9) guide the beam into the correct path through the filter and focus it on the cathode of the photomultiplier (11).

When the light pulse meets the cathode of the photomultiplier, an electrical pulse is obtained which is amplified in the multiplier. The signal is further amplified in a transistor amplifier (12) which is followed by a threshold detector.

Rangefinding

The time at which the laser pulse is transmitted is recorded by a photodiode (13) which is activated by the laser pulse. The photodiode emits a trigger pulse to a range counter. A stop pulse is obtained from the receiver.

Trigger and stop pulses are fed to the binary counter (14) which presents the range in binary decimal form (4 digits). The range is fed out to a mechanical counter (15). Zeroing takes place only on renewed firing.

Laying equipment

Aiming takes place through the receiver optics via a mirror system. The diaphragm aperture of the receiver optics is seen in the sight as a black dot (19), which is aimed at the object of which the range is to be measured. Digital range presentation is included in the sight (16). This arrangement implies that only two optical axes need be made parallel.

Power supply

The power source consists of a 24 V storage battery. Two DC converters deliver high voltage for flashlight and photomultiplier (17). The flashlight is fed by 8 electrolytic capacitors which were chosen in view of the desirability of keeping down the weight. For the relay system, motors and counters, different voltages are taken from the storage battery. The power unit and binary counter are carried in a pack on the back.

Safety devices

Safety circuits are incorporated for protection of personnel and equipment.

When any of the cables between the gun and the equipment carried on the back is disconnected, all voltages are automatically switched off and the capacitor bank is discharged. A switch also disconnects the voltages when the covers of gun or pack (18) are opened. A warning lamp is lit when the capacitors are charged.

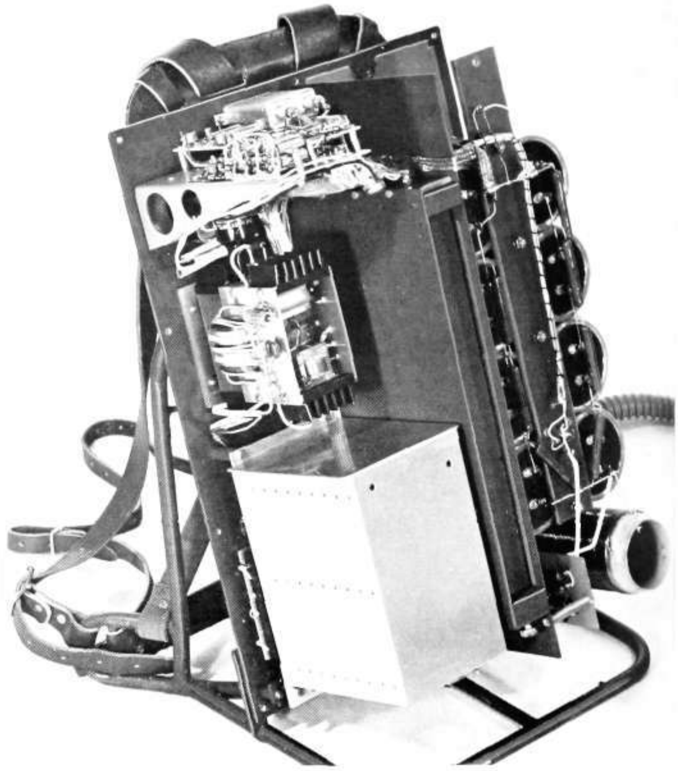

Fig. 4
Left, laser gun; right, pack with power supply and binary counter

The sight has a shutter mechanism as protection against reflexes from near-by objects. Firing cannot take place until the shutter is in position, i.e. when the field of view has been screened off. In addition, a filter can easily be placed in the sight for further protection.

The photomultiplier is protected against unintentional illumination from sunlight, for example, by a special diaphragm which opens only when firing takes place. The optical bandpass filter also limits the effect of sunlight.

The trigger has a mechanical safety catch.

Measuring procedure

When the main switch is turned on, the capacitor bank starts to charge and the cooling fan starts. When the charge has nearly reached the required level for laser action, the fan is stopped automatically. This is an indication that rangefinding can start. The firing mechanism is out of operation until the fan has stopped.

Firing takes place in two stages. At the first trigger pressure the photomultiplier with amplifier, stop pulse generator, Q-switch motor, automatic synchronizing mechanism and counters start. The counters are zeroed.

When the binary counter has determined the range, the range value is transferred to the sight indicator. Thereafter all voltages which were connected at the time of firing are switched off and the flashlight capacitor bank starts to charge again. The cooling fan starts and a new measuring cycle can begin.

Laser gun and pack with power supply are shown in fig. 4.

Applications

Some examples of the military applications for the rangefinder are shown in fig. 5.

For fire control in field and coast artillery units the positions of target and impacts can be quickly and accurately determined at large distances from the observation points. Rapid rangefinding from tanks, naval vessels, ground attack aircraft, armed light aircraft and helicopters is possible with simple equipment. In these cases the available fixed power sources allow a higher measuring frequency.

Rapid measurement of cloud altitude is of considerable value to meteorologists and in civil and military aviation. Land surveys can be simplified.

The laser can be simply incorporated with other equipment for aiming and finding of bearings, e.g. TV optics or light amplifiers. In the latter case the equipment can be used in the dark. Remote-controlled rangefinding will also be possible.

Future Developments

The laser rangefinder described is well adapted for a number of uses. For many applications, however, improved performance is needed in different respects and often, too, modifications in the mode of operation and design.

Present developments are being directed to improvement of the ruby laser and to the use of other laser components.

As regards the ruby laser the main aims are to reduce its weight and volume and to simplify its structure.

Work is proceeding on a passive Q-switch in which saturation of the absorption in an optical filter gives the desired change of Q-value, and studies are also being made of the use of microcircuits, one reason being to reduce the size of the range counter.

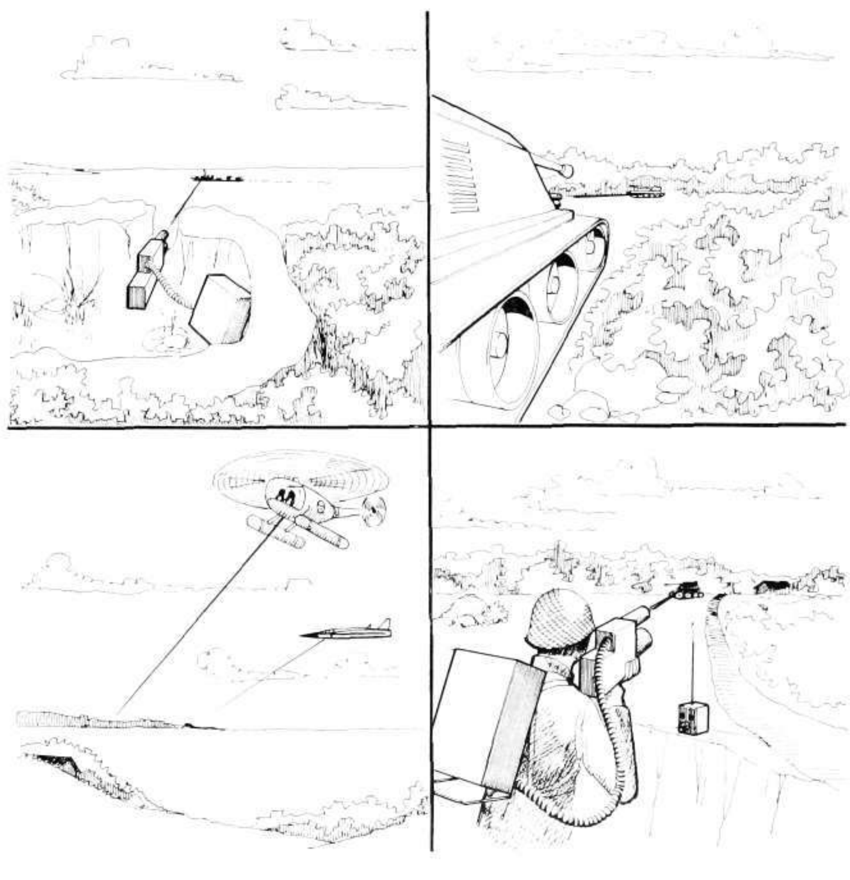

Fig. 5
Examples of use

As already noted, other types of laser than the pulsed ruby laser allow a high pulse repetition frequency. Developments are proceeding on a semiconductor laser which can deliver thousands of pulses per second. Continuously pulsed laser rangefinders for anti-aircraft fire control units are an example of the probable future applications for such lasers.

L M Ericsson is working on laser developments on behalf of the Swedish Armed Forces.

Technical Data

Principle

Ruby laser with rotating prism as Q-switch

Measuring frequency

Ca. 2 measurements per minute. 40 measurements per battery charge. With other power supply max. 5 measurements per minute.

Pulse data

Length ca. 70 ns (3 db width)
Wavelength 0.6943 μm

Lobe width

Ca. 2 mrad (can be reduced)

Laser head

Flashlight max. 600 Ws/flash
Ruby 3" long, sapphire-clad
Rotating prism, 15,000 r.p.m.

Transmitter optics

Enlargement—ca. 6.5 times

Receiver optics

Alt. 1 Focal aperture ∅ 110 mm
Lobe width ca. 3 mrad
Alt. 2 Focal aperture ∅ 80 mm
Lobe width ca. 4 mrad
Optical filter bandwidth 0.005 μm

Amplification

Photomultiplier 10^5—10^6 times
Transistor amplifier ca. 30 times

Sights

Mirror system via receiver optics

Range measurement

Binary counter: clock frequency 30 c/s
Counter range: 0—19.99 km. Presentation in the sight
Accuracy ± 5 m

Safety systems

Eye protection. High voltage protection

Power supply

Batteries: 20 cells of 1.24 V, 3.5 Ah

Dimensions

Gun: 810 × 145 × 175 mm (without handle)
Pack: 450 × 320 × 215 mm (without carrier)

Weight

Total ca. 25 kg, including pack (gun weight ca. 7 kg).

AKD 791, P.A.B.X. with Code Switches for 300—4800 Extensions

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Very high requirements are placed on the communications systems in large business and other organizations, especially on the telephone system. The system must be reliable and flexible, incur very low maintenance and other operating costs, and offer all modern traffic facilities. It must be adapted to the needs of the enterprise and be easily modifiable when organizational changes occur.

L M Ericsson's P.A.B.X. system AKD 791 introduced in this article fulfils all these requirements.

L M Ericsson's P.A.B.X. *AKD 791* (fig. 1) is designed for large enterprises or groups of enterprises. It has an initial economic capacity of about 300 extensions and a practical ultimate capacity of about 4800 extensions in its standard design. The number of connecting circuits for internal calls, and of exchange lines for external calls, can be varied as desired. The exchange is designed to carry a very large traffic but can be adapted to normal or low traffic conditions by equipment reductions.

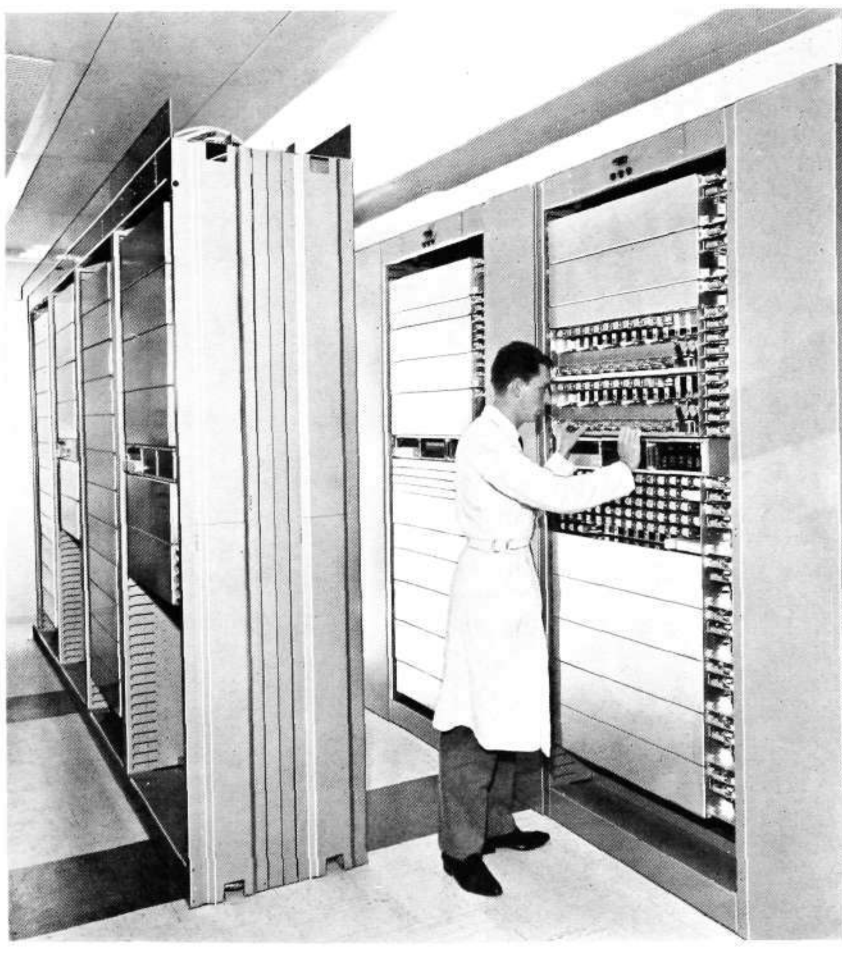

Fig. 1
Code Switch exchange AKD 791

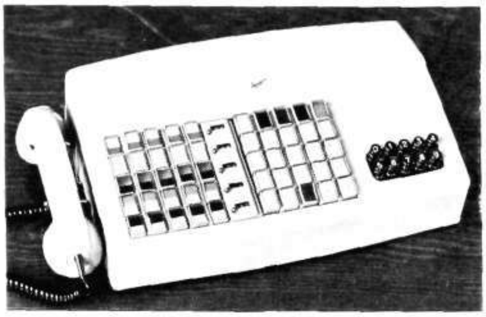

Fig. 2
Operator's console

AKD 791, in its standard design, offers the traffic facilities required of a modern P.A.B.X. today. With additional equipment various extra traffic facilities can be provided, such as automatic call-back, automatic transfer of unanswered calls to an answering point common to a number of extensions, paging equipment with answer from any extension telephone, direct access (i.e. single digit) calls, etc.

AKD 791, in its standard design, is based on the "number group" principle. This means that extension numbers need not be associated with specific multiple positions. Several extensions with different internal directory numbers, for example, can be connected to the same line and later, if required, be given their own lines without change of the internal directory number. The number group principle also permits extensions with high traffic to be moved from their respective multiple positions to other multiple positions, so allowing a better traffic distribution, while retaining their original internal directory numbers. The internal directory can thus be kept up to date for a relatively long period and the operators' work is simplified.

The extension telephones are ordinary subscriber telephones of the same type as in public telephone systems. Special apparatus such as loudspeaking telephones, secretary telephones, telephones with keyset instead of dial, can also be connected. Keyset telephones, however, require certain additional equipment in the exchange.

The operators' equipments are designed to simplify the work of the operators to the greatest possible extent. Incoming calls are switched extremely quickly, yet without loss of the perfect service needed in relation to outside subscribers. All switching is done on the operator's console or switchboard, which are fitted

Fig. 3
Example of arrangement of operator's switchboards

with push-buttons and supervisory lamps (fig. 2 and 3). The exchange is also equipped for in-dialling, i.e. external calls can be dialled direct to the desired extension without the aid of an operator.

Being equipped only with relays and relay-contact switches, *AKD 791* requires a minimum of maintenance. Special arrangements exist for simplification of fault tracing, one such arrangement being a supervisory equipment which keeps a record of the work of the exchange. Advance selection of switching paths through the exchange is also possible for testing circuits on which faults are suspected.

Owing to its compact structure *AKD 791* takes up very little space. Nor does it impose special requirements on the switchroom.

Normal Traffic Facilities

Internal Calls

All internal calls are set up automatically with the dial or keyset. A three- or four-digit numbering scheme may be employed.

Number Group

The standard exchange has a number group equipment. This is in principle a translation unit. Identification of the called extension is done on a wire or strap in the translation unit. The wire is jumpered from the terminal corresponding to the extension's internal directory number to the terminal corresponding to the extension's multiple position (fig. 4). The former terminal field is much larger than the latter, so that a large vacant number stock can be maintained.

Figs. 4 a and b show examples of the strapping of a number group in which three persons share a single extension line. They have their individual internal directory numbers—1130, 1131 and 1132—which they retain when they are given extensions lines of their own (fig. 4 b).

There are commonly certain extensions which ring more than others (the "heavy callers"). These extensions should as far as possible be placed in different extension groups so as to obtain as smooth as possible a traffic through the exchange. It may therefore be necessary sometimes to regroup some extensions in the multiple when the exchange has been in operation for some time. Regrouping of the heavy callers, however, should not imply that they change their directory numbers. Thanks to the number group, which allows any directory numbers to be strapped to any multiple position, the internal directory numbers of *AKD 791* can be retained irrespective of future regroupings (fig. 4 c).

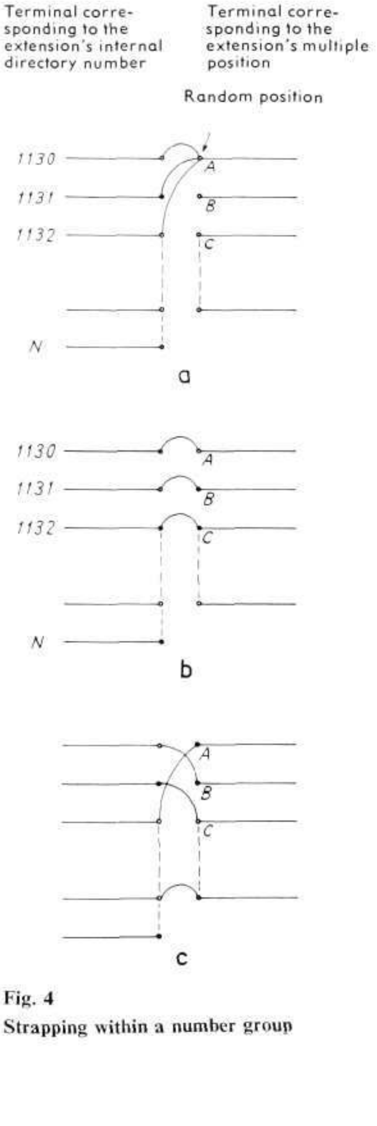

Fig. 4
Strapping within a number group

Priority

Priority can be allotted to any extension desired. On meeting an engaged number, a priority extension can enter the circuit by dialling 2. A warning tone is then issued to indicate that a third party is on the line. Priority connections cannot be established on circuits engaged on trunk calls.

Categorization of Extensions

In respect of external calls the extensions can be categorized as follows:

- ☐ Non-restricted extensions. Can set up all kind of calls.
- ☐ International trunk-restricted extensions. In the event of an attempt to dial an international call the extension is disconnected in the P.A.B.X.
- ☐ National trunk-restricted extensions. These can dial local calls but are disconnected in the event of an attempt to dial international or trunk calls. Such calls must be put through by an operator.
- ☐ Semi-restricted extensions. These can receive but not initiate external calls. External calls must be put through by an operator.
- ☐ Restricted extensions. Can be used for internal calls only.

International and national trunk restriction requires some extra equipment in the exchange (see "Extra Traffic Facilities").

If desired, the exchange can be wired so that different ringing signals are received on external and internal calls.

External Traffic

Outgoing Calls

Normally all outgoing calls are set up automatically. The extension dials a prefix (usually 0), is connected to the main exchange, *HC*, and can then dial the external number. In its standard design *AKD 791* is equipped for ten outgoing routes to different main exchanges.

Enquiry and Transfer

During a conversation with an external subscriber an extension can set up an enquiry call to another extension by dialling one digit followed by the extension number. The internal conversation cannot be overheard by the external subscriber. The extension returns to the external call by dialling a further digit. As long as the third party does not replace his handset, the extension can switch between the external and internal parties any number of times by dialling one digit.

An external call can also be transferred between extensions any number of times without the operator's assistance.

Enquiry calls can also be made and transferred to an operator.

Operator Functions

Incoming calls are answered by one or more operators. If there are several operators, an allotter ensures that the calls are evenly distributed among them.

The incoming exchange lines can be divided into a large number of groups, each of which is served by one or more operators, while some operators may serve all groups. The latter can then work as concentration operators during low-traffic periods when most or all groups are normally not attended, as replacement operators in the event of an operator on any one group not being on duty, and as auxiliary operators if the traffic on any group is so heavy that the waiting time with the ordinary operator is too long.

A division can also be made within the various groups, e.g. to distinguish between local and trunk calls. The category of call is indicated on lamps on the operators' equipment. The operator answers and puts through the call solely with the aid of push-buttons. The condition of the extension—free, engaged with call waiting, etc.—is also marked by lamp signals.

The operators have a number of facilities, some of the most important of which are mentioned below:

Waiting Facility

If the wanted extension is engaged, the operator can place the incoming call on a waiting circuit. As soon as the extension becomes free, the call is put through automatically.

Announcement of Trunk Calls

If an incoming call is urgent (e.g. a trunk call), the operator can enter the engaged extension circuit and announce the call. A warning tone is at the same time issued on the engaged circuit.

Parking

If the operator is engaged on putting through a call when a new call arrives, she can park the original call while answering the new one. After putting through the new call she can return to the parked circuit.

Transfer to Other Operator

An incoming call can be transferred to another operator or group of operators in which, for example, there are operators with special linguistic ability.

Operator Recall

In order that an external subscriber shall not be forgotten when an operator has parked his call or placed it on a waiting circuit etc., the operator's attention is recalled after a predetermined time by automatic reconnection of the subscriber to the operator. Some form of signal, moreover, is always sent to the subscriber during the waiting period etc., so that he does not get the impression that his call has been forgotten.

Consecutive Calls

If the calling subscriber wishes to speak to several extensions in succession, the operator can connect the call in "series". After every completed conversation the call is then returned to the operator, who puts it through to the next extension.

Night Service

When the operators have completed their duties for the day, incoming calls are automatically directed to predetermined night extensions from which they are answered and transferred to the called parties.

Night service may be arranged on a common basis, all incoming calls being connected to a single extension (e.g. the janitor), or on an "individual" basis, the calls being directed to different extensions depending on the exchange lines on which they arrive.

Keyset for Dialling Outgoing Calls

To save time, the operators set up external calls as well with the aid of push-buttons. The operator's console also has subscriber meters for recording the conversation period on chargeable trunk calls.

Operators' Lines and Record Lines

Every operator has her own internal directory number, so that each can be called individually. The operators can also be called on record lines with common or individual number.

Answering Machine

In order that operators shall not need to repeat the name of the firm every time they answer a call, an answering machine can be connected for this purpose.

Number Memory

The operator's console can be fitted with an extra unit, a "number memory", which records the extension number keyed by the operator. When the exchange line recalls the operator, the extension number is automatically signalled on her position equipment.

The memory is zeroed as soon as the call leaves the operator, whether due to the extension answering or to the subscriber replacing his handset.

Extra Traffic Facilities

Internal and External Calls

AKD 791 can, if desired, be equipped for several extra traffic facilities. Among these the most important are:

Push-button Dialling

Subject to the addition of certain equipment for pulse reception etc. the telephone dials can be replaced by keysets. Push-button and ordinary dial telephones can be connected to the exchange in any desired combination.

Group Calls

Several extensions can be combined into a group with a common group number, and calls then go to any free extension in the group. This is useful when one wishes to speak to any one of a number of persons on a similar job, such as filing personnel etc. All extensions in the group can also be called individually on their own extension numbers.

With another type of group call facility an extension is called first on his own number. If he is engaged or has arranged for transfer of incoming calls in his absence, the call is put through automatically to a free extension in the group.

Automatic Call-back

If an extension is engaged, the calling extension need not call again but can be automatically put through to the wanted extension as soon as the latter becomes free.

The supervisory circuit for this purpose is brought into operation by dialling a code digit on receipt of the engaged signal and thereafter replacing the handset. The call-back signal goes first to the calling party. When the latter answers, the extension who has just become free is rung and the connection is established.

The extension who initiates this procedure is not blocked during the supervisory period but can use his telephone for other calls.

Automatic Transfer of Unanswered Calls

If a person is not in his room or does not answer a call within about 10 seconds, the call is connected to an answering set common to a number of extensions. Ringing signals are then sent to both telephones and the call can be answered on either of them.

The number of extensions with this transfer facility, and the number of answering sets, is unlimited.

Paging

A visual paging system can be connected to the exchange. The procedure is that the wanted extension number is sent in code form to lamp panels. Paging can take place in two separate areas simultaneously.

When the wanted person notices his combination on the lamp panels, he goes to the nearest telephone and dials a code digit. Connection is then established automatically with the caller.

The paging equipment is intended mainly for use by the operators but can also be used by the extensions. The operators can in such case interrupt a paging call from an extension and take over the equipment themselves when important calls come in.

The equipment can be adapted to a radio paging system.

Conference Equipment

Up to six extensions can be interconnected for a telephone conference. External subscribers can also be connected to the conference.

Tie Lines to Other Private Exchanges

AKD 791 can interwork with other private extensions on a linked numbering basis, i.e. an extension dials the prefix and extension number in one sequence.

Trunk Discrimination

If the public system allows automatic international or trunk traffic, the P.A.B.X. can be equipped for discrimination of outgoing dialled calls. Any desired extensions can be debarred from dialling such calls or allowed to call only on certain trunk routes. Unrestricted extensions are unaffected by the discriminating equipment and can dial calls on all routes.

Metering

The exchange can be equipped with individual subscriber meters which are connected to each extension from which calls are to be charged. This presupposes the transmission of the necessary fee pulses from the main exchange.

Central Dictation

A special code number is used for calling an automatic dictating machine. The machine is operated with the earth button on the telephone set or by dial pulses for start, record, playback, etc.

Tape Recording of Conversations

Before or during an external conversation one can call an operator to connect a tape recorder for recording of the conversation.

Night Watchman Control

By dialling a special code number a record is obtained of the calling extension and of the time of calls. An alarm is issued if calls to the control equipment are not made at given intervals.

In-dialling

If an external subscriber knows the internal directory number of an extension, the operator's work is limited to receiving the number and setting up the connection. A very large part of the operator's work consists of such connections, but she renders no particular service in these cases.

In *AKD 791* such calls can be put through to the extension automatically if the main exchange allows the transmission of signals between the exchanges. This means that the subscriber can ring through to the wanted extension without the assistance of an operator. In *AKD 791* an in-dialling equipment is needed for this facility, in which all external incoming calls are received and the dialled number is analysed. According to the number dialled the call is then put through direct to the extension or switched to an operator.

The lesser work for the operators means that the number of operators can be reduced.

System Structure

Switching Stages and Marker Organization

The P.A.B.X. *AKD 791* consists of an extension stage *SL*, switching stage *FS*, and traffic-carrying devices such as connecting circuits, exchange lines, enquiry units, etc. (fig. 5).

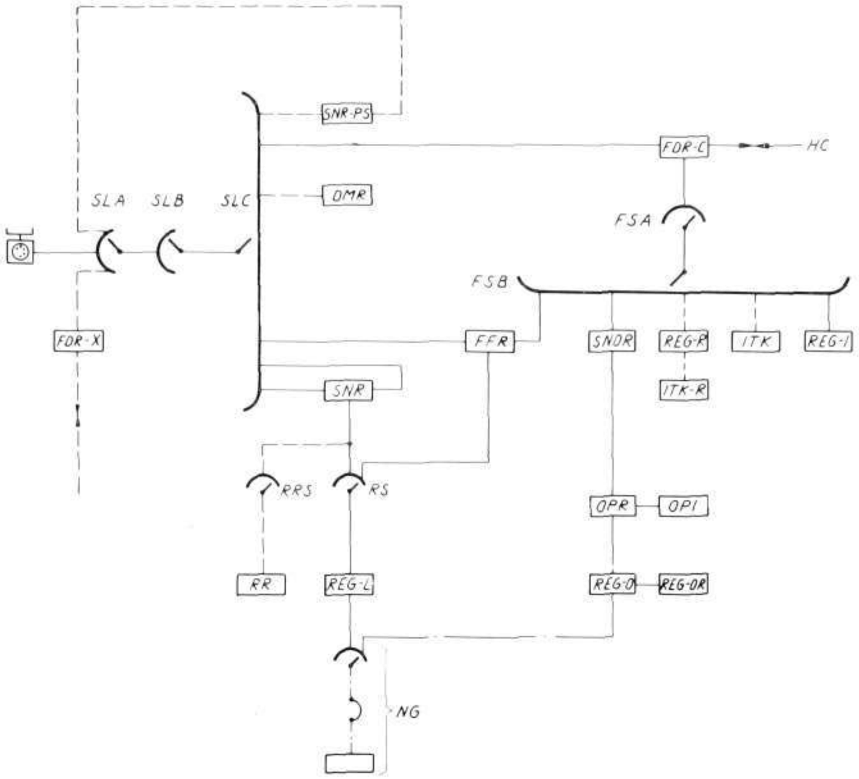

Fig. 5
Trunking diagram

DMR	Line to dictating machine
FDR-C	Exchange line
FDR-X	Tie line to other private exchange
FFR	Enquiry circuit
FSA, B	Switching stages
HC	Main exchange
ITK	Trunk discrimination
NG	Number group
OPI	Operator's console
OPR	Operator's relay equipment
REG-I	In-dialling register
REG-L	Extension register
REG-O	Operator's register
REG-OR REG-R	Registers for translation of keyset code on outgoing calls REG-OR (operator) REG-R (extension)
RR	Call-back unit
RRS	RR finder
RS	Register finder
SLA, B, C	Extension stages
SNR	Internal connecting circuit
SNR-PS	Connecting circuit, paging
SNOR	Operator's link

The extension stage *SL* can be divided into substages *A*, *B* and *C*, which on a grouping basis form a 300-line unit.

The exchange is built-up on a single marker system. This means that a group of 300 extensions forms a closed unit working with its own marker organization.

In the same way a group of devices, e.g. connecting circuits and register, form their own marker organization.

By making the markers in the various groups as independent as possible and limiting their interworking to a minimum, an optimal traffic-handling capacity is attained for these devices.

The single marker system has many advantages, among which short holding times and simple functions.

The marker connection relays have been decentralized to the respective devices. This means that the marker need never be larger than is required for the particular size of exchange.

The exchange is characterized by the fact that the *C* stage is reversed in relation to the *A* and *B* stages (fig. 5). The *C* stage is so arranged that the *C* vertical is directly connected to a given *B* vertical. Traffic-carrying units terminate on the multiple of the *C* stage, which has 480 or 360 outlets.

By this reversal of the *C* stage the final capacity of the exchange is independent of the number of extensions and is dependent solely on the traffic to be carried by devices terminating on the *C*-stage multiple.

Expansion of the exchange is done by connecting groups of 300 extensions in parallel to the common *C* multiple.

Switching Equipment

The *SLC* multiple common to the exchange accommodates the traffic-carrying units—connecting circuits, exchange line relay sets, record line relay sets, and various special equipments such as central dictation equipment.

The tie lines terminate on the *A* multiple (on an extension position). The connecting circuits together with the enquiry units are divided into groups of 30, each equipped with its own marker.

The connecting circuits are not seized on external calls. They are used, however, for traffic with other private exchanges and can therefore be through-connected.

The registers are reached via the connecting circuits or enquiry units and are divided into groups of ten. Each such group of ten registers is connected via special selectors *RS* to two groups of connecting circuits.

The registers are normally designed for reception of dial pulses but can be equipped for reception of keyset signals.

In order that the registers shall not be held for an unnecessarily long time, they are equipped for automatic release if dialling does not start within 7—10 seconds.

The exchange lines may be one-way or two-way and—like the connecting circuits—are formed in groups of 30, each with its own marker.

These groups can be combined into larger groups or divided into smaller groups which, in respect of incoming traffic, can be served by different operators.

The exchange lines are connected via two switching stages *FSA* and *FSB* and links *SNOR* to the operators' equipments *OPR* and *OPI*. Each operator has her own register *REG-O*.

Mechanical Structure

Components

The components in *AKD 791* consist principally of relays and code switches. The code switch (fig. 6) is a type of pressure-contact switch with binary ope-

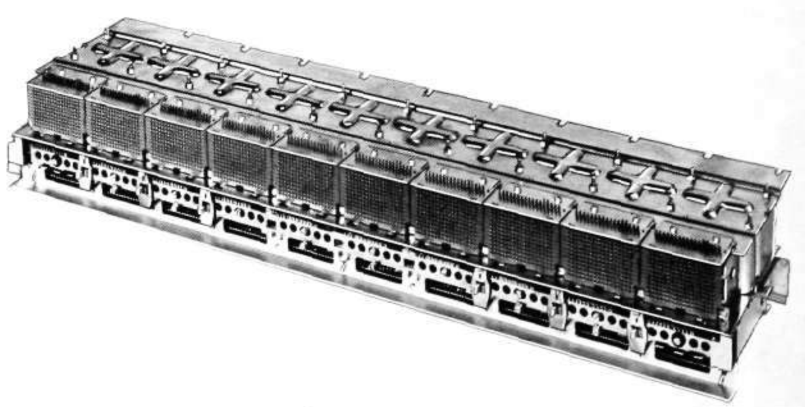

Fig. 6
Code switch

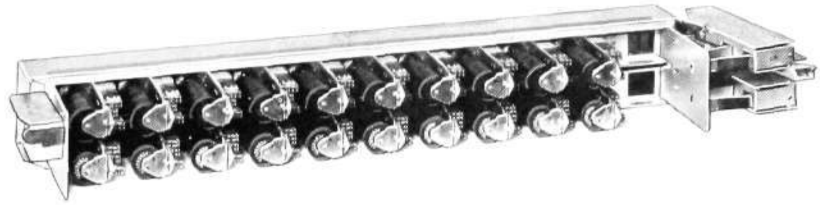

Fig. 7
Relay set

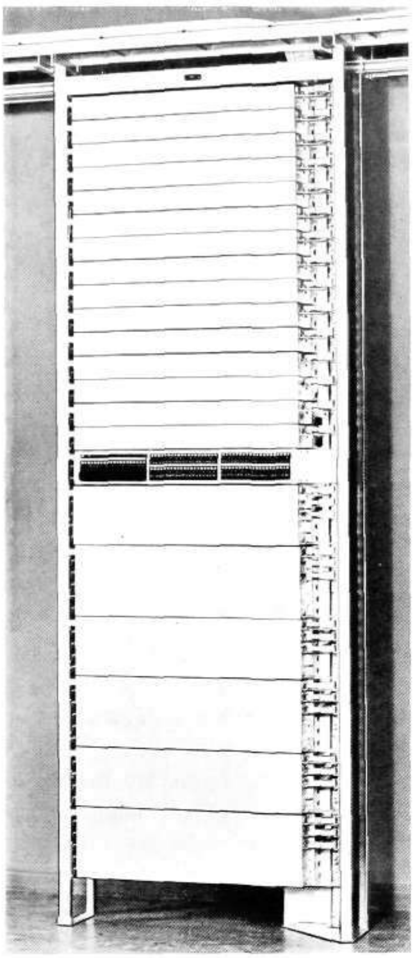

Fig. 8
Rack

ration of a selected outlet. The switch performs very small mechanical movements in the setting-up of connections. Wear is therefore minimal and the reliability of the switch very high.

The preventive maintenance which is so important in step-by-step or motor-driven systems is altogether unnecessary in code switch systems (see also article on Code Switch in Ericsson Review No. 3, 1964).

Racks

The racks (fig. 7) are of the same type as used in L M Ericsson's wellknown crossbar switch exchanges. They are robust, easy to assemble and adaptable to different premises. Since all relay sets are connected by plug and jack, the racks can be set up in pairs, back to back. At the top of each rack there is space for fuses, alarm lamps, etc.

All internal wiring of the racks is done in the factory, whereas the inter-rack cabling is done at the time of installation. Rack height 2400 mm.

Relay Sets

All relay sets are of uniform type. They are robustly constructed and are connected to the exchange cabling by plug and jack. All relay sets can therefore be easily removed for inspection and replaced again. The code switches as well are assembled in the same way and can be plugged-in individually (fig. 8). Each relay set has its own dust cover.

Main Distibution Frame

To reduce the floor space requirements for the M.D.F. and to simplify jumpering work, a special frame has been designed for *AKD 791*. For termination of the jumpers this frame is equipped with jacks instead of screw terminals. The jumpers are inserted into the jacks, the bushes of which are so designed that the wire is under high pressure at four points along the bush, so ensuring very good contact (fig. 9).

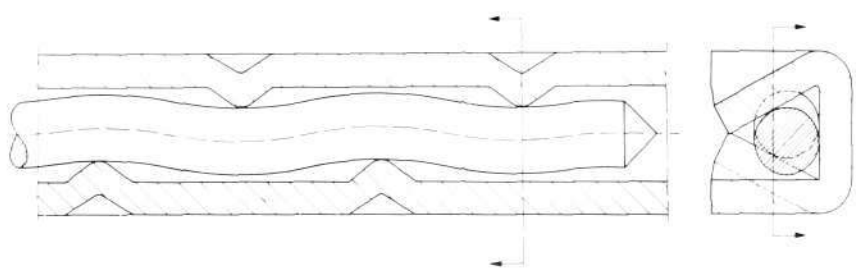

Fig. 9
M.D.F. jack

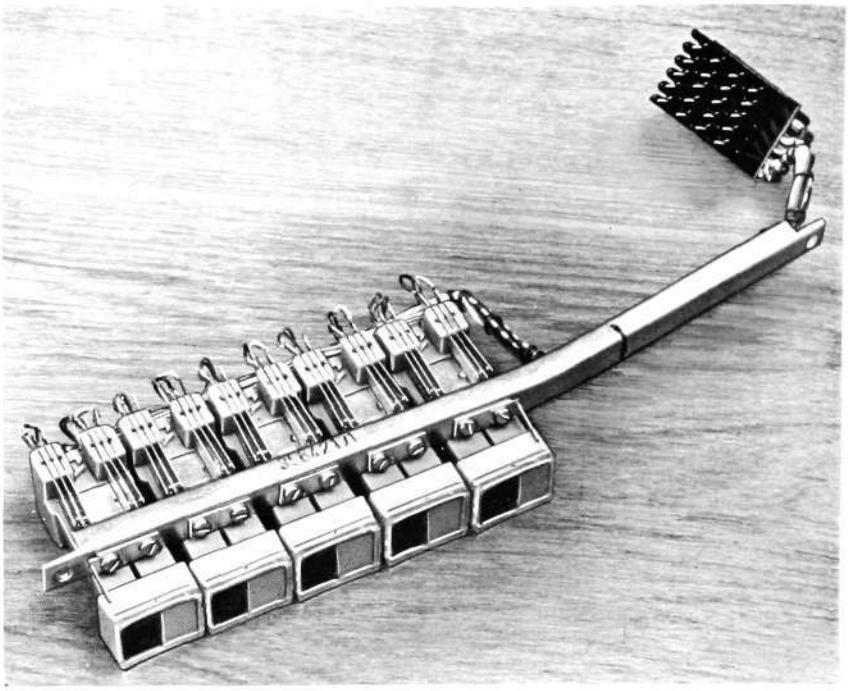

Fig. 10
Lamp-button unit

The jumper wire is a two-coloured twin conductor made of suitable material. After removal of the plastic insulation and forming of the wire in a special tool, a jumper is obtained with a double plug at each end. One is plugged into the jack on the line side, the other into the jack on the exchange side.

Operator's Equipments

There is a choice of two types of operator's equipment: a switchboard of tropical wood in different designs (fig. 3 shows an example) or a console in pastel-grey polystyrene for placing on a table (fig. 2). Both equipments contain a built-in panel with push-buttons, supervisory lamps and keyset, and in some cases also meters for charging trunk calls. The push-buttons are formed as "lamp-buttons", i.e. buttons with built-in supervisory and call lamps, which reduces the dimensions of the panel and simplifies the operator's work. The lamp-buttons are placed on mounts to form units which can normally be released from the panel individually for inspection or replacement. The units connect to the panel cable by plug and jack (fig. 10).

The handset is of the latest design and is characterised by its good transmission properties and low weight. It plugs-in to the switchboard or console and can thus be easily replaced by a headset.

The switchboard can be provided with extra signal equipment if desired, e.g. equipment for blind operators.

Power Equipment

Operating Voltage

The exchange normally operates on 48 V but variations between 44 and 56 V can be allowed without affecting the reliability of operation. The voltage-sensitive components (transistors and the like) permit peak voltages up to 60 V for max. 1 second.

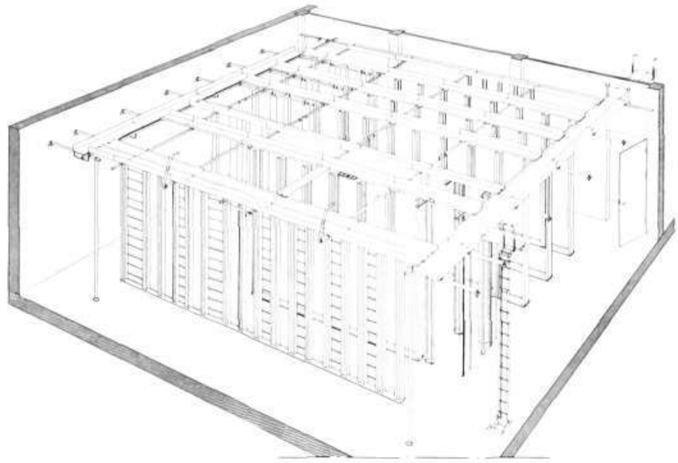

Fig. 11
Rack layout

The power equipment consists of a charging unit and floating batteries. The charging unit should be dimensioned to cover the normal power consumption of the exchange during the busy hour (see Technical Data) with a margin to spare for future expansion.

Signal Voltage

In addition to the battery voltage, 48 V a.c. is required for signalling between markers and ringing and tone voltages for signalling to the extensions. The 48 V a.c. voltage is normally taken from the mains via a separate transformer, 300 VA/1000 extensions. There must be a standby unit against power failures. The frequency may vary between 25 and 150 c/s. Tone signals and ringing voltage are obtained from a battery-driven equipment.

Installation and Space Requirements

Since the racks in *AKD 791* are of the same type as those for public exchanges, the installation is very similar to that of public exchanges (fig. 11).

Space should be reserved for the anticipated final capacity of the exchange. The equipment lay-out (fig. 12) shows the space required for an exchange with the following capacity:

Extensions	900	Anticipated	final	capacity	1800
Connecting circuits *SNR*	50	,,	,,	,,	100
Exchange lines *FDR*	85	,,	,,	,,	170
Operators' equipments *OP*	6	,,	,,	,,	12

The size of the manual switchroom will, of course, depend on whether the operators have switchboards or consoles.

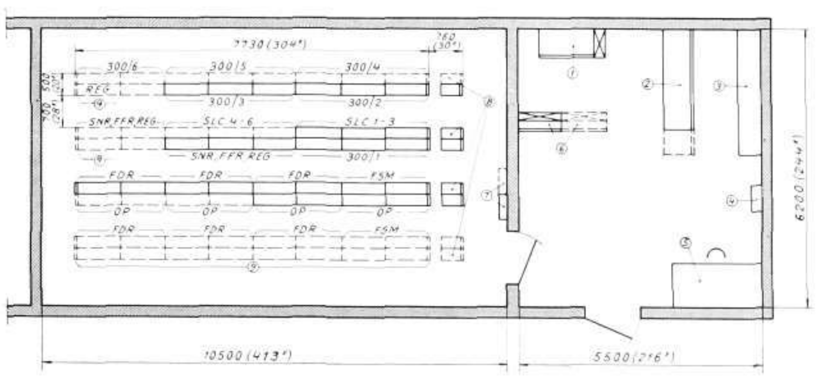

Fig. 12
Equipment layout
Free ceiling height 2700 mm (106")
1. M.D.F.
2. Power equipment
3. Batteries
4. *Signal equipment*
5. Repair position
6. Number group with terminal field
7. Service observation
8. I.D.F.
9. Spare for extra equipments

Service Observation

Even if the number of faults in modern equipments is very low, there must be continuous control of the quality of service, which should be done on a fully automatic basis. The tracing of faults, on the other hand, should take place only when faults come to light, which is relatively seldom, and manual equipment suffices for this purpose.

The supervision of *AKD 791* takes place largely through information obtained from the common switching units. These units contain circuits which, in the event of fault, can call the recording devices and transfer to them information concerning the phase of the connection in which a disturbance has occurred.

All markers are equipped with these "fault-informing" circuits. The sign of a disturbance (a fault) is that the marker has been held for longer than a predetermined time. Through this supervision of the marker, faults can be identified in common switching units.

The standard service observation equipment is as follows:

☐ A lamp strip on each rack for signalling faults from equipment on the rack (certain selector racks, however, excepted).

☐ A lamp panel per suite, indicating alarm from a rack in the suite.

☐ An equipment containing common alarm lamps for the exchange, counters for congestion on connecting circuits, outgoing exchange lines, enquiry links, record lines to operators and operators' links: also counters for service failure alarms.

All alarms are graded in respect of urgency.

In addition to the standard equipment, very advanced equipment for supervision and traffic measurement can be supplied.

To assist fault tracing *AKD 791* can offer a new facility. From a special extension position on the *SLA* multiple one can select a predetermined path through the exchange. By path is here meant a vertical, link, connecting circuit, register, exchange line etc. In this way the units concerned are blocked against normal extension calls but are used for test calls. The path can be tested without disturbing normal traffic.

Technical Data

Capacity and traffic-handling

Theoretically *AKD 791* can be built up for any number of extension lines. But as only a certain number of switching units (connecting circuits, exchange lines, enquiry units etc.) may be connected for a given grouping, the number of extensions must not be greater than that the various units can "swallow" the traffic to and from them. For up to 4800 extensions, however, the traffic-handling capacity is very good: 0.15—0.20 erlang per extension with 2 ‰ congestion.

The *C*-stage multiple, to which the traffic-carrying units are connected, normally has 480 outlets. Each connecting circuit requires two outlets, while the other units require one outlet each. *The maximum number of units*, therefore, depends on the distribution between them.

The present remarks concerning the capacity apply to exchanges of standard type. *AKD 791* is a very flexible exchange, however, and larger capacities can be discussed in each particular case.

Operating voltage

48 V: the exchange is guaranteed to function between 44 and 56 V.

Feed

Individual. The resistance of the feed coils is normally 2×400 ohms but other resistances can be arranged if desired.

Release

First party. When an extension replaces, the switching path is released and busy tone is sent to the other party.

Line resistance

Max. 1000 ohms including telephone set.

Leakage resistance

Min. 20,000 ohms.

Pulsing

The dial speed may vary between 8 and 13 pulses per second. The pulse ratio may vary between 30/70 and 50/50.

Current consumption

Since the verticals of the code switch are devoid of current during conversation, the current consumption of the exchange is determined principally by the traffic-carrying units and by equipment interworking with them. The number of traffic-carrying units is always adapted to the present traffic irrespective of the number of extensions. This results in good utilization of these units and means that one can calculate the current consumption of the exchange during the busy hour simply as a function of the number of traffic-carrying units, without consideration of the number of extensions and traffic per extension.

Approximate current consumption during busy hour:

Per 30 SNR incl. *REG-L*	15 A
Per 30 *FDR-C*	10 A
Per 2 operators	6 A

Traffic Signals for Dalaplan Road Junction, Malmö

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UDC 625.746
LME 869

This article contains an account of the traffic conditions and of the planning of the signalling system for the large road junction at Dalaplan, Malmö. It also describes the L M Ericsson signalling system chosen for the junction.

A road traffic signalling system supplied by L M Ericsson was commissioned in April 1964 at Dalaplan, Malmö. Dalaplan is one of the major junctions in the city, situated on the southern side where highway 101 from Ystad joins highway E 6 (fig. 1). In the vicinity of the junction and close to the traffic routes which meet at this point, large residential areas have been built and are still growing up, such as Blekingsborg, Almhög, Nydala, Hermodsdal,

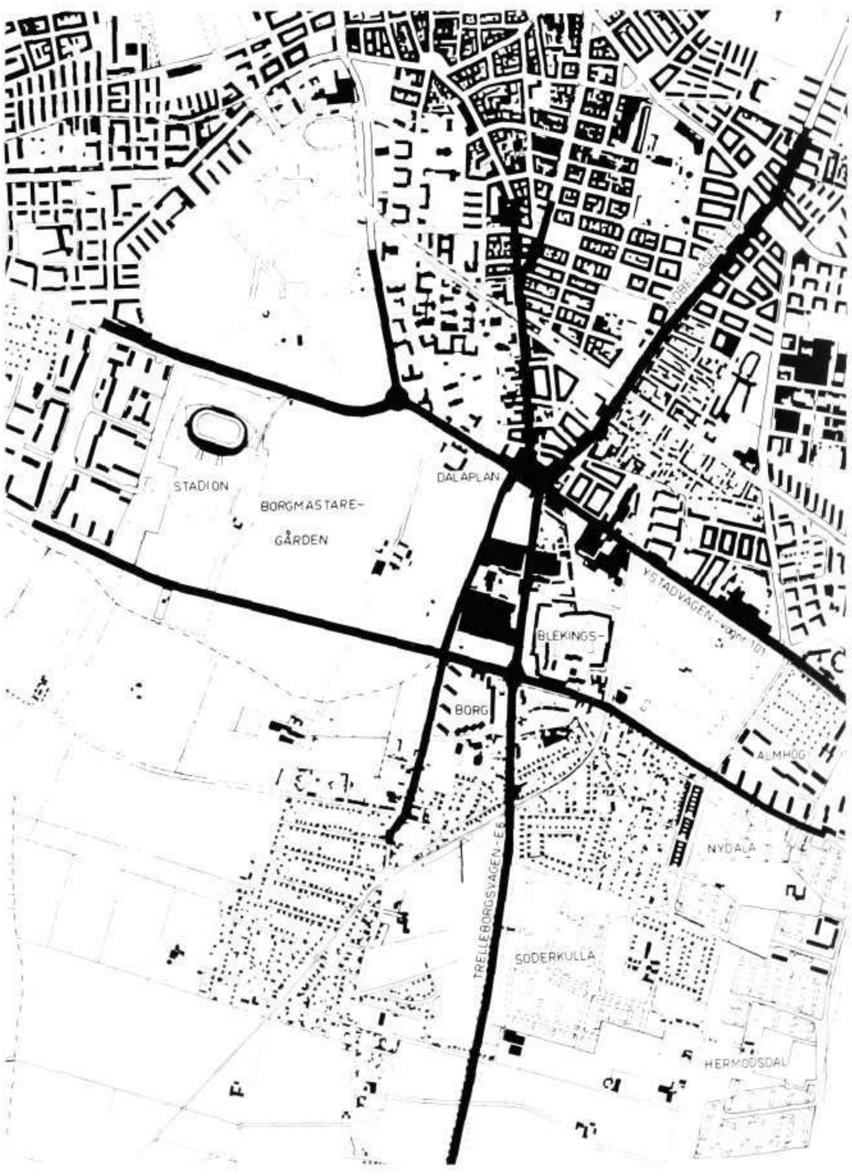


Fig. 1
Map of southern Malmö with Dalaplan in the centre

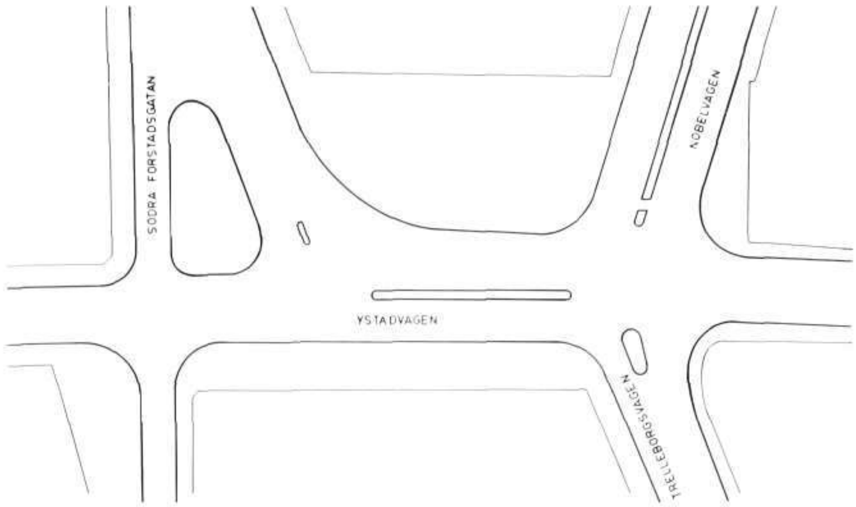


Fig. 2
Dalaplan prior to reconstruction

Söderkulla and Borgmästaregården. Another traffic-generating factor at the junction is the vicinity of the largest sports arena in the city, the Stadium. In summer the junction is passed to a large extent by people travelling to and from the beaches and the weekend cottage areas at Skanör and Falsterbo and along the Scanian south coast. These conditions result in the varying traffic configuration with peaks not only in mornings and evenings, but also seasonal and holiday peaks, in conjunction with fine bathing weather and with sports events. The total incoming traffic to the junction during 1964 was 43,000 cars/annual mean day.

Plans for Traffic Regulation

The existing and the expected increase of traffic load rendered some form of traffic regulation at the junction necessary. The layout of the junction prior to its reconstruction is shown in fig. 2. Having regard to the traffic distribution, it was considered best to retain the general layout with two four-street crossings and to install signals. A proposal on these lines was drawn up and the reconstruction was completed for the most part during 1963 (fig. 3). In view of the planned design of the signalling plant, among other things, it was considered necessary to run a pedestrian tunnel under the main east-west 8-lane carriageway.

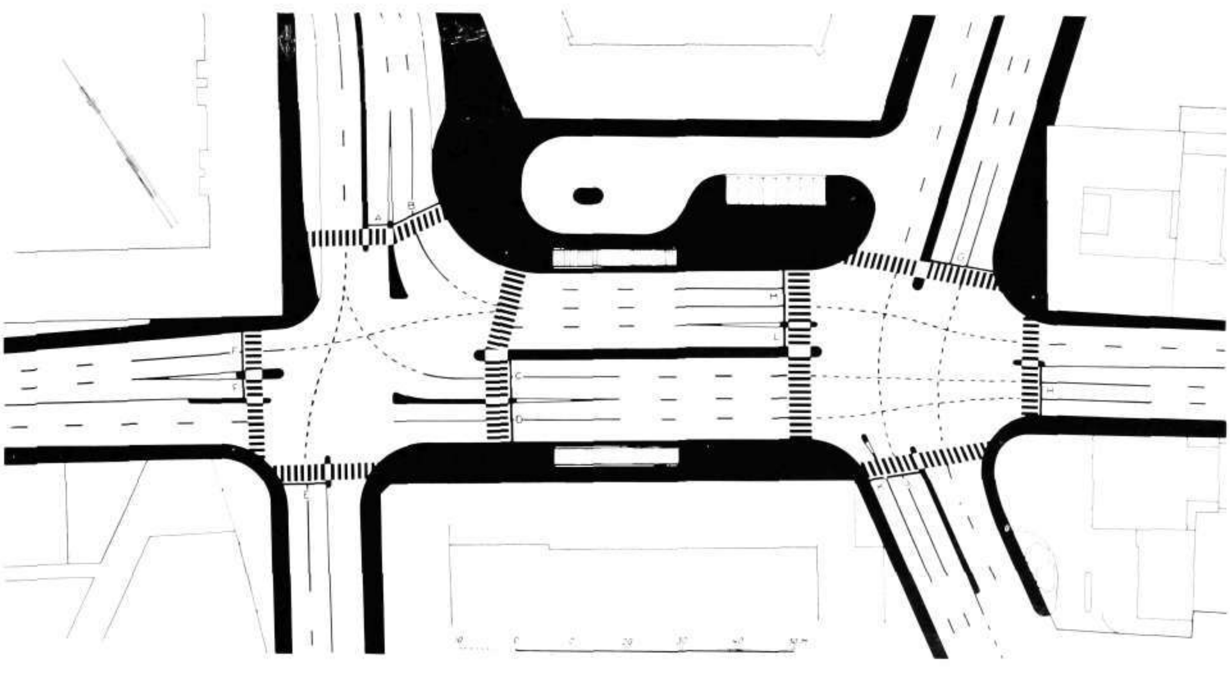


Fig. 3
Dalaplan after reconstruction

Specifications for the Signal Equipment

For signal control of two crossings as close as those at Dalaplan, very strict coordination is required having regard to the limited space and risks of traffic congestion. From the capacity point of view, moreover, it is desirable that the signals on each approach route should be separately timed so that traffic losses due to the coordination requirements shall be as small as possible.

Central Control System JZC 11

The requirements to be met by the planned signalling system were thus known and it was merely a question of finding a system which complied with them. L M Ericsson offered its new central control system *JZC 11*, which proved appropriate.

JZC 11 is a time-controlled system designed for coordinated control of signals at a series of street crossings. The coordination is effected by means of different preset signalling programmes. The choice of programme is vehicle-controlled, so that the signals follow the changes of traffic intensity very closely. The system also allows a simplified form of vehicle-control of indi-

Programme	Detector				Programme	Detector				Detector				Programme	Detector				Programme
	1	2	3	4		1	2	3	4	1	2	3	4		1	2	3	4	
P1	L	L	L	M	P3	L	H	H	H	L	L	L	L	P4	M	M	H	M	P2
	L	L	M	L		M	H	L	L	L	L	L	M	P1	M	M	H	H	P2
	L	L	M	M		M	H	L	M	L	L	L	H	P2	M	H	L	L	P3
	L	M	L	L		M	H	L	H	L	L	M	L	P1	M	H	L	M	P3
	L	M	L	M		M	H	M	L	L	L	M	M	P1	M	H	L	K	P3
	L	M	M	L		M	H	M	M	L	L	M	H	P2	M	H	M	L	P3
	L	M	M	M		M	H	M	H	L	L	H	L	P2	M	H	M	M	P3
	M	L	L	L		M	H	H	H	L	L	H	M	P2	M	H	M	H	P3
	M	L	L	M		H	L	L	L	L	L	H	H	P2	M	H	H	L	P6
	M	L	M	L		H	L	L	M	L	M	L	L	P1	M	H	H	M	P6
	M	L	M	M		H	L	M	L	L	M	L	M	P1	M	H	H	H	P3
	M	M	L	L		H	L	M	M	L	M	L	H	P2	H	L	L	L	P3
	M	M	L	M		H	L	H	L	L	M	M	L	P1	H	L	L	M	P3
	M	M	M	L		H	L	H	M	L	M	M	M	P1	H	L	L	H	P5
	M	M	M	M		H	L	H	H	L	M	M	H	P2	H	L	M	L	P3
						H	M	L	L	L	M	H	L	P2	H	L	M	M	P3
P2	L	L	L	H		H	M	L	M	L	M	H	M	P2	H	L	M	H	P5
	L	L	M	H		H	M	M	L	L	M	H	H	P2	H	L	H	L	P3
	L	L	H	L		H	M	M	M	L	H	L	L	P3	H	L	H	M	P3
	L	L	H	M		H	M	H	L	L	H	L	M	P3	H	L	H	H	P3
	L	L	H	H		H	M	H	M	L	H	L	H	P3	H	M	L	L	P3
	L	M	L	H		H	M	H	H	L	H	M	L	P3	H	M	L	M	P3
	L	M	M	H		H	H	L	L	L	H	M	M	P3	H	M	L	H	P5
	L	M	H	L		H	H	L	M	L	H	M	H	P3	H	M	M	L	P3
	L	M	H	M		H	H	L	H	L	H	H	L	P6	H	M	M	M	P3
	L	M	H	H		H	H	M	L	L	H	H	M	P6	H	M	M	H	P5
	M	L	L	H		H	H	M	M	L	H	H	H	P3	H	M	H	L	P3
	M	L	M	H		H	H	M	H	M	L	L	L	P1	H	M	H	M	P3
	M	L	H	L		H	H	H	L	M	L	L	M	P1	H	M	H	H	P3
	M	L	H	M		H	H	H	M	M	L	L	H	P2	H	H	L	L	P3
	M	L	H	H		H	H	H	H	M	L	M	L	P1	H	H	L	M	P3
	M	M	L	H						M	L	M	M	P1	H	H	L	H	P3
	M	M	M	H	P4	L	L	L	L	M	L	M	H	P2	H	H	M	L	P3
	M	M	H	L						M	L	H	L	P2	H	H	M	M	P3
	M	M	H	M	P5	H	L	L	H	M	L	H	M	P2	H	H	M	H	P3
	M	M	H	H		H	L	M	H	M	L	H	H	P2	H	H	H	L	P3
						H	M	L	H	M	M	L	L	P1	H	H	H	M	P3
P3	L	H	L	L		H	M	M	H	M	M	L	M	P1	H	H	H	H	P3
	L	H	L	M						M	M	L	H	P2					
	L	H	L	H	P6	L	H	H	L	M	M	M	L	P1					
	L	H	M	L		L	H	H	M	M	M	M	M	P1					
	L	H	M	M		M	H	H	L	M	M	M	H	P2					
	L	H	M	H		M	H	H	M	M	M	H	L	P2					

Table 1

The traffic intensity is measured every third minute on four approaches and is classified as high (H), medium (M) and low (L). This classification is used for automatic selection of programme (P 1 — P 6).

vidual crossings by the installation of certain auxiliary equipment, by means of which minor corrections of the green period at a crossing can be made without affecting the remainder of the signalling system. The resulting gain in green period can be utilized, for example, for improved coordination.

In a time-controlled system with vehicle-controlled choice of programme, the equipment for a single group of signals is comparatively simple. One can therefore have a large number of groups of signals at a relatively low cost, so improving the traffic flow.

Choice of Programme

For measurement of the traffic intensity, detectors have been laid in the carriageway in four of the six approaches to Dalaplan. The number of vehicle pulses from these detectors during a given period is compared in the controller with two preset limits for each set of detectors, and the traffic intensity is classified on the basis thereof as low, medium or high. A suitable length of period has proved to be 3 minutes. The lower traffic intensity limit is 10–15 vehicles per 3 minutes and 2 lanes, and the higher 30–50 vehicles per 3 minutes and 2 lanes.

According to the combination of low, medium and high traffic intensity on the four approaches during the period, the programme selector selects a programme corresponding to that combination. The eighty-one different combinations are thus distributed over all programmes in use (table 1).

The vehicle-controlled programme selection is the new feature in this equipment that has been most noticeable to traffic-users, and the results hitherto have been extremely promising. The choice of programme can also be effected, however, by means of a timer if for any reason vehicle-controlled selection cannot be employed. The various programmes can also be switched manually.

Switching of Programme

After the central equipment has decided which programme is to be adopted, it passes on this information to the local equipments at the next change of cycle, after which they switch to the desired programme at a time in the cycle that is suited to each local traffic situation. Thus it is not necessary for all local equipments to switch to the new programme at the same time, and this facilitates the choice of programme.

The cycle time of the programme in use is measured in steps at, in this case, one-second intervals. In the formulation of programme, therefore, a group of signals can be connected at any time in the cycle (fig. 4). The only restriction is that opposing groups of signals must not show the green aspect simultaneously.

The Dalaplan plant has 12 vehicle signal groups and 15 pedestrian signal groups. Four of the latter—P, Q, Å and Ö—are normally extinguished and light only at times when it is desired that the pedestrian tunnel shall be kept closed (fig. 5). The pedestrian crossings controlled by these groups of signals are then closed and opened through gates in the railings.

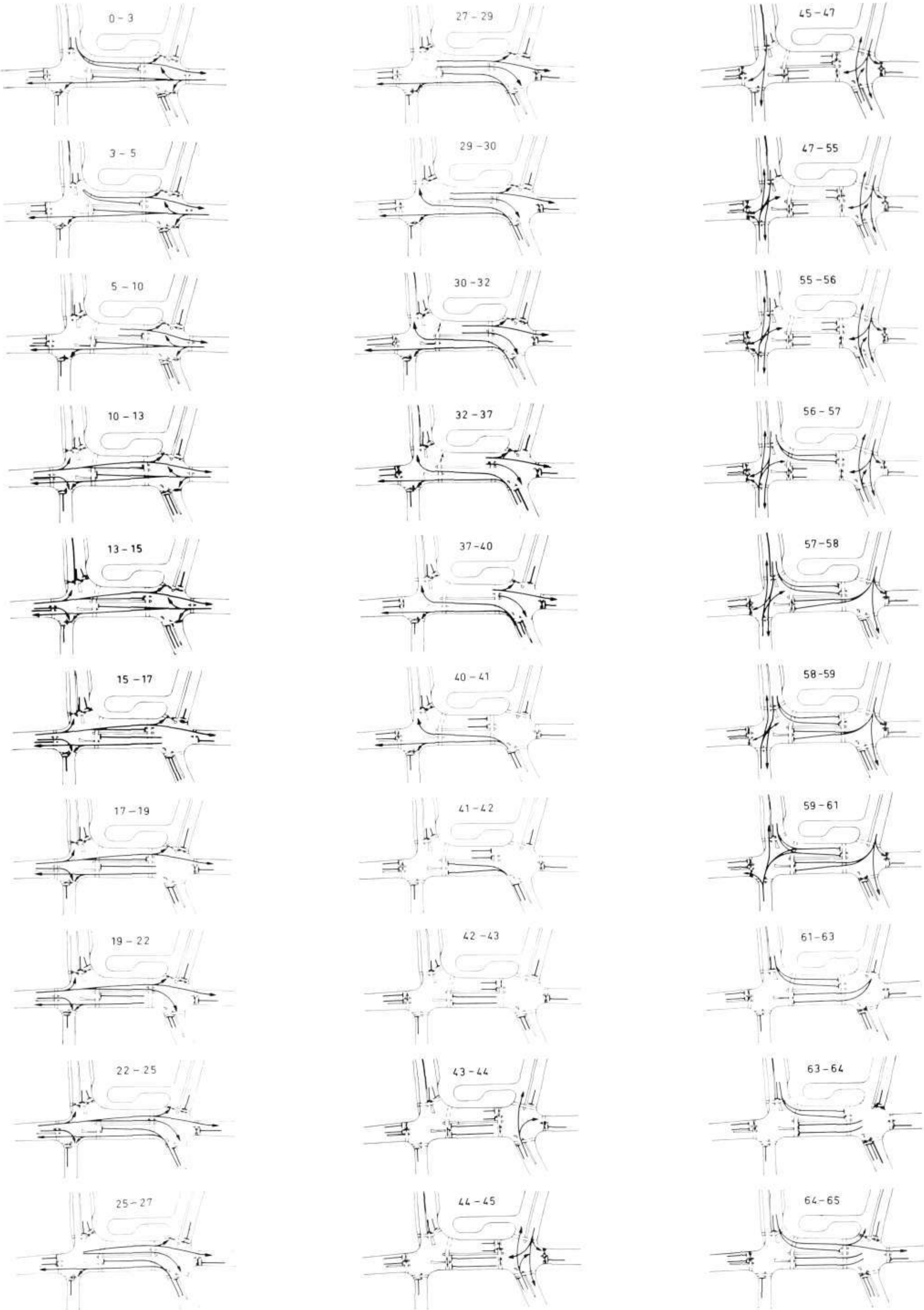


Fig. 4. Traffic situation at different periods (the figures indicate the time in seconds when a given situation applies in the cycle for programme 1)

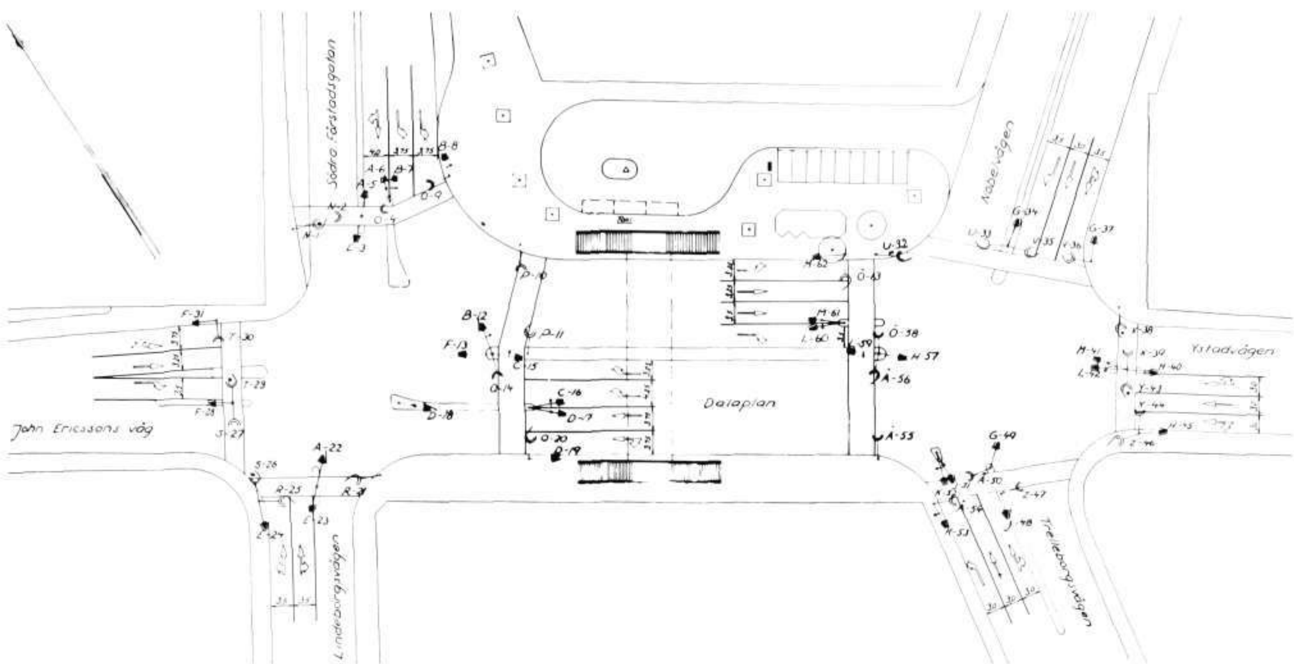


Fig. 5

Dalaplan with its groups of signals and lane markings

- Vehicle signal
- ditto with right-turn arrow in green aperture
- ditto with left-turn arrow in green aperture
- ditto with straight-ahead arrow in green aperture
- Pedestrian signal
- Carriageway sign showing permissible direction of traffic
- ditto
- ditto
- ditto
- ditto

Timing of Signals

Fairly accurate traffic surveys are required for calculation of the timing data for this type of installation. The length of measuring period was fixed at 3 minutes after practical trials, a time which proved to provide sufficiently rapid changes of programme without too great disturbance of the traffic. The various programmes were timed on the basis of traffic counts and capacity calculations. The limits of traffic intensity on the various approaches were thereafter determined and the combinations of low, medium and high traffic intensity were distributed among the various programmes so that a suitable combination, and so a suitable programme, was obtained at the desired times.

Of the seven programmes available in this installation six are used at present, namely a normal programme with 65-second cycle time, a morning programme with 75-second cycle time, an evening programme with 85-second cycle time, a night programme with 45-second cycle time, and two programmes for events at the Stadium, one with 85-second cycle time for traffic

Table 2

The times in the cycle at which the signals change in different programmes

Signal group	P1 Cycle = 65 s				P2 Cycle = 75 s				P3 Cycle = 85 s				P4 Cycle = 45 s				P5 Cycle = 80 s				P6 Cycle = 85 s			
	Red-amber	Green	Green-amber	Red	Red-amber	Green	Green-amber	Red	Red-amber	Green	Green-amber	Red	Red-amber	Green	Green-amber	Red	Red-amber	Green	Green-amber	Red	Red-amber	Green	Green-amber	Red
A	43	45	56	59	54	56	68	71	56	58	73	76	40	42	2	5	49	51	67	70	49	51	74	77
B	54	56	65	3	60	62	75	3	23	25	40	43	42	44	5	8	49	51	68	71	20	22	49	52
C	27	29	38	41	25	27	49	52	22	24	51	54	21	23	35	38	28	30	44	47	19	21	44	47
D + R	63	0	38	41	1	3	49	52	79	81	51	54	8	10	35	38	73	75	44	47	80	82	44	47
E + S	45	47	58	61	56	58	73	1	58	60	74	77	41	43	3	6	50	52	68	71	51	53	64	67
F + N	8	10	22	25	3	5	20	23	79	81	17	20	8	10	16	19	73	75	22	25	80	82	14	17
G + X	42	44	58	61	43	45	63	66	56	58	81	84	35	37	43	1	43	45	74	77	54	56	84	2
H + Z	63	0	12	15	69	71	16	19	2	4	21	24	3	5	11	14	0	2	14	17	5	7	29	32
J + Ä	41	43	54	57	42	44	59	62	55	57	72	75	34	46	43	1	42	44	71	74	53	55	67	70
K	20	22	37	40	23	25	39	42	27	29	41	44	17	19	30	33	19	21	37	40	35	36	49	52
L	17	19	37	40	21	23	38	41	26	28	50	53	16	18	30	33	19	21	37	40	34	36	49	52
M + U	62	64	37	40	68	70	38	41	0	2	50	53	3	5	30	33	78	0	37	40	3	5	49	52
O	—	5	—	41	—	5	—	52	—	78	—	17	—	10	—	35	—	75	—	41	—	77	—	14
P	—	30	—	37	—	28	—	48	—	48	—	54	—	24	—	33	—	30	—	41	—	70	—	73
Q	—	43	—	58	—	54	—	71	—	56	—	74	—	40	—	3	—	51	—	68	—	46	—	73
T	—	27	—	3	—	25	—	73	—	22	—	74	—	21	—	3	—	30	—	68	—	19	—	75
V	—	63	—	32	—	68	—	33	—	1	—	46	—	3	—	25	—	0	—	37	—	4	—	44
Y	—	17	—	56	—	21	—	62	—	26	—	18	—	16	—	43	—	21	—	74	—	34	—	84
Å	—	59	—	13	—	64	—	16	—	77	—	21	—	3	—	11	—	76	—	14	—	72	—	29
Ö	—	42	—	55	—	43	—	61	—	55	—	78	—	35	—	43	—	44	—	71	—	54	—	81

situations before the event and the other with 80-second cycle time after the event (table 2). The plant can also be controlled manually from a control panel at each crossing with a choice of 6 different phases. The cycle can, however, be completed in three of the six phases, and there is the choice either of coordinated control or of separate control of each crossing (table 3).

Future Control of Signals at Dalaplan

It is planned that additional local equipments shall be installed at Dalaplan. Most of them will be used for control of the major crossing along the 3-kilometre Nobelvägen which forms part of highway E 6 through Malmö. It will then be necessary to have one or more detector points for measuring the traffic intensity along that street.

A possible line of development for the future signalling system is that a number of master controllers will control the signalling plants within their respective areas. The areas should be so limited that coordination is obtained for naturally associated signalling systems and that the traffic intensity on the larger routes within the area can be measured from not too great a number of points. In the determination of the area limits it is also important to ensure that buffer zones are formed between the areas, which can take up and smooth out conflicting traffic flows from different areas. The buffer might consist of an uncontrolled crossing, vehicle-controlled signal-regulated crossing or a non-level crossing, depending on the local conditions.

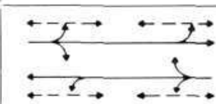
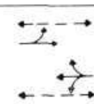
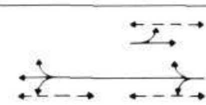
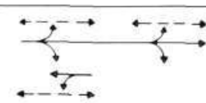
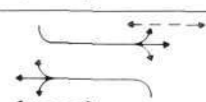
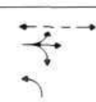
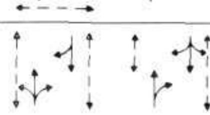
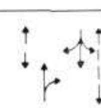
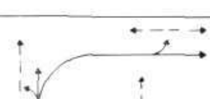
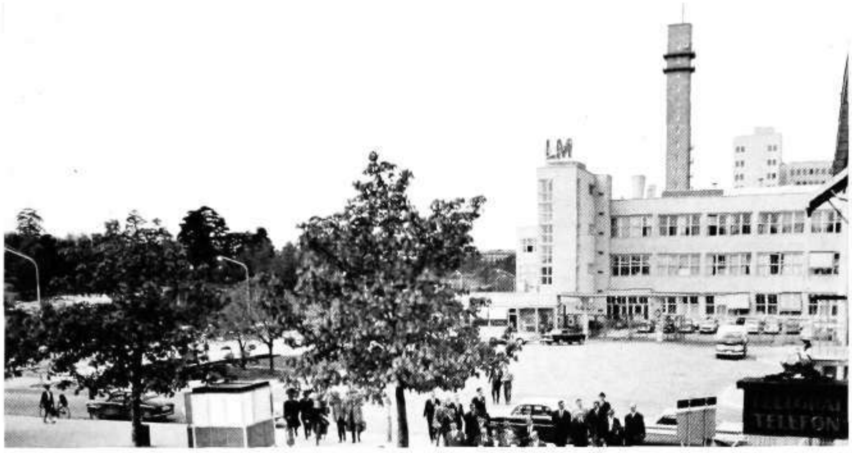
Coordinated control			Separate control	
Group of signals showing green aspect in respective phases	Phase	Button	Phase	Group of signals showing green aspect in respective phases
D, F, (N), O, (R), H, M, (U), V, (Z), Å.		①		D, F, (N), O, (R).
D, F, (N), O, (R), L, M, (U), V.		②		
C, D, (R), H, M, (U), V, (Z), Å.		③		C, D, (R).
B, C, D, (R), K, L, M, (U), V.		④		B, C, D, (R).
A, E, Q, (S), T, G, J, (X), Y, (Ä), Ö.		⑤		A, E, Q, (S), T.
D, P, (R), G, (X), Y.		⑥		

Table 3

The signals can also be controlled manually with buttons 1—6, either each crossing separately or both crossings in coordination. The figures show the phases for the different buttons.

NEWS *from* *All Quarters of the World*

Maintenance Conference 1965



The delegates on their way from the opening ceremony in the Head Office Exhibition Room to the Conference Room at Midsommargården.

For a manufacturer of telephone exchange equipments it is essential not only to sell the equipments but also to follow their destiny during their life-span. One way of doing this is to keep close contact with our customers' maintenance staffs, and in the course of the years, therefore, conferences on maintenance questions have been arranged at the head office in Stockholm.

The conference this year, from May 3 to June 4, was attended by 46 delegates from the major administrations in Sweden, Denmark, Norway, Finland, Iceland and the Faroes. The conference dealt with maintenance problems within the fields of subscribers' apparatus, outside plant, and transmission and switching equipments. Organizational questions, supervision of all-automatic and trunk traffic, and the dawning of the data age, set their mark on the conference. Terminology and service statistics questions were also discussed.

This year's conference was the first of a new series. The next will be held in 1966 for our English-speaking customers, followed by a Spanish-language conference in 1967.

From the visit to the Västerås District of the Swedish Telecommunications Administration are seen (from left): E. Jensen, Norwegian PTT, J. Kiil, Danish PTT, J. Skulason, Iceland PTT, N. Ericsson, Swedish Telecommunications Administration, and S. A. F. Pauli, Head of Installations Division, Västerås, who demonstrated the planning routines.

New L M Ericsson Records in 1964

The progress that has characterized L M Ericsson's activities in recent years continued during 1964. Consolidated sales and bookings were higher than in any previous year in the company's history.

Group sales amounted to 1653 million kronor compared with 1481 million in 1963, an increase of 12 %.

Orders received by the Group reached the record figure of 1947 million kronor, an increase of 28 % over 1963. Despite increased shipments the backlog of orders rose during the year from 1739 to 2032 million kronor.

The number of employees within the Group rose slightly, being 41,700 at the year end compared with 40,600 at the end of 1963. This increase was entirely within the overseas organization.

The board's proposal, in view of the expansion of the business, to increase the company's capital stock by 85,445,000 kronor to 427,225,000 kronor by a bonus issue of 1,708,902 B shares, the shareholders receiving one new B share in return for four old A and B shares, was approved by the Ordinary General Meeting.

Donation of Shares for Jubilee Fund

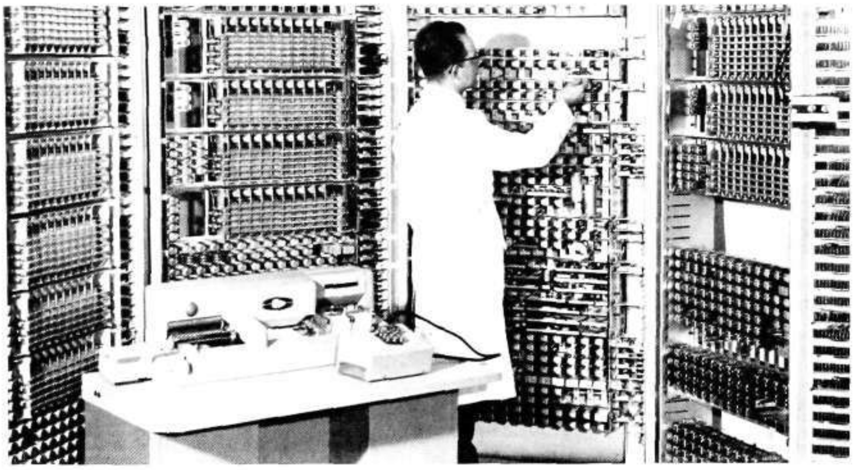
L M Ericsson, ASEA and Svenska Radioaktiebolaget have donated to the Stockholm Institute of Technology shares in the two former companies to a market value of some 170,000 kronor and around 9000 kronor in cash. The donation was made as a mark of honour to Waldemar Borgquist, former Director General of the State Power Board, on his 80th birthday. It will be used to establish a fund aimed at promoting the future development of electrotechnics in accordance with statutes ratified by the donatory.

Organizational Change

Mr. Nils Sterner retired from the vice-presidentship of the company on pension on June 30, 1965.

At the same time the Board of Directors nominated Mr. Gunnar Svalling as vice president from July 1, 1965.

Automatic Transmission Equipment for British Post Office and Deutsche Bundespost



Laboratory equipment for automatic measurement of transmission characteristics of telephone circuits. In the foreground a punched card reader for control of the measurements.

Ericsson Review No. 2, 1963, contained an account of an automatic transmission measuring equipment for national circuits. Since that publication L M Ericsson has developed a corresponding equipment for international use.

Great interest has been shown in this equipment, which complies with the CCITT requirements for field tests within the European network. Orders have earlier been received from Norway, Denmark and Finland, and now also from Britain and W. Germany.

The British order is for equipment for London's international Exchange in Faraday Building and trunk exchange in Manchester—the German for Fernmeldeamt 1, Düsseldorf.

The equipments are normally intended for punched tape control but can be adapted for punched cards. The results of measurements on international circuits are presented on teleprinters. The recording of engaged and faulty circuits is effected with a separate teleprinter, which at the same time punches a tape. The tape can thereafter be used for repeated measurements on those circuits.

Field trials are soon to be made in Helsinki, Copenhagen, Stockholm and elsewhere.

In this context it may be mentioned that L M Ericsson has earlier received orders for telex switching equipments for Sydney, the Fiji Islands and Iceland.

Première for All-Automatic Trunk Traffic in Tunisia

"L M Ericssons achievements have been of extremely great importance for the building-up of the Tunisian telecommunications. The rapidity of this development has been aided in particular by the training of Tunisian technical personnel under Swedish leadership."

This statement was made by the Minister of Communications, M. Farhat, in his address to President Bourguiba at the opening of Tunisia's first two all-automatic trunk centres linking Tunis and Sfax, with multiple capacity of, respectively, 600 and 400 lines of ARM equipment.

Also present at the opening ceremony was the Swedish Ambassador, Per-Bertil Kollberg.

The aim is that in due course the entire telephone network shall be fully automatic. A further step in that direction is the opening of the first rural exchange at Manouba near Tunis. This exchange is of type ARK.

Intercontinental Telex in Canada

The telex section of the intercontinental switching centre at Montreal, supplied by L M Ericsson to Canadian Overseas Telecommunication Corporation (COTC), has now come into operation. This was at the beginning of June this year and, if the calculations hold, the corresponding centre at Vancouver will open its telex office at the end of July.

The establishment of the telex connection constitutes the second stage in COTC's linking-up of the British Commonwealth round-the-world telephone and telex network. The telephone sections of the project were brought into practical operation at Montreal and Vancouver some 18 months ago. The centres connect up the COMPAC cable between Australia and the Canadian West Coast with the Atlantic cable and Early-Bird connection with Europe.

The telex offices handle semi-automatic telex traffic from the Canadian network to Europe, the United States and South America via Montreal, and to Australia, Japan and New Zealand via Vancouver.

Incoming traffic to the Canadian network is fully automatic, as is also the intercontinental transit traffic, for instance the Australia-Britain connection which is transited through Canada.

At the opening of the Tunis exchange President Bourguiba dialled the first call to the Governor of Sfax. Beside the President (from the left) are the Technical Director of the PTT, H. Mili, Ambassador Kollberg, the Chairman of the National Assembly, Dr. Sadok Mokaddem, and the Minister of Finance, M. Ben Salah.

During his goodwill tour around the world H.R.H. Prince Bertil visited L M Ericsson Pty. Ltd., Broadmeadows, Victoria, Australia. On behalf of the staff Mr. Sten Snekker (right) presented Prince Bertil with an authentic boomerang and didgeridoo. The didgeridoo is a 4 ft. 6 in. long wind instrument used at ritual native dances. Both souvenirs had been made by natives of the Waradjerie tribe in N. Australia.

Among SAS' guests on the Tanzania-Stockholm première flight were the Tanzanian Minister of Communications, Sheikh Makeme and wife. During their visit to Stockholm they visited L M Ericsson's Midsommarkransen factory. In the photograph, taken in the Exhibition Room, Sheikh Makeme (right) and the Tanzanian Ambassador to Sweden, P. P. Muro, are studying two transparent models of the Ericofon and Ericovox. Standing beside Sheikh Makeme is L M Ericsson's president, Björn Lundvall. In the background C. G. Nordström of the Communications Department, Stockholm (right), and H. Augustinson of L M Ericsson.

For the first time in L M Ericsson's history a foreign subsidiary has held its Ordinary General Meeting and Board Meeting on the premises of the parent company. This was when the board of Société des Téléphones Ericsson (STE) were on a recent visit.
During a tour of the Bollmora plant Mr. P. Ahlström demonstrated different telehone sets to (from left) M. Ch. Bischoff, A. Duprez, president of STE, and M. M. Meunier. In the background Mr. C.-H. Ström, L M Ericsson, and Mr. F. Stranninge, *STE (slightly concealed).*

Chief Engineers Julio Bayona and José Parra of the Spanish Telecommunications Administration, Madrid, have been on a visit to L M Ericsson. Sr. Parra is seen trying out an 1878 model telephone. Obviously Mr. Lars Mjöberg of L M Ericsson has something funny to say on the considerably younger Ericofon.

In May this year an engineer's congress—"Primera asamblea ingeniería eléctrica"—was held at Caracas, Venezuela, which aroused great interest. A reception at the end of the congress was attended by over one hundred of the leading personages of the city.
Two Ericsson delegates, Dr. Yngve Rapp and Mr. Arne Boeryd, delivered highly applauded addresses on the planning of telephone networks from the points of view of economy and intelligibility.
(From left) Dr. Alfredo Ramirez-Torres, chairman of Cia Nacional de Teléfonos de Venezuela, Dr. Félix Martinez Espino O, Secretary General of the Caracas Chamber of Commerce, Mr. Nils Kjellander, president of Cia Anónima Ericsson, Caracas, Dr. Yngve Rapp, L M Ericsson, Ambassador Knut Bernström, *and Mr. Arne Boeryd, L M Ericsson.*

One of L M Ericsson's stands at the year's Hannover Fair.

L M Ericsson's New Plant at Bollmora

The plant at Bollmora, some 12 miles south of Stockholm, taken over by L M Ericsson in 1963, has now been completed and altered to suit the company's requirements. The ERGA Division started to move in in 1963 and, as new parts of the plant have been completed, additonal ERGA departments have been accommodated there.

The site area is about 645,000 sq. ft. and the present floor area 194,000 sq. ft. Of this figure 86,000 sq. ft. are allocated to office accommodation and 108,000 to laboratories and workshops.

The ERGA Division is responsible for the design and sale of telephone instruments and private automatic exchanges. The products are manufactured at the parent company's factories in Sweden and abroad.

A modern anechoic chamber, the "quiet room", has been arranged for acoustical precision measurements, especially on microphones, loudspeakers and other sound generators.

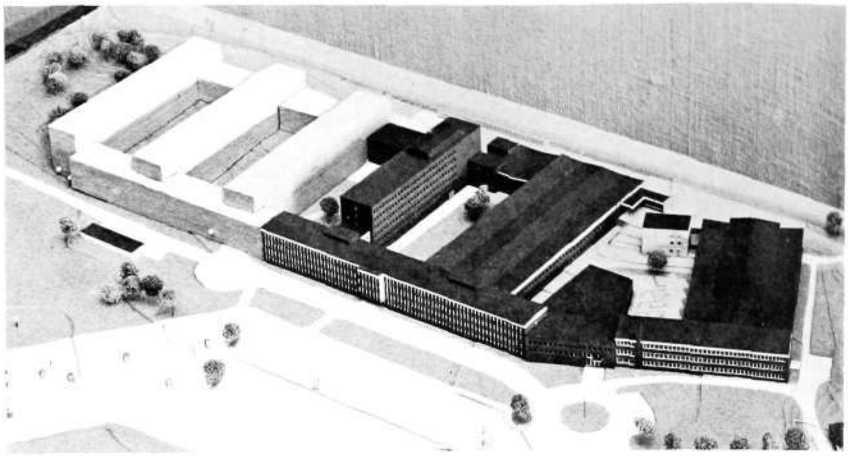
For measuring acoustical energy there is an echo room in which the efficiency of loudspeakers and other sound generators is determined. The room is designed to allow variation of the reverberation time in order to simulate the acoustical properties of different premises.

There are also sound cabins for determination of volume reference equivalents, intelligibility and judgement tests.

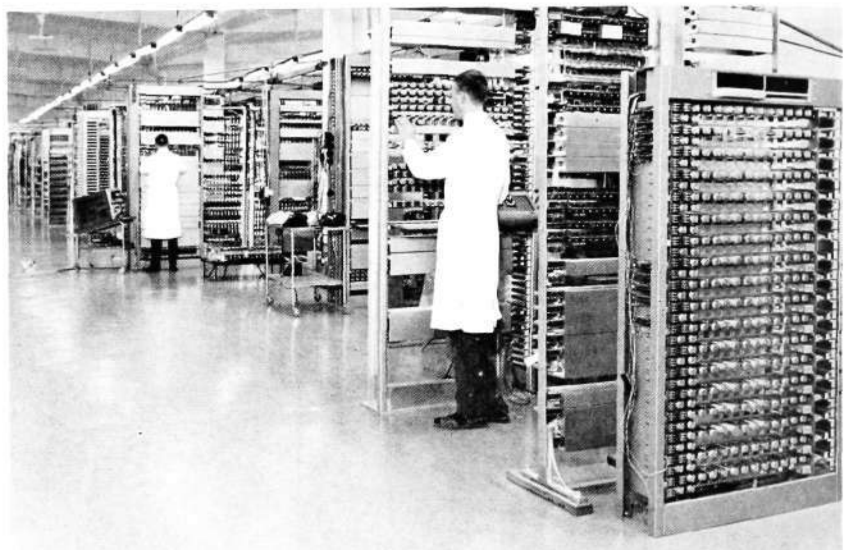
Thanks to the modern design of the laboratories and the excellent instrumentation, the national and international goodwill enjoyed by L M Ericsson within telephonometry can be upheld.

The designers' offices are specially furnished with office and laboratory facilities, which are a stimulus to rationalized work.

In the exchange laboratory the laboratory positions are also combined with writing accommodation and convenient facilities for hanging of diagrams. Special supporting iron structures facilitate the assembly and dismantling of switching equipment racks. The laboratory has access to a small wiring shop for experiments and manufacture of special relay sets for delivery to customers. The sales department has a well furnished exhibition room and conference room in which films can be shown.



Model of Bollmora plant. The white buildings represent planned additions to the plant.



The circuitry laboratory for automatic exchanges.

Measurements on the Ericovox loudspeaking telephone in the "quiet room".

L M Ericsson's Bollmora plant.

UDC 621.3.72.55
LME 743

WIDL, W.: *Equalizers for Telephone Channels.* Ericsson Rev. *42*(1965): 2, pp. 34—41.

The existing telephone networks belonging to telecommunications administrations have been established with a view to permitting satisfactory speech connections between subscribers. However, the introduction of data transmission places new requirements on the network transmission characteristics. These can be fulfilled by introducing supplementary equipment in the circuits used for data transmission. The equipment developed by the L M Ericsson Telephone Company for this purpose is described in this article.

UDC 625.746
LME 869

AHLSTRÖM, O. & HANSSON, K.: *Traffic Signals for Dalaplan Road Junction, Malmö.* Ericsson Rev. *42*(1965):2, pp. 66—72.

This article contains an account of the traffic conditions and of the planning of the signalling system for the large road junction at Dalaplan, Malmö. It also describes the L M Ericsson signalling system chosen for the junction.

UDC 621.317.39
621.375.9
LME 7292

LOFTSJÖ, O. & AVERDAL, A.: *L M Ericsson Laser for Rangefinding.* Ericsson Rev. *42*(1965): 2, pp. 42—50.

L M Ericsson has been engaged on development work within the field of laser for some time past. A first result of this work is the laser rangefinder made at the Military Electronics Division of L M Ericsson. In its present design the rangefinder can without difficulty be carried and operated by one man. After minor modifications it can, of course, also be permanently installed, for example in an aircraft or tank. Among the civil uses of the rangefinder may be mentioned the measurement of cloud altitude for meteorological and airtraffic requirements, and in land survey. Among military applications are accurate rangefinding for different kinds of fire control, e.g. for artillery and coast artillery units. The rangefinder can also be used in tanks and naval vessels, and as rangefinding element in the sights of ground attack aircraft.

UDC 621.395.24
LME 8372

LIE, B. & KILANDER, S,: *AKD 791, P.A.B.X. with Code Switches for 300 — 4800 Extensions.* Ericsson Rev. *42* (1965): pp. 51—65.

Very high requirements are placed on the communications systems in large business and other organizations, especially on the telephone system. The system must be reliable and flexible, incur very low maintenance and other operating costs, and offer all modern traffic facilities. It must be adapted to the needs of the enterprise and be easily modifiable when organizational changes occur.

L M Ericsson's P.A.B.X. system *AKD 791* introduced in this article fulfils all these requirements.

The Ericsson Group

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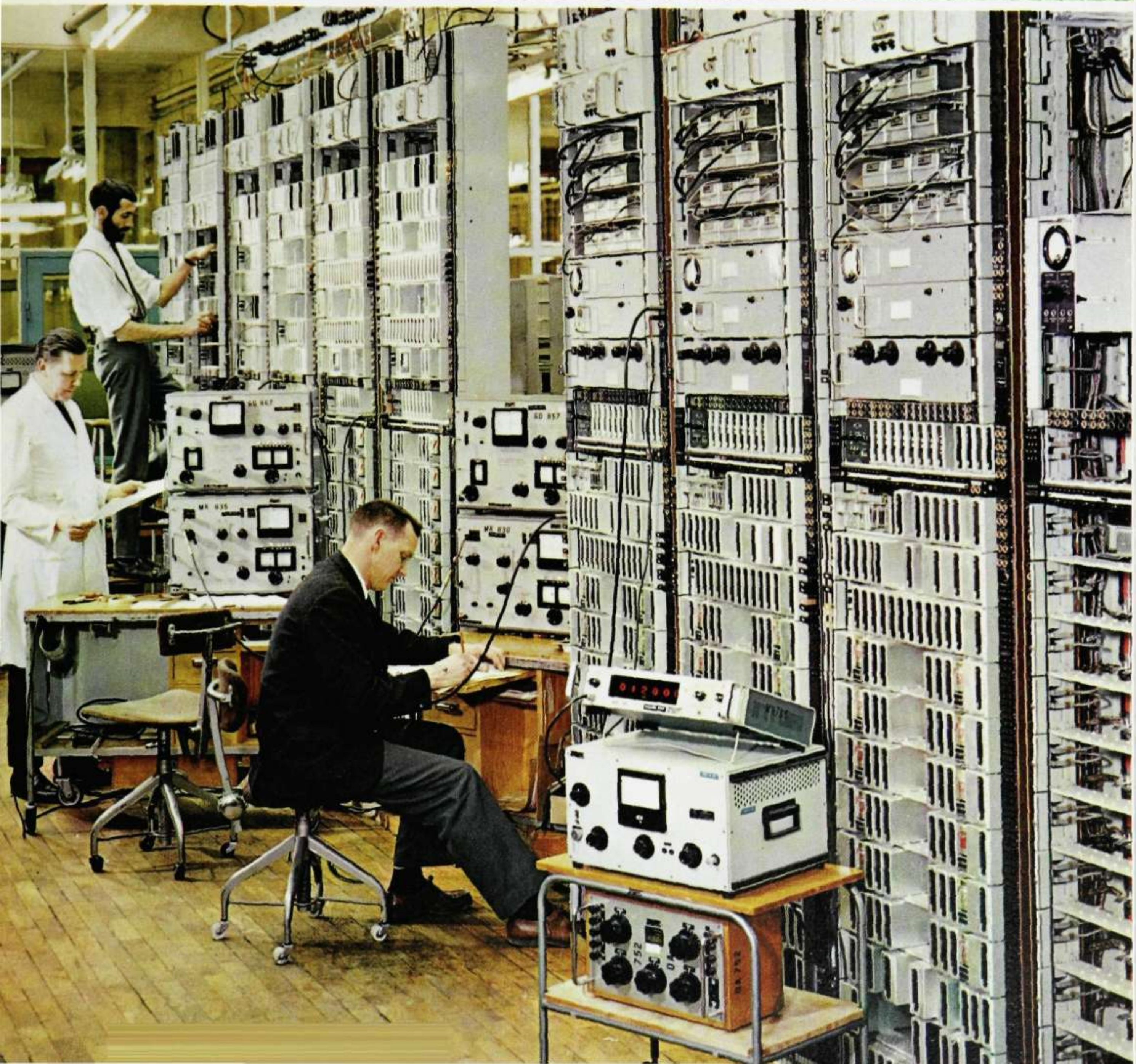

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On cover: Test-room measurements on carrier systems

L M Ericsson's H. F. Line Equipment for Small-Diameter Coaxial Cable

S. TRONSLI, TELEFONAKTIEBOLAGET L M ERICSSON, STOCKHOLM

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LME 8424

This article presents briefly the economic arguments in favour of the small-diameter coaxial cable systems and describes L M Ericsson's repeater equipments with 1.3 and 4 Mc/s bandwidth for this type of cable. These equipments, and the methods for their connection to the cable, have been developed in consultation with the Swedish Board of Telecommunications.

Through the advent of the silicon-planar technique within the transistor field, the h. f. line designer of today has amplifying elements at his disposal which have opened up entirely new possibilities. The very high reliability and insignificant aging of the silicon-planar transistors, combined with low current consumption, permit burial of intermediate repeater stations and considerably simplified remote power feeding. This has resulted in a lower cost of the intermediate repeaters compared with vacuum tube repeater equipment which, for maintenance reasons, should preferably be placed indoors.

To attain the minimum price per channel-kilometre, an optimal balance is required between cable cost and repeater cost. This lower cost of amplification may therefore warrant a change of the cable dimension.

Economic Considerations

An increase of the coaxial tube diameter results in a higher cable price and lower repeater cost per kilometre, and vice versa. Simple calculations show the minimum channel-kilometre price for a tube diameter D_{opt} to be $k \cdot N^{0.25}$

where k = constant
N = number of channels

The value of the constant k depends on which costs one is considering. Fig. 1 shows three curves for D_{opt}. Curve 1 relates to the first cost, curve 2 to the annual cost on the basis of 30 and 15 years depreciation period, respectively, for cable and repeater equipment at a rate of interest of 6 per cent per annum. Curve 3 relates to the annual cost, but at 30 and 10 years depreciation, respectively, at the same rate of interest.

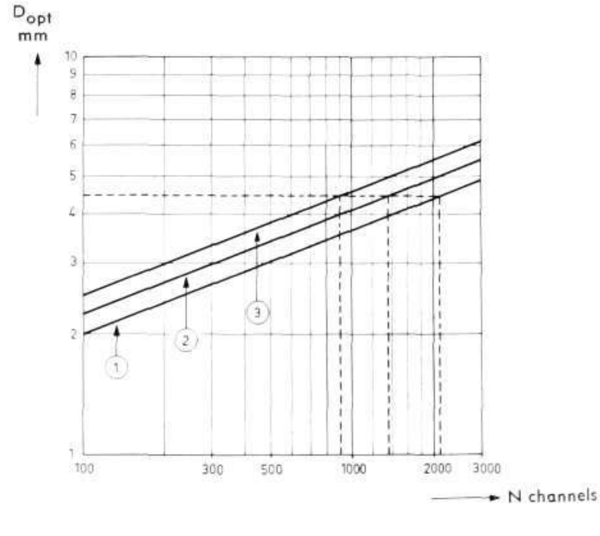


Fig. 1
Optimal coaxial tube diameter as function of number of channels in the system

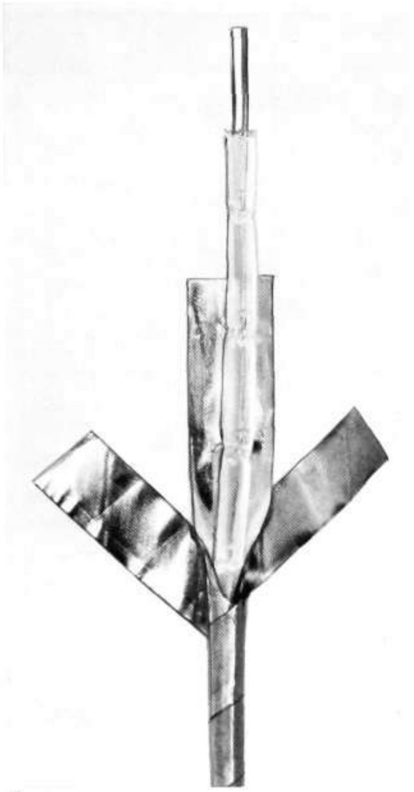


Fig. 2

Structure of small-diameter coaxial tube, type A, with balloon insulation

The curves show that the small-diameter coaxial cable standardized by C.C.I.T.T. with the diameter ratio 1.18/4.43 mm has an optimal system size of $N \approx 900$ channels when the annual costs are considered. On the basis solely of first cost, the nearest optimal system size will be about 2700 channels.

For purposes of conversion a 2700-channel system will under all circumstances be economically advantageous compared with the installation of new cable.

The saving in per cent of the first cost for three sizes of system through the use of small-diameter coaxial cable instead of the heavier 2.6/9.5 mm cable has been calculated below. The costs of laying of the cable have not been included since they are virtually independent of the diameter of the coaxial tubes.

System	300	960	2700
Saving	50 %	20 %	0

Another factor which makes small-diameter coaxial cable attractive also on heavy-traffic routes is that the cost of standby equipment in a multitube small-diameter coaxial system is small compared with the conditions in a normal coaxial cable system with small number of tubes.

Small-Diameter Coaxial Tube

Two coaxial tubes have been standardized by C.C.I.T.T., both having the dimensions 1.18/4.43 mm, which gives an impedance of 75 ohms. The difference lies mainly in the structure of the outer conductor. Type *A* has an outer conductor consisting of a 0.15 mm thick copper tape, formed to a tube with a longitudinal slit, surrounded by two layers of copper-plated steel strip (fig. 2). Type *B* has an outer conductor thickness of 0.18 mm and steel strip without copper-plating.

Owing to their different designs of outer conductor, the two types have slightly differing attenuation curves below about 500 kc/s. The insulation of type *A* consists of a polythene tube of outside diameter equal to the inside diameter of the coaxial tube, the polythene tube being crimped on to the inner conductor at intervals of about 20 mm (fig. 2). This procedure makes for simple manufacture and the inner conductor is well centered, which ensures high homogeneity. The cable also has a high dielectric strength and a minimum of dielectric adjacent to the inner conductor. Type *B* is supplied with different forms of insulation and may have a slightly higher attenuation constant in the high frequency range.

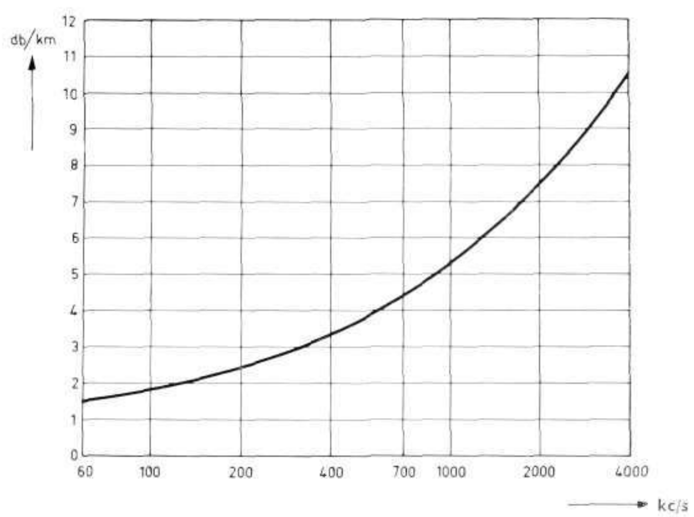


Fig. 3

Attenuation constant α as function of the frequency for small-diameter coaxial tube, type A, at + 10°C

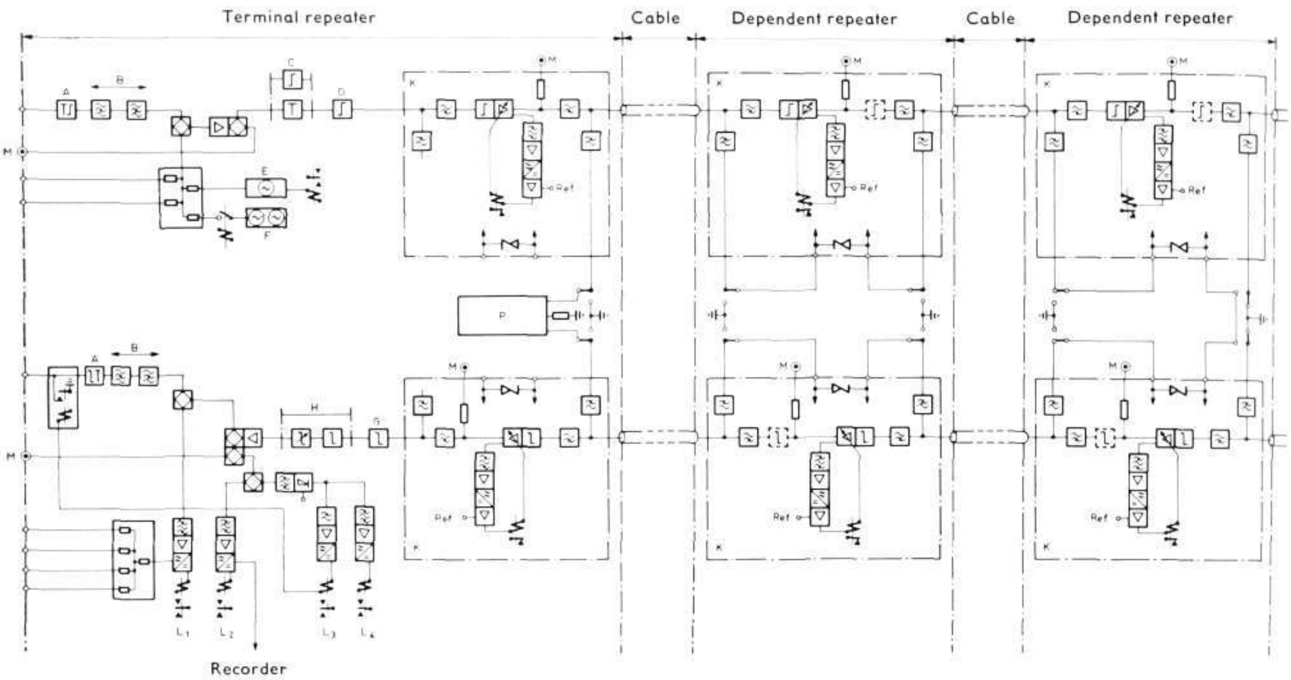


Fig. 4

Block schematic of h.f. line equipment for small-diameter coaxial cable

- **A** Equalization network for station cable
- **B** Pilot suppression filter
- **C** Mop-up equalizer on send side, if required
- **D** Pre-emphasis network
- **E** Pilot generation equipment
- **F** Generation of test frequencies for supervision of intermodulation
- **G** De-emphasis network
- **H** Equalization equipment
- **K** Line amplifier unit
- **L_1** Equipment for frequency comparison pilot
- **L_2** Pilot receiver for supervision of a line section
- **L_3** Noise blocking receiver
- **L_4** Receiver for supervision of intermodulation
- **M** Mainteaance test point
- **P** Remote power feed unit
- **Ref.** Reference voltage

Type *A* has been considered the best and is the standard type in Sweden. The reasons for this are its good impedance characteristics and high dielectric strength, and the anticipated better crosstalk characteristics, since the copper-plated steel strips ensure good electrical connection across the slit in the outer conductor. This is important having regard to the future extension of the small-diameter coaxial system to 12 Mc/s.

L M Ericsson's h. f. line equipment is designed for use in conjunction both with type *A* and type *B*. Fig. 3 shows the attenuation per kilometre at + 10° C for type *A* as function of the frequency.

Repeater Spacing

One of the most important factors in the economy and technical performance of a h. f. line is the choice of repeater spacing. This has been made 8 km for the 300-channel system having regard to the available repeater elements, remote power supply, and future convertibility.

When converting to a larger system it is convenient to halve the repeater spacing and the following series of systems is realized:

Repeater spacing	System	Bandwidth
8 km	300 channels	1.3 Mc/s
4 ,,	960 ,,	4.2 ,,
2 ,,	2700 ,,	12.4 ,,

These numbers of channels are in full accordance with what has already been standardized for the 9.5 mm coaxial cable. At its last plenary meeting C.C.I.T.T. also standardized 4 km as repeater spacing for 960-channel small-diameter coaxial cable systems.

Electrical Features of the Line Equipment

Fig. 4 shows a block schematic of a terminal repeater station and two intermediate repeater stations with remote power supply.

In broad outline the arrangement is the conventional one for a four-wire coaxial cable system.

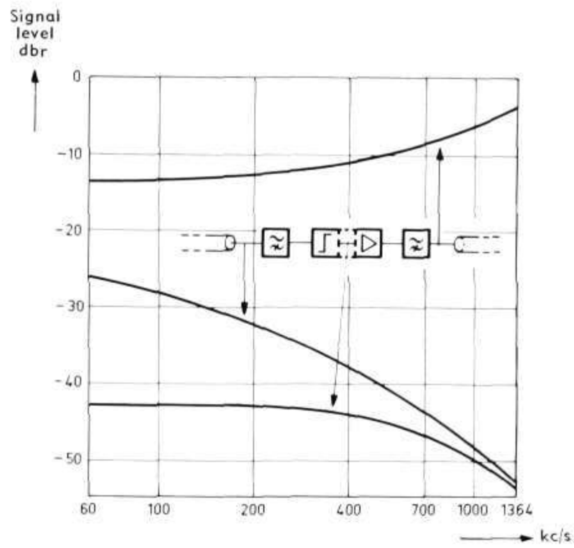


Fig. 5
Relative levels within the line repeater for 1.3 Mc/s system

The function of the intermediate repeater is to compensate for the attenuation of the signal over a cable length equal to the repeater spacing, in the 1.3 Mc/s case 8 km, corresponding to 49.2 db at the highest frequency. The required gain curve is achieved by a combination of a three-stage amplifier, the gain of which rises with the frequency, and a special gain equalizing network at its input. The dependence of the gain on the frequency is achieved by means of negative feedback which varies with the frequency. This is essential to the use of pre-emphasis in the system and thus has a great significance on the repeater spacing that can be achieved with given types of transistors. Fig. 5 shows the level conditions in the 1.3 Mc/s repeater. A three-stage amplifier was chosen since it is the type which makes best use of the transistors.

Each intermediate repeater is equipped with automatic level regulation under the control of the main pilot.

Owing to temperature variations in the soil the cable attenuation varies by about 2 ‰ per °C, which for the 1.3 Mc/s system and ± 10° C represents about ± 1 db per repeater section. For this purpose regulation at each third intermediate repeater station would be acceptable, but great advantages are gained by providing each intermediate repeater with a pilot receiver.

Each regulator has a range of ± 4 db. Of this quantity ± 1 db is allotted to temperature correction as noted above. The remaining ± 3 db can then be allocated as follows:

□ ± 1 db for manufacturing tolerance of the cable.

□ ± 2 db can be used to take up tolerances in the length of repeater sections, which in the 1.3 Mc/s case corresponds to about ± 300 m, without needing to lengthen the cable.

This principle results in simplification of the installation work and eliminates the need for different types of amplifiers. On replacement of a line amplifier no adjustment of the gain need be made.

If desired, the manufacturing tolerance for the cable and the repeater section tolerance can be eliminated at the time of installation. The entire regulating range of ± 4 db is then available for temperature correction, which means that overhead cable can be used.

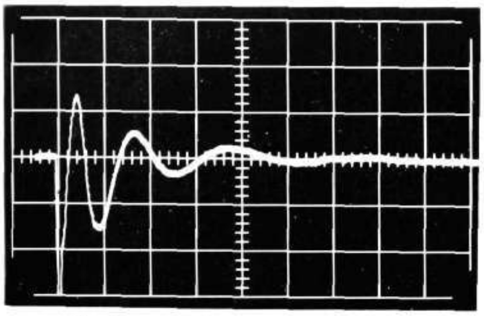


Fig. 6

Oscillogram of transient response of line regulating equipment for a section consisting of 26 intermediate repeater stations

Ordinate: 0.06 db per division
Abscissa: 0.2 second per division

The principle of using a pilot receiver in each intermediate repeater also means that the supervision of the intermediate repeaters can be based on testing of the outgoing pilot level. This permits the simplest and most reliable method of fault tracing. The regulators, which are of proportional type, are accurately designed in respect of envelope gain, and therefore no stability problems arise even on long pilot sections (several regulators in cascade).

Fig. 6 shows an oscillogram of the transient response of the line regulating equipment over a distance comprising 26 intermediate repeaters when the transmitted pilot level is changed in steps of 1 db. Note the short regulating time and that no overshoot occurs.

A simplified circuit diagram of a repeater with associated regulator is shown in fig. 7.

The repeater equipment has been designed for very high reliability. Miniaturization has therefore not been taken too far. The number of components has been kept as low as possible, and only silicon-planar transistors have been used.

The function of the terminal repater on the left in fig. 4 is, on the send side, to handle the band from the modulating equipment, adding the pilots required for the h. f. line and producing the desired output level characteristic. On the receive side the equipment restores the frequency band from the cable to a flat level curve and filters out the line pilots. The receive side also contains an equalizing equipment, the function of which is to eliminate the inevitable variation of equivalent of the h. f. line. This variation may suitably be divided into a fixed portion and a portion which varies with time, each being treated separately in the equalizing equipment. The fixed portion is caused by systematic addition of inevitable small deviations in each intermediate repeater from the ideal gain curve. By means of advanced calculation and manufacturing technique it has been possible to reduce these deviations to very small values, but despite this great accuracy it is necessary to insert an equalizing network after some 20 intermediate repeaters.

The portion which varies with time is caused in the same way by systematic addition of small deviations of the regulation characteristic of the repeaters from the ideal and is eliminated by means of a simple manually adjustable network. Manual adjustment was adopted since the variations take place very slowly; they are a function of the variation of the cable temperature according to the season of the year. The temperature dependence of the repeaters themselves is negligible.

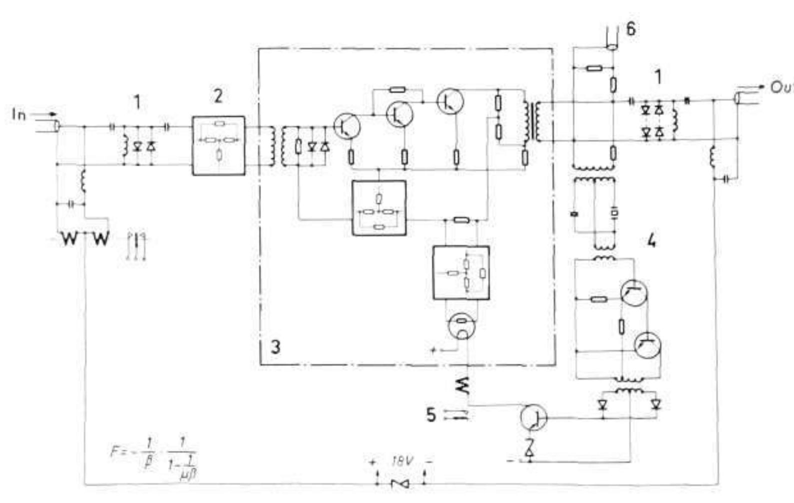


Fig. 7

Simplified circuit diagram for line amplifier

1 Power separation filter
2 Gain equalizer
3 Amplifier
4 Pilot receiver
5 Pilot alarm
6 Test point

Owing to the stability of the intermediate repeaters the form of the variation is constant. The use of cosine equalizers is therefore not warranted and they have been avoided in order to attain the simplest possible adjusting procedure.

Pilot Equipment

To achieve the greatest possible flexibility in operation, the line equipment has its own pilot generation. Pilot suppression is also provided on the send and receive sides. In this way the modulating equipments are always satisfactorily protected, while at the same time the pilot injection is protected from interference and full protection is obtained on through-connection between h. f. lines.

The terminal repeater equipment also has facilities for the through connection and distribution of the frequency comparison pilot. The arrangements for injection and extraction of this pilot must lie in the line equipment. Traffic rearrangements can then be made without affecting the distribution network for the frequency comparison pilot, which is important from the point of view of achieving a clearly arranged and easily handled network. Suppression of the frequency comparison pilot follows the same principle as for the line pilots.

Remote Power Supply

The power requirement for an intermediate repeater is 18 volts, 60 mA d. c. per repeater and direction of transmission. The power is transmitted on the inner conductors of the two coaxial tubes at constant current. The repeaters are connected in series and receive their voltage from a zener diode. In the case of a two-way intermediate repeater the voltage drop is then 36 V. The nominal current output is 75 mA, thus allowing 15 mA in the zener diode. With a 500 V feed between the inner conductors, 10 two-way intermediate repeaters can be supplied in the 1.3 Mc/s case, and the distance between the supply points will be max. 168 km. This agrees well with the spacing at which equalization is needed, and a power-feeding intermediate repeater station is a variant of the terminal repeater equipment.

The intermediate repeater stations have been provided with a switching facility which, in conjunction with a mobile supply unit, permits the elimination of all feeding voltages on a cable section and metallic earthing of the inner conductors without traffic interruptions.

This arrangement ensures the greatest possible safety of maintenance staff, with the possibility of using higher feed currents, which is of significance for the future economic utilization of small-diameter coaxial cables by conversion to larger systems. Different safety arrangements have been discussed within C.C.I.T.T., among other things the limitation of the current to 50 mA, but this has been considered insufficient.

The mid-point of the supply voltage is connected to earth via a high impedance in the supply point. This means that the sensitivity of the system to undesired external induction is halved and that unilateral earth faults do not jeopardize the remote power supply. These faults can be located by measurement of unbalance currents. The supply unit which has to supply a constant current of 75 mA has been designed as a transductor regulator to ensure the maximum reliability and resistance to induction voltages.

Overvoltage Protection

Owing to their thin semiconductor layers, high-frequency transistors are sensitive to overvoltages. A well designed protector against voltages induced in the cable will therefore be of greatest significance for the reliability of the h. f. line. The long metallic circuits required by the d. c. supply render such protection even more necessary.

The introduction of protector elements must, however, be done with the greatest caution. Repeater equipments are nowadays buried and must therefore operate with a minimum of maintenance. The use of carbon arresters or rare gas tubes is not compatible with this principle and should therefore be avoided.

L M Ericsson have therefore based their overvoltage protector solely on semiconductors in combination with filters. It consists of a transverse protector, patented by L M Ericsson, on the inputs and outputs of the repeaters and a longitudinal protector in the power supply path.

The overvoltage protector allows the equipment to operate with the outer conductors of the coaxial tubes earthed, which was highly desirable from the point of view of personal safety. All metallic objects with which staff may come into contact are in this way always at earth potential.

Fault Tracing and Supervisory Equipment

Any faults on long h. f. lines, primarily cable faults, must be immediately reported to the terminal stations and the staff there must be able accurately to locate the fault without comprehensive and time-consuming measurements, despite the many repeaters involved. It is important that the principle should be as simple as possible in order to arrive at the minimum fault rate for the fault-locating equipment.

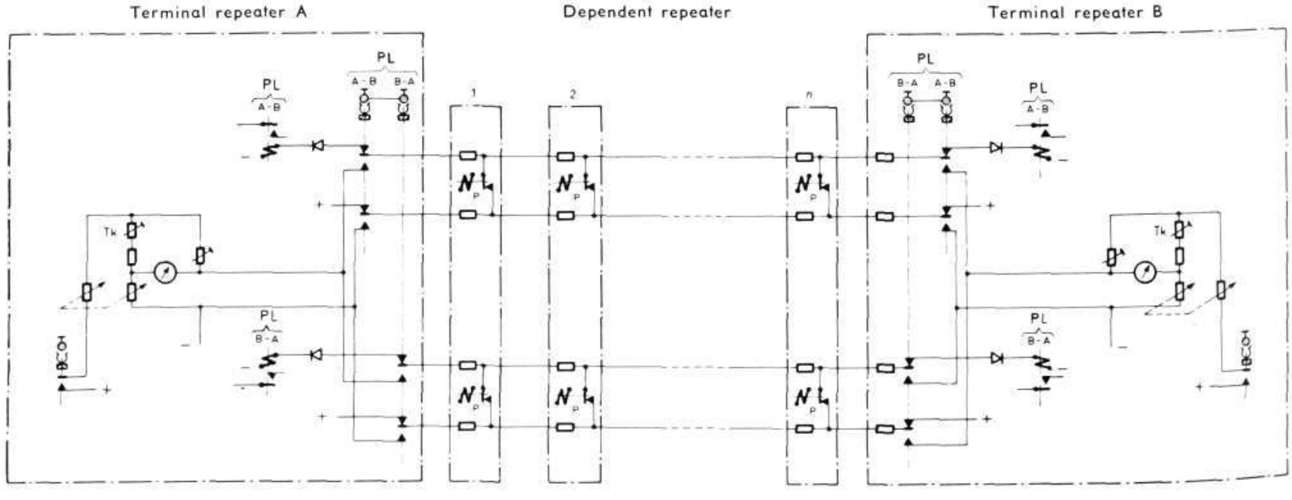
Since the fault-locating equipment must operate when there is a fault in the main system, it was considered advisable to make it as independent of the main system as possible. Interstitial pairs in the cable are therefore used for the purpose.

By basing the fault-locating arrangements on the systematic use of pilot receivers, the latter have been further exploited so as to permit a simple fault-locating system. Fig. 8 shows a simplified diagram of the system. Every pilot receiver has a mercury-wetted relay which, on loss of the pilot, applies a short-circuit to one interstitial pair in the cable. Level alarm is thereby obtained at both terminal stations and, by measuring the loop resistance for

Fig. 8

Simplified diagram of fault-location equipment

P Pilot alarm relay
PL Pilot alarm control
Tk Temperature compensation



the pair up to the short-circuit point, the location of the fault can be read on a station-graduated bridge. One pair is required for each direction of transmission. Up to 50 stations can be supervised in this way. The supervising section may therefore consist of two power-fed sections and a power-feeding intermediate repeater need not be attended.

A circuit patented by L M Ericsson, by sensing the current-voltage condition on both sides of the fault, permits the correct issue of alarm even in the event of an open on a power feed loop. Otherwise accurate location would be impossible, since all repeater stations in the loop would be dead and give an alarm.

The fault-location equipment incorporates an accurate level supervision device after the last amplifier in the receive section of the terminal repeater equipment. This pilot receiver has an adjustable alarm limit and can be furnished with recording instruments so as to check the stability of the line (block schematic, fig. 4).

For customers who so desire, equipment for intermodulation supervision and noise blocking can be added in the terminal repeater.

The function of the noise blocking equipment is to short-circuit the line output when the noise level per channel exceeds -40 dbm0 (limit adjustable). This prevents the disturbance of traffic on other circuits by noise which—for example in the event of a cable fault—might be transmitted via group through-connections.

Even if the h. f. line has pilot-controlled level supervision, it may be desirable to supplement this by intermodulation measurement. With heavy feedback in the repeaters these may show the correct gain but nevertheless have too high a non-linear distortion.

On the send side the measuring equipment injects two frequencies between the useful band and the regulating pilot, in the 1.3 Mc/s system 1309 kc/s and 1313 kc/s. The intermodulation product $2f_1-f_2$, which is 1317 kc/s, is obtained in each repeater. Since the frequencies lie within a narrow band, the product adds on a voltage basis, and its level can be checked in the receiving station. The principle is shown in the block schematic in fig. 4.

Speaker Circuit

A speaker circuit can be arranged, if desired, along the line. The main use of this circuit is when there is a fault in the system, and it must therefore be as independent of the system as possible. For this reason a four-wire circuit with terminal amplification has been adopted on ordinary interstitial pairs in the cable. The dimensions and loading of the pairs should be such that the attenuation at 800 c/s between the terminal points does not exceed 40 db. The amplifiers need be placed only in terminal and power-feeding intermediate repeater stations.

A portable telephone set for plugging into the intermediate repeater stations enables conversations to be established between them or to the terminal stations.

D. c. signalling is employed and provides a simple means of selective calling.

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The four-wire circuit permits a long speaker circuit connection without stability problems, which is a general requirement.

The terminal repeaters also contain the necessary hybrid for directly connecting to various two-wire trunks in the repeater station.

A. c. signalling is used on the two-wire side.

Mechanics

Terminal Repeaters

The terminal repeater—containing high frequency equipment, power supply equipment, fault locating and alarm equipment, and speaker circuit equipment—is made up of plug-in, electrical and mechanical functional units mounted on a single-sided bay according to L M Ericsson's standard principles as described in Ericsson Review No. 4, 1960. The exception is the units which contain send and receive line amplifiers, which are constructed on the principles described below for repeater amplifiers. This was done in order to avoid variant types of equipment, with the trouble which this involves in spare parts stocks. The lower part of the bay is therefore slightly differently arranged in order to provide space for these line amplifier units.

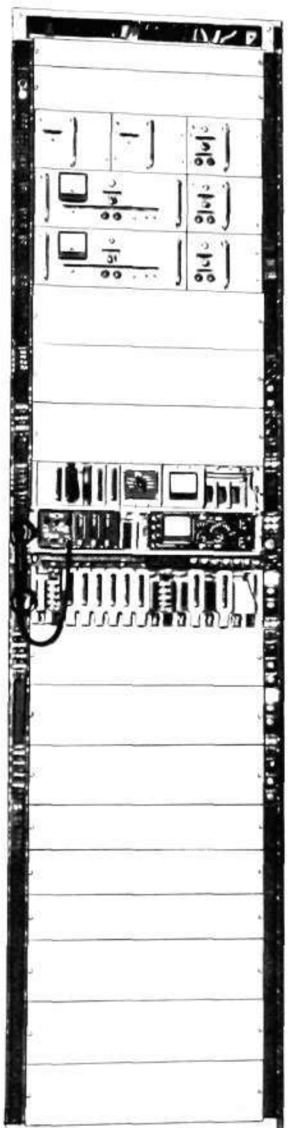


Fig. 9

Terminal repeater bay for 1.3 Mc/s system
Three dust covers removed

Fig. 9 shows a terminal repeater bay for the 1.3 Mc/s system. At the top is the distribution frame which allows convenient connection of the bay equipment to the station cable. Thereafter follow power pack and remote power feeding unit. In the middle of the bay is the fault locating and speaker circuit equipment, surrounded by the high frequency equipment. The lower part of the bay accommodates send and receive line amplifiers. All maintenance test points are shortcircuitproof and placed on the sides of the bay.

The bay accommodates two complete h. f. line equipments containing all the above-mentioned auxiliary equipments.

Used as a power-feeding intermediate repeater, the capacity is reduced to one system per bay.

Intermediate Repeaters

The intermediate dependent repeater stations must be of a type which can be buried. Arrangements should, however, exist for easy access to the line amplifier equipment so as to cut down the time taken to replace a faulty unit to acceptable limits. The replaceable equipment should consist of hermetically sealed units which are insensitive to moisture. This is of vital significance for preventing unnecessary disturbances of operation on account of moisture damage. The units must be so placed as to eliminate the risk of freezing in the soil in wintertime.

For human safety all accessible equipment should be at earth potential.

It is also desirable that the coaxial tubes of the main cable terminate on a distribution frame into which the repeater equipment is plugged. The coaxial

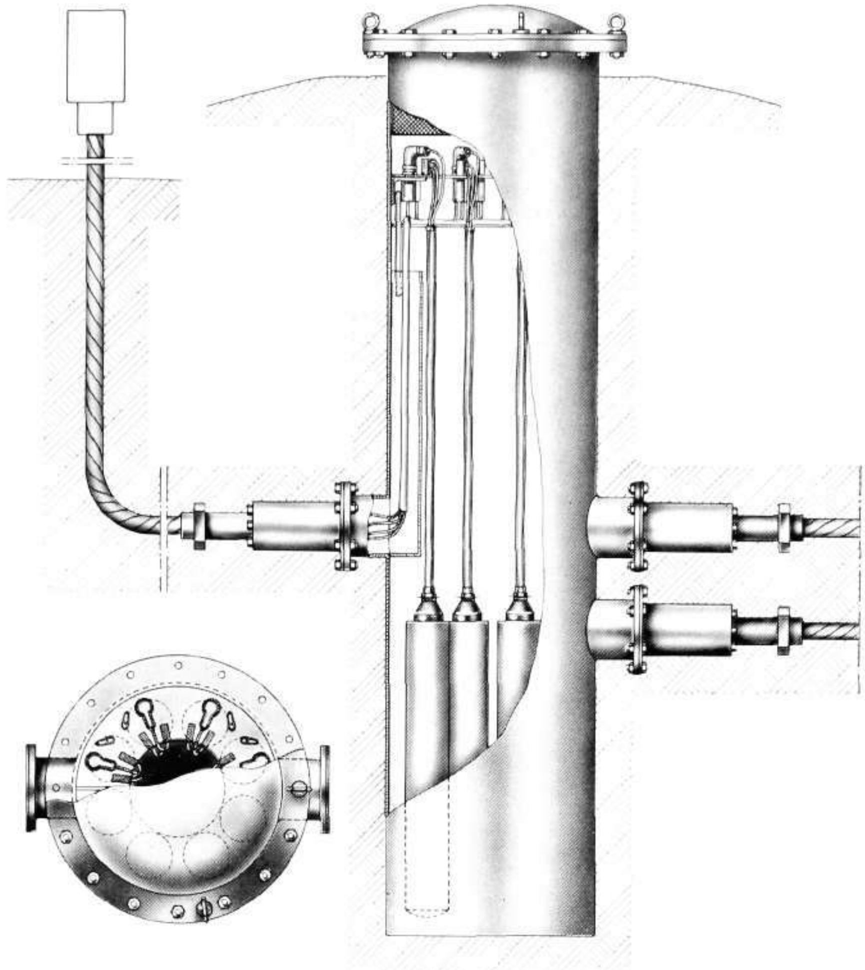


Fig. 10

Dependent repeater housing with stub cables

tubes are then easily accessible for cable fault tracing. This solution is also advantageous during conversion operations and allows the quickest possible replacement of a faulty repeater.

Checks of the functioning of the equipment should be possible without extensive excavation work.

To fulfil these requirements it was necessary to develop a special mechanical structure.

This is shown in figs. 10 and 11 and consists of a watertight cylindrical steel housing of 470 mm diameter. At the top is a terminal panel incorporating terminals for line amplifiers and switches for the power supply. The housing has stub cables for simple connection to the main cables. The cables are fitted with gastight plugs to permit sectioning of the gas pressurization, if any, of the main cable.

The use of stub cables allows convenient adaption to different sizes of main cable. If there are quads in the main cable, they are not taken into the repeater housing but led in a separate cable between the two branch joints shown in fig. 12. If desired, a cable can be arranged up to a small test pillar above ground, in which the functioning of the equipment can be checked. The pillar also contains a termination for a speaker circuit telephone. All test points are protected against short-circuits, so that any damage to the equipment above ground causes no disturbance of the traffic.

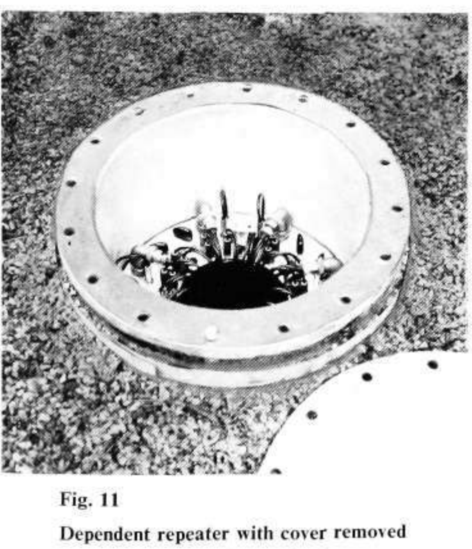


Fig. 11

Dependent repeater with cover removed

Note terminal panel with terminals

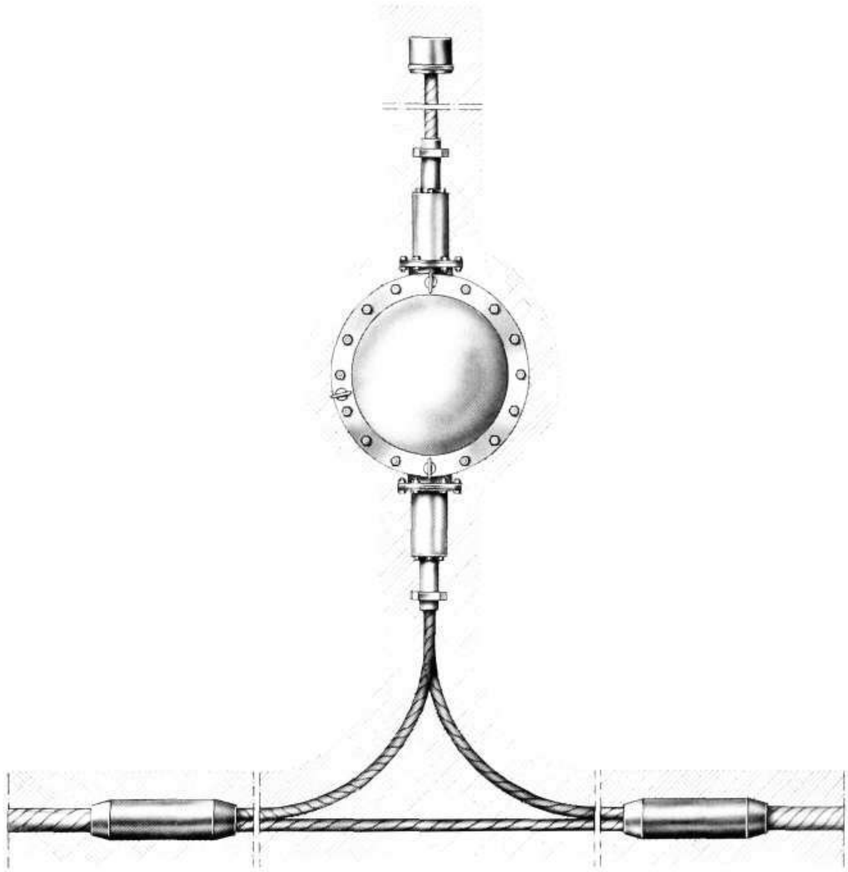


Fig. 12

Example of connection of main cable to repeater housing

All apparatus in the signal path is combined into plug-in, hermetically sealed units, one per system and direction of transmission, connected to the repeater housing terminal panel. The combination of all high frequency equipment into a single unit results in maximum precision of the gain curve. The principle also has the advantage of requiring a minimum of terminals in the housing.

Fig. 13 shows such a line amplifier unit for 1.3 Mc/s bandwidth.

The 4 Mc/s line amplifier has exactly the same mechanical design. The repeater housing is constructed so as to be usable for the 4 Mc/s system without modification.

On conversion from a 1.3 Mc/s to 4 Mc/s system, new housings are so located that the repeater spacing is halved and the 1.3 Mc/s repeaters are replaced by 4 Mc/s repeaters.

The housing accommodates up to 4 systems, i.e. 8 amplifier cylinders.

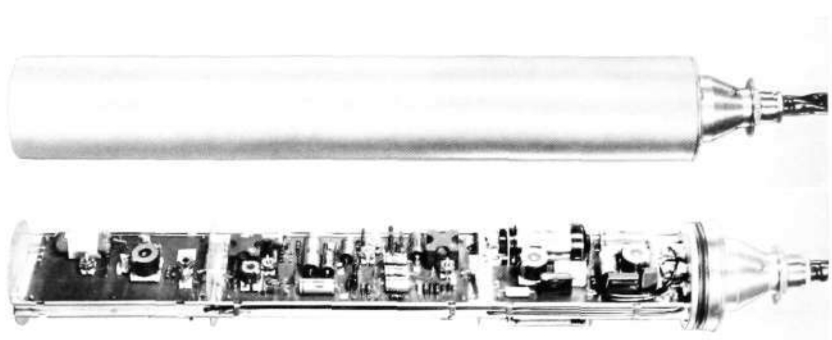


Fig. 13

Line amplifier for 1.3 Mc/s system

(Below) with cover removed

Technical Data

	System type	
	1.3 Mc/s	4 Mc/s
Frequency band (kc/s)	60–1300	60–4188 or 60–4028
Number of channels	300	900 or 960
Signal levels to terminal (multiplex). Sender/receiver (dbr)	min. – 37/max. – 22	min. – 37/max. – 22
Nominal levels in line interconnection point. Sender/receiver (dbr)	– 36/– 23	– 36/– 23 or – 33/– 33
Impedances for inputs and outputs (ohm)	75 unbal.	75 unbal.
Output level to cable for highest channel (dbr)	– 3.5	– 10
Pre-emphasis (db)	10	10
Gain per intermediate repeater station at pilot frequency (1364 and 4287 kc/s) (db)	49.2	43.5
Weighted noise per channel at zero level point for loaded system (– 15 dbm0/channel) (pW/km)	< 2	< 2
Near-end and far-end crosstalk attenuation per station within and between systems (db)	90/95	90/95
Line-regulating pilot (kc/s)	1364	4287
Level (dbm0)	– 10	– 10
Regulating range per intermediate repeater station at pilot frequency (db)	± 4	± 4
Residual error at pilot frequency from regulator at max. regulation (db)	< ± 0.15	< ± 0.15
Equipment for frequency comparison pilot (kc/s)	60	60 or 300
Remote power supply	d. c., series	d. c., series
Max. number of dependent repeater stations per power unit	10	13
Max. distance between power-feeding stations (km)	168	108
Supply current (mA)	75 ± 5	75 ± 5
Supply voltage (V)	500 V	550 V
Data for a line section = 280 km		
Variation of equivalent with frequency after line-up: spread (db)	< 1	< 1
Level stability (db)	1	1

AKD 735, Code Switch P.A.B.X. for 30 Extensions

A. GUDMARK & B. ROMARE, TELEFONAKTIEBOLAGET L M ERICSSON, STOCKHOLM

UDC 621.395.25
LME 8372

This article presents a Code Switch P.A.B.X. designed to cover requirements up to 30 extensions and 7 exchange lines. The new P.A.B.X., AKD 735, is a register-controlled code switch unit working on the bypath principle.

L M Ericsson's new 30-line P.A.B.X., *AKD 735*, is characterized by high traffic capacity, low maintenance expenditure and silent operation. The equipment is accommodated in a grey-enamelled rack which takes up little space and harmonizes well with modern office furnishings (fig. 1). The exchange is based on the code switch (with pressure contacts of precious metal), the small operating movements of which result in a minimum of wear. The exchange therefore has a long life and costs very little in maintenance.

The maximum capacity of the exchange is 30 extensions, 7 exchange lines and 4 internal connecting circuits.

AKD 735 has a very high traffic capacity. When fully equipped, up to 15 extensions can be conversing at the same time. *AKD 735* can also be furnished with all the traffic facilities required by a modern enterprise.

Fig. 1
Code switch exchange AKD 735
(Right) with doors open

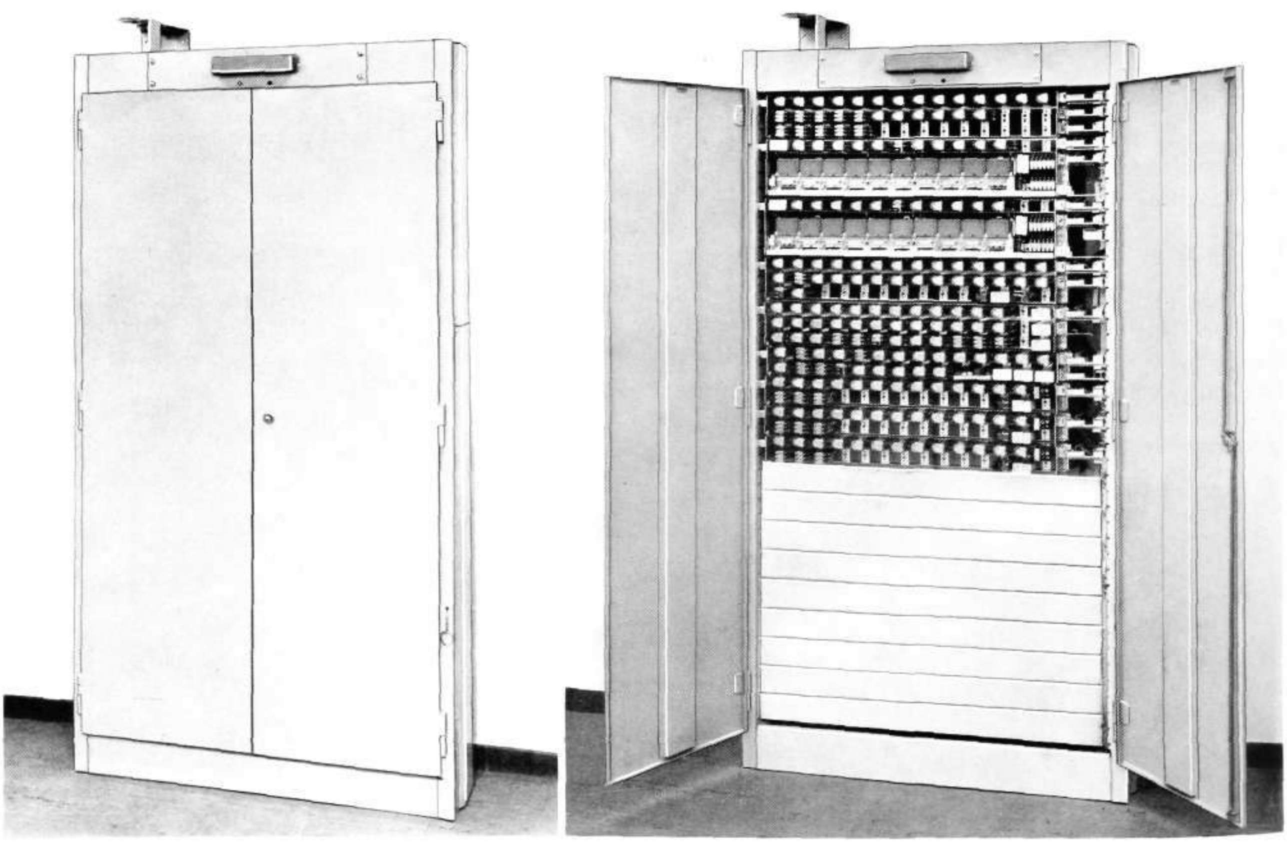


Fig. 2
Operator's console

The standard model of *AKD 735* incorporates a number of traffic facilities such as enquiry calls, transfer, automatic camp-on, priority, busy lamps, two types of night service connection, etc.

With additional equipment various special services can be obtained such as automatic paging, supervision of dialled trunk calls, group calls, etc. The operator's console (fig. 2) is of modern design with a grey plastic cover. Since each extension is represented by its own key on the console, incoming calls can be put through very quickly.

The extension telephones are normal telephone sets with earth button.

Traffic Facilities

Internal calls. The extensions have two-digit numbers and the operator a one-digit number. Four internal conversations can take place simultaneously.

External calls. Calls to the public exchange are initiated by a single-digit prefix.

Incoming calls are indicated on the operator's console. Connection to the extension is effected by pressing a key. Under night service conditions calls can be answered from one or more extensions.

Priority. Any extension can be given priority, which implies that the extension can enter an engaged circuit. A faint busy tone is issued to the conversing parties to indicate that a third party is on the line.

Extension categories. The extensions can be divided into four categories, viz.:

- ☐ Unrestricted extensions with full traffic facilities.
- ☐ Trunk-restricted extensions with facilities for all kinds of traffic except dialled trunk calls. (Trunk discrimination equipment is required for this purpose.)
- ☐ Semi-restricted extensions with full internal traffic facilities. These can receive incoming calls from the public exchange, but external calls can only be set up with the assistance of an operator.
- ☐ Restricted extensions which can be used for internal calls only. All external traffic is barred.

The extensions can be allotted individually to any desired category.

Enquiry calls. During an external conversation an enquiry call can be made to another extension, to the operator, or via an exchange line to a public exchange subscriber.

Transfer. External calls can be automatically transferred any number of times either to an extension or to the operator.

Night service. There are two types of night service, viz.:

- ☐ Individual night service, which implies that incoming calls are automatically put through to predetermined extensions connected to the respective exchange lines. The exchange lines can also be combined into groups.
- ☐ Common night service, which implies that incoming calls are signalled on one or more separate bells. The call can be answered on any non-restricted extension.

Serial calls. An incoming call can be put on a "series circuit" by the operator, which means that it is automatically reconnected to the operator after each completed conversation. In this way the operator can connect the call to a number of extensions in the desired sequence.

Parking. The operator can place an incoming call on a parking circuit. In order that a parked call shall not be forgotten, the operator is recalled automatically after about 30 seconds.

Recall to operator. If an incoming call is not answered by an extension within about 30 seconds, the operator is recalled automatically. If an incoming call is placed on an automatic waiting (camp-on) circuit for an engaged extension and the latter does not become free within about 30 seconds, the operator is also automatically recalled. This ensures good telephone service.

Busy indication. The individual extension keys on the console are fitted with busy lamps. This makes for quicker switching and better telephone service.

Announcement of incoming call. The operator can announce incoming calls both to free and engaged extensions. When the operator enters an engaged circuit to announce a call, a special warning tone is issued.

The exchange can be supplied with extra equipment for the following traffic facilities:

Group calls to a group of extensions dealing with the same kind of business. Extensions allotted to a group number can also be called on their individual numbers.

Visual paging both from extensions and from operator.

Automatic tie lines to other private exchanges.

Subscriber meters for metering dialled trunk calls when the public exchange has facilities for transmission of metering pulses.

Trunk discrimination equipment, which prevents unauthorized extensions from initiating calls over the trunk network.

Operator's Console

The operator's console (fig. 2 and 3) allows efficient telephone service.

On the left-hand side of the console are the exchange line keys. Each exchange line is represented by a key, a call lamp and a supervisory lamp.

The switching equipment, which is placed on the right, consists of 15 keys including splitting key and keys for night service, serial calls, paging, cancellation, bell signal, and transfer to extensions.

Fig. 3
Operator's console

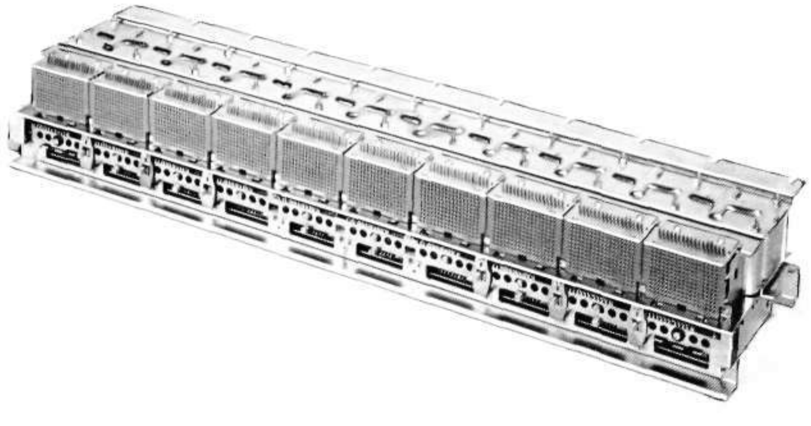


Fig. 4
Code switch

There are 30 extension keys for putting-through incoming calls to the extensions. Each key corresponds to one extension number (20–49). In each of the keys there is a lamp which, if the extension is engaged, lights when the operator answers the call or presses the test key. An exchange line call that has been connected to an extension can be visually supervised until the extension has answered.

The dial, which is used by the operator when setting-up external calls, has been placed on the right of the console for greater ease of dialling. Three subscriber meters can be placed under the dial.

Equipment

Code Switches and Relays

The code switch (fig. 4) has a capacity of 10 inlets and 30 outlets and a 6-pole multiple. The small dimensions of the switch are due to the use of a new type of contacts and a new method of multipling between the verticals.

The moving contact consists of a wire spring with a cylindrical contact tip. The fixed contact is V-shaped. This arrangement and the high contact pressure ensure excellent contact performance. In operated position the moving contact is locked in the vee, so that the contacts are insensitive to impact or vibration. The contact action ensures very efficient self-cleaning of the active contact points.

The relays (fig. 5) are the well-known *RAF* and *RAH* relays which are used also in public exchanges.

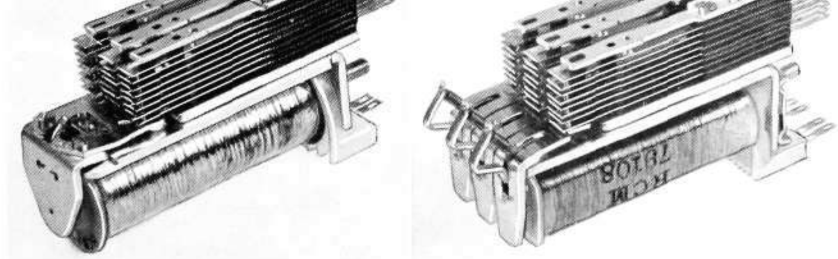


Fig. 5
RAF relay (left) and RAH relay

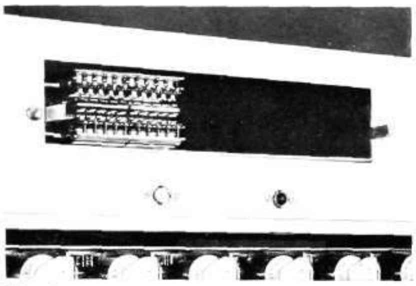


Fig. 6
Fuse and lamp panel

Rack

The rack has a light-grey enamel finish and is made of extruded sheet steel. Its dimensions are: height 1948 mm, width 1025 mm and depth 250 mm.

At the top of the rack are fuses for all switching units (fig. 6). Blocking buttons for the exchange lines are placed on the respective relay sets.

The rack has a retractable wheel and can be swung out from the wall to allow access to the back of the P.A.B.X. (fig. 7). The front is fitted with locked doors and the back with cover-plates, also with locks (fig. 8).

The rack is supplied cabled for its maximum capacity. The fixed cabling on the rack terminates in multipole jacks into which the relay sets and switches are plugged. The incoming cables enter the rack at the top left-hand corner and terminate on an M.D.F. located under a panel on the left-hand side of the rack (fig. 9).

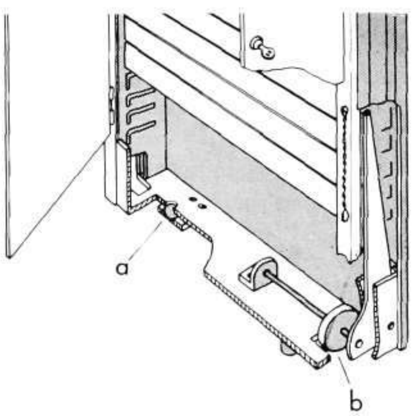


Fig. 7
a. Steel ball
b. Wheel

Operator's Console

All switching operations are done with push-button keys. In each key are one or two lamps which facilitate the supervision of established connections. Five such keys are mounted as a unit. The push-button contact springs and lamps are wired to a multipole plug. The key units plug into the console (fig. 10). The entire console is covered with a grey plastic casing. The plastic tops of the buttons are easily removable for change of lamp or engraving. The handset plugs into the console. The dial is used only for setting up external calls and is placed on the right of the console, as dialling is normally done with the right hand.

Fig. 8

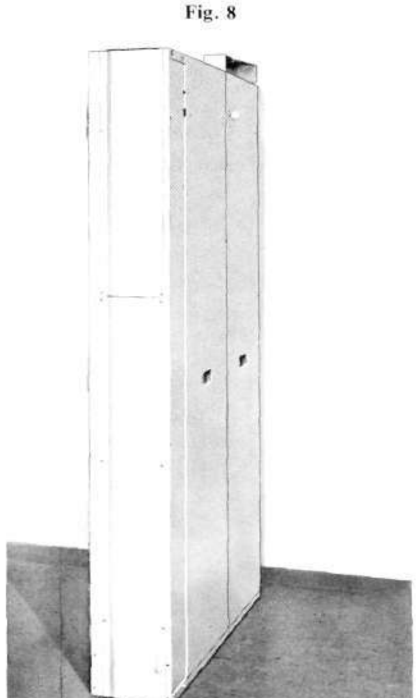


Fig. 9

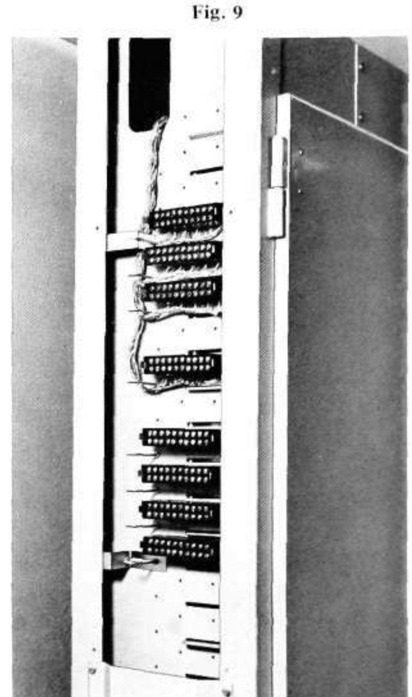


Fig. 8
AKD 735 swung out from wall

Fig. 9
Position of M.D.F.

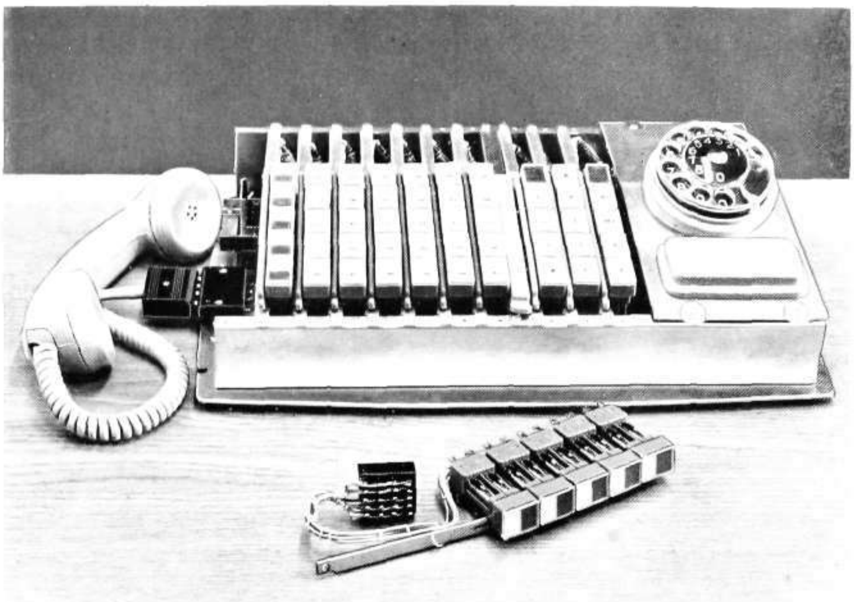


Fig. 10
Operator's console with dust cover removed

Power Supply

The P.A.B.X. is designed for an operating voltage of 48 V, which may fluctuate between 48 V and 56 V without loss of reliability.

At places where power failures are relatively rare a battery eliminator is recommended as it requires no maintenance. The battery eliminator should be rated 48 V, 8 A, and have an extra tapping for 90 V, 5 VA AC for ringing current. In the event of a power failure the exchange lines are automatically connected direct to certain predetermined extensions. A suitable battery eliminator for these exchanges is *BMN 2425* (fig. 11).

At places where a battery and charger are required, the batteries should be of sealed type for 48 V. Sealed batteries have several advantages over previous types—they take up less space and do not require a separate battery room.

The charger should be rated 48 V, 4 A. It should have an extra tapping for 90 V ringing current. When operating off a battery and charger the P.A.B.X. is equipped with a transistorized ringing current unit.

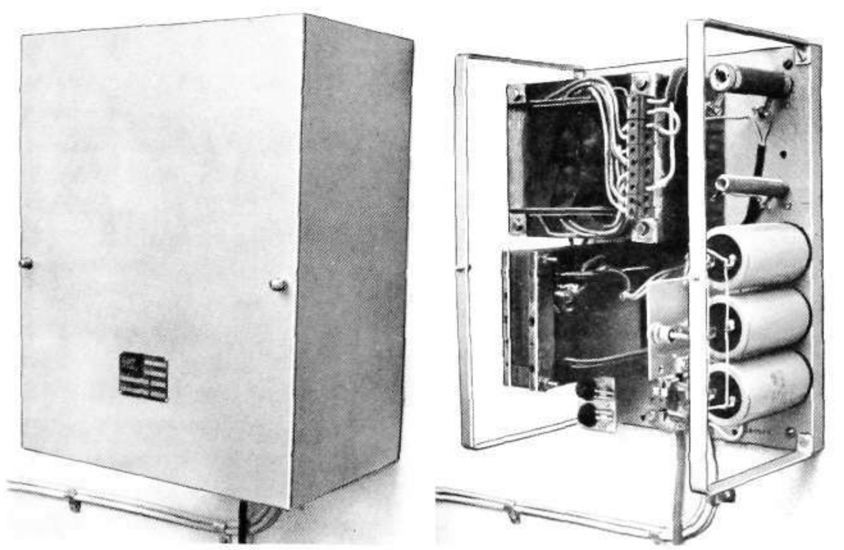


Fig. 11
Battery eliminator BMN 2425
(Right) with cover removed

The tones are generated by a transistor unit placed on one of the exchange relay sets and have a frequency of 425 c/s. The length of the tones and ringing signals is controlled by relays in the exchange.

Switching Procedure

The trunking diagram of the P.A.B.X. is shown in fig. 12.

Internal Calls

When the extension raises his handset, his line is identified by *ID*, which seizes the marker *M*. The marker connects the extension to a free register *REG*, after which marker and identifier release. *REG* extends dial tone to the extension, who can then dial the wanted 2-digit number.

On receipt of the called number, *REG* seizes the marker *M*. The calling and called lines are now connected to a free connecting circuit *SNR*. *M* and *REG* release simultaneously with the transmission of the first ringing signal. Intermittent ringing continues concurrently with the transmission of ringing tone to the caller. When the called party raises his handset, connection is established. If the called extension is engaged, the caller hears busy tone. If the caller has priority, he can enter an engaged circuit by dialling one digit. A faint busy tone is sent to the conversing parties as a sign that a third party is on the line.

As soon as either of the extensions replaces his handset, his line is cleared.

Outgoing Calls to Public Exchange

When an extension raises his handset and receives dial tone from *REG*, he can dial the prefix of the public exchange. This prefix may be either 0 or 1. On receipt of the prefix *REG* connects the extension to a free *FDR-C* and then releases. The extension now receives dial tone from the public exchange and can dial the wanted subscriber's number.

Incoming Calls from Public Exchange

Incoming calls are registered on an exchange line relay set *FDR-C*, and a call lamp on the operator's console *OPI* lights. The call is answered by the operator pressing the key in which the lamp is lit. Connection with the operator is now established. The operator puts the call through to the wanted extension by pressing the extension's line key. On the console there are three lamps, one green, one yellow and one red, which indicate whether the extension is free, engaged or restricted. If either of the first two lamps are alight, the operator can leave the connection by depressing the X button. If the extension is engaged, the call can be placed on an automatic camp-on circuit. If the red lamp lights, the operator has no possibility of putting the call through to the wanted extension.

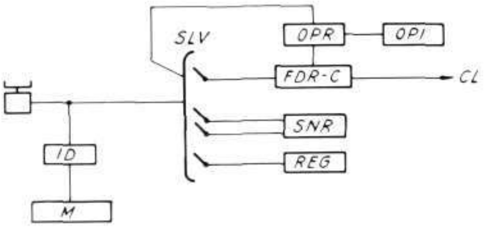


Fig 12.

Trunking diagram

ID	Line and cut-off relays combined with identification equiment
M	Marker
OPR	Operator's relay set
OPI	Operator's console
FDR-C	Exchange line relay set
REG	Register
SNR	Connecting circuit
SLV	Line finder — final selector
CL	Exchange line

Enquiry Calls

Enquiry calls can be made by an extension during a conversation on an exchange line. There are three types of enquiry calls.

An *enquiry to the operator* is initiated by pressing the earth button on the telephone set and, on receipt of dial tone, dialling 9. The operator observes the call through the lighting of the call lamp in the exchange line key. After the operator has answered the enquiry call, the extension can transfer the call.

An *enquiry to another extension* is initiated by pressing the earth button. *REG* is then connected in parallel with *FDR-C* and dial tone is returned. When the extension has dialled the number, he is connected to the wanted extension and *REG* releases.

On completion of the enquiry call the extension presses his earth button once again and is reconnected to the public exchange subscriber. If the consulted extension does not replace, the former extension can reconnect to him by pressing the earth button once again.

An *enquiry call on another exchange line* can be made by pressing the earth button and, on receipt of dial tone from *REG*, dialling the prefix to the public exchange. The extension is thereby connected via the already occupied *FDR-C*, *SLV* and a new *FDR-C* to the public exchange. On the receipt of dial tone from the public exchange he dials the subscriber's number. After completion of the call the extension returns to the original connection by pressing the earth button, whereupon the last used *FDR-C* is restored.

Transfer

If an extension wishes to transfer an external call to another extension authorized to take external calls, he first sets up an enquiry call. When the enquiry circuit has been established he replaces his handset and the rung extension takes over the call.

If the call cannot be established, either because the called extension is restricted, because the call is unanswered or because dialling is not completed, the calling extension is rerung. This provides a good assurance that the external connection is not lost.

Night Service

Two types of night service can be set up from the operator's console.

Individual night service. When the operator leaves her position she presses the button marked *N1*. The lamp then lights in that button.

Incoming calls are registered in *FDR-C*, which seizes the marker *M*. The marker connects the code switch *SLV* to the extension line allotted to that exchange line. Intermittent ringing signals are sent from *FDR-C*. When the extension raises his handset, connection is established. If the extension does not answer the call, *FDR-C* releases after a given period.

If the extension is engaged, a short tone is sent to the extension in return to indicate that an exchange line call is waiting. The waiting call is put through as soon as the previous conversation has terminated.

The night-connected extensions can be connected individually to the respective exchange lines. Several exchange lines can also be combined into a group. Incoming calls to that group are directed to a single extension.

Common night service. The operator presses button *N2* on her console before going off duty. The lamp lights in that button.

Incoming calls are signalled on one or more bells placed at strategic points in the premises. The call can be answered from any non-restricted extension by raising the handset and dialling the public exchange prefix. If the call is not answered, it is cleared in the same way as under individual night service.

Automatic night connection is established if the operator forgets to press either of the night service buttons.

Serial Calls

If a subscriber wishes to speak to more than one extension, the operator presses the serial call button. She thereafter puts the call through to the first extension in the usual way. When the conversation with the first extension has been completed, *FDR-C* recalls the operator, who then connects to the next extension. When the last conversation has been concluded the operator presses a restore button and *FDR-C* is released.

Installation and Maintenance

Relay sets and switches are connected to the rack cabling via multipole plugs. This means that all switching units can be easily inserted and removed, which greatly assists testing and maintenance.

When the rack has been placed in its final position, the extension and exchange line cables and the cable from the power equipment are connected to easily accessible terminal blocks on the left-hand end of the rack. After jumpering and strapping for extension categories have been completed in accordance with the customer's desires, the relay sets are plugged-in. The rack has multipole jacks for plugging-in of the operator's console.

The extension telephones are connected to the exchange on three wires, one of which may be a common wire.

Technical Data

The operating voltage for *AKD 735* is 48 V, but the exchange operates satisfactorily between 44 V and 56 V.

Line Data

Extension line resistance: max. 1000 ohms including telephone set.

Insulation resistance between the two branches of a line or between one branch and earth: min. 25,000 ohms.

Line resistance between push-button telephone set and positive terminal: max. 400 ohms.

The line and insulation resistances of the exchange lines are dependent on the performance of the public exchange.

Feed

The resistance of the feed coils is 2 × 400 ohms.

Dial

The dial speed may vary between 8 and 13 I.P.S. and the impulse ratio (make/break) between 30/70 and 50/50.

Attenuation

The transmission loss is max. 1.3 db on internal as well as external calls, measured between 300 and 3400 c/s. The crosstalk attenuation within the same frequency range is above 78 db.

Psophometric Noise

Noise caused by hum from the battery eliminator or crosstalk from tone and signal circuits does not exceed 0.5 mV on internal or external calls.

Tones

The frequency of the tones is 425 c/s.

1. Dial tone is a continuous tone.
2. Busy tone: approx. 0.3 sec. on
approx. 0.35 sec. off
3. Ringing tone: approx. 1 sec. on
approx. 4 sec. off
4. The warning tone on priority connections is a faint busy tone.

Ringing Signals

The frequency of the ringing signals is 50 c/s with battery eliminator and 25 c/s with charging rectifier. The voltage is 90 V.

The first ringing signal is always sent as soon as a connection has been set up. The subsequent signals are sent at intervals of approx. 1 sec. on, 4 sec. off.

Main Features

1. High traffic capacity
2. Low maintenance cost
3. Silent operation
4. Automatic enquiry and transfer
5. Automatic camp-on busy
6. Priority for selected extensions
7. Serial call facility
8. Two alternative night service facilities
9. Facilities for paging and automatic tie lines to other private exchanges
10. The P.A.B.X. can be equipped to the desired exchange line capacity and thereafter extended simply by plugging-in the desired number of units
11. Small space requirement, since the P.A.B.X. can be placed against a wall
12. Tropical finish
13. The equipment is enclosed behind doors with locks
14. Operator's console of attractive appearance and easy to operate

Radio Alarming of Fire Brigade

G. ANDERSSON, L M ERICSSON TELEMATERIEL AB, STOCKHOLM

UDC 621.396.9
614.842
LME 861 852

Fig. 1
Keyset

Of the systems used hitherto for alarming of part-time staff within a fire defence organization there have been three main types, namely sirens, signals issued to the firemen's telephones via a signal distributor, or bells installed in the firemen's homes and connected in series to an alarm loop.

None of these systems has been considered to meet the demands of today, and therefore L M Ericsson Telemateriel AB, in close co-operation with Svenska Radioaktiebolaget, have adapted the ERICALL radio paging system, designed by the latter company, for fire alarm purposes.

The result of this team project is reported in this article.

In order to gain experience of the usability of the system for the purpose, an ERICALL system was installed at the new fire station at Oxelösund during 1963 and was in full operation by February 1964. During the period of six months from the start of the full-scale test, detailed statistics were kept of failure of signals, false signals, battery consumption, repairs etc. An analysis of the statistical data showed that supplementary equipment must be added and how the receiver should be redesigned for adaptation of a normal ERICALL system into a fire brigade alarm system.

ERICALL — Normal System Design

The trial system consisted of an ERICALL system of normal design, which may be briefly described as follows.

A complete system comprises a keyset, encoder with relay register and tone generator, transmitter with aerial, and up to 392 receivers.

The keyset (fig. 1) has eight numbered buttons with associated indication lamps.

The encoder (fig. 2) contains a relay register, AF generator and power pack. The register is operated from the keyset and the combination of three successive tones modulates the transmitter carrier.

The transmitter (fig. 3) is crystal-controlled and works with amplitude modulation at a frequency of 27.45 Mc/s.

The aerial is usually of ground plan type with a radiator and three ground plan elements directed obliquely downwards.

The receiver is sized 142 × 57 × 16 mm and issues audible as well as visible signals in response to an alarm call. The selective calling principle is used, so that a call actuates only the called receiver.

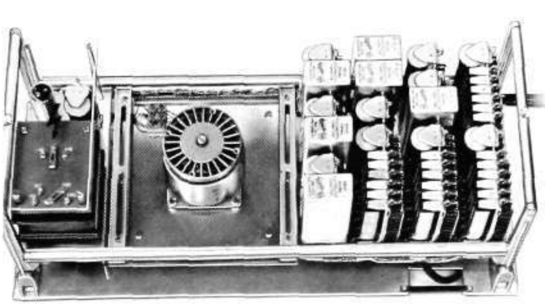


Fig. 2
Encoder

Operation

In addition to the eight numbered buttons with indication lamps, the control board has a green lamp which lights when the mains voltage is switched on, a red lamp which indicates that an alarm is being issued, and a stop button for interrupting an alarm signal.

Each button corresponds to one of eight audio frequencies within the range 250–425 c/s in the encoder. The AF code which modulates the transmitter carrier is composed of three of these frequencies.

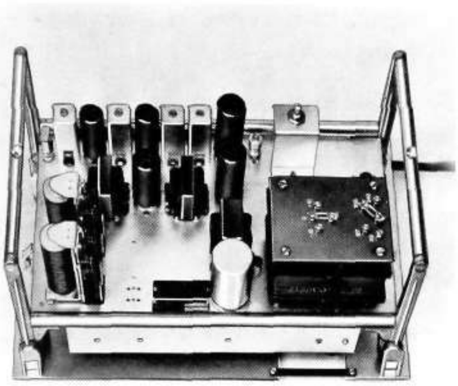


Fig. 3
Transmitter

To describe the operation of the system briefly, we assume that code 123 is to be transmitted. On the depression of button 1, this is recorded in the encoder register, the tone generator starts and the red lamp on the keyset lights. When button 2 is pressed, this is recorded by a second group of registers, and when button 3 is pressed, by the last group of registers. The register has now been informed which audio frequencies are to be transmitted and in which order. Simultaneously with the depression of button 3 the transmitter starts and tone 1 (250 c/s) is sent on the line linking the encoder and transmitter. Tone 1 now modulates the transmitter carrier during 0.5 second. By means of delayed action relays, tone 1 is then disconnected and followed by tone 2 (275 c/s). The interval between the tones is about 0.3 second. Tone 2 is also sent to the transmitter during 0.5 second and, after 0.3 second, is followed by tone 3 (300 c/s). When tone 3 has been sent for the same period as tones 1 and 2, both the tone and the transmission are cut-off. After about 5 seconds the entire procedure is repeated and continues at roughly 5-second intervals for 45 seconds, after which the register relays release and the encoder is ready to receive a new call.

During transmission of an AF signal the corresponding white lamp on the keyset lights.

The AF code is sent to the transmitter on a two-wire line which may be up to 10 kilometres in length. The transmitter is also started on this line by change of polarity of a DC voltage from the encoder.

The AF voltage is amplified in the transmitter and the resulting signal is then amplitude-modulated.

The HF signal from the transmitter is received by all receivers in the system. The low-frequency signal following after detection of the HF signal is amplified and actuates three frequency-tuned relays in the receiver. If the tuned reeds of the relays, which are in series, have the correct frequency and lie in the correct sequence, the receiver signalling device comes into operation. The alarm signal ceases on depression of the receiver restore button but is started again by the next AF code.

The time schedule for AF code transmission is shown in fig. 4.

Use of the System for Fire Alarm

The trial operation at Oxelösund provided experience which indicated that the normal ERICALL system should be supplemented by special equipment adapted to fire alarm purposes and that certain equipment should be redesigned. Svenska Radioaktiebolaget therefore developed an entirely new receiver and L M Ericsson Telemateriel AB designed the necessary supplementary equipment as indicated under the following points:

- ☐ The receiver has two signal characters for calling both individually and on a group basis.
- ☐ Replacement of the receiver mercury cells by nickel-cadmium cells.
- ☐ Stronger signal to call attention even when the possessor of the receiver is asleep.
- ☐ Elimination of risk of false signals.
- ☐ Increase of range of the system.
- ☐ Equipment for remote control of group alarm and its supervision.
- ☐ Division of group alarm into six groups.
- ☐ Automatic connection of other alarm units in the event of mains failure or fault in the system.

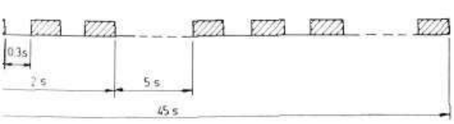


Fig. 4
Time schedule for AF code transmission

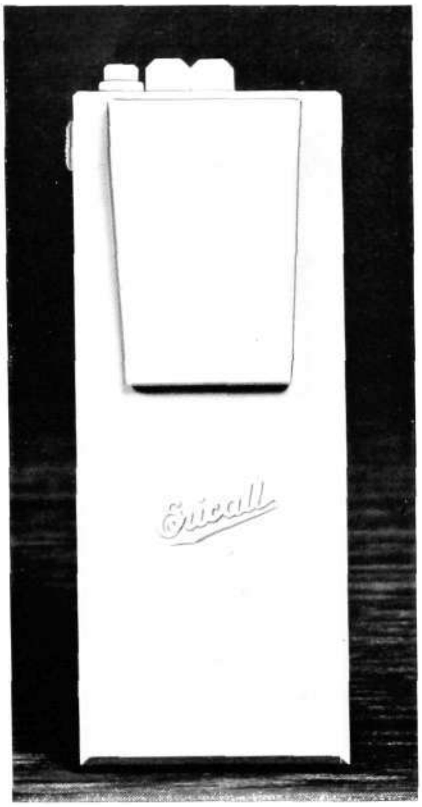


Fig. 5
Receiver

The system in its present form consists—apart from keyset, encoder and transmitter with aerial equipment—of the following units:

Selector unit containing six keys for selection of alarm group, pressure contacts for issue of major and minor alarm, and lamps for fault indication.

Relay set for automatic issue of group alarm to a preselected group.

Power transmitter with about 50 W output. In conjunction therewith the frequency has been changed to the more exclusive 29.75 Mc/s.

Monitoring unit containing, among other equipment, a receiver which checks that the transmitter delivers normal power for group alarm.

Monitoring relay controlled by a pulse from the monitoring unit on execution of an alarm. Failure of an alarm brings into operation equipment for fault indication and connection of other alarm units.

Note. In order to be able to fulfil their function on mains failure the monitoring units are designed for connection to a 24 V battery.

Receiver (fig. 5) both for individual and group alarm. Individual alarm is indicated by a white light and a continuous audible signal. Group alarm is indicated by a red light and an intermittent audible signal. The receiver is equipped with spring clips and its dimensions are 142 × 57 × 16 mm.

Power supply: three 1.5 V carbon-zinc, mercury or nickel-cadmium cells.

Receiver for group alarm alone. Of similar design to that described above.

Alarm unit (fig. 6) with plug-in connection for the receiver. The unit issues a powerful audible signal and is supplied from the receiver batteries.

Alarm unit similar to the above but with built-in rectifier for charging of batteries. Designed for connection to the commercial lighting network, 220 V, 50 c/s.

Brief Description of Operation

In contradistinction to the receiver for radio paging, the receiver in this system has two relays for individual alarm and two for group alarm. The relays for individual alarm light the white lamp on the receiver and start the sounder oscillator. The signals have a constant character. The relays for group alarm light the red lamp and start the sounder oscillator.

Since the alarm code consists of only two tones, the maximum number of combinations will be 56, i.e. 6 codes for group alarm and 50 for individual alarm.

To prevent interference from radio paging systems in the vicinity, the radio frequency has been changed by permission of the Swedish Board of Telecommunications to the exclusive 29.75 Mc/s frequency used for fire services.

The figures in brackets below refer to the block diagram (fig. 7).

Individual alarm calls are set up from the keyset (9) in the manner already described.

Fig. 6
Alarm unit

Group alarm signals can be issued either locally by means of the alarm buttons on the selector unit (3) or by remote control via the Telecommunications Administration lines and special transmission equipment, the last element of which is a siren relay set (1). The relay set (2) starts and converts the starting pulse into three pulses, each of which passes its make contact on the preset

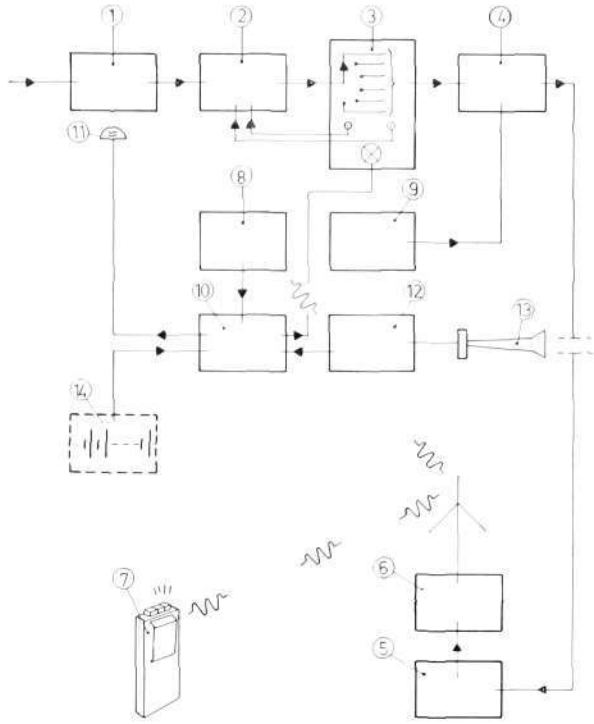


Fig. 7
Block schematic
1 Siren relay set
2 Relay set
3 Selector unit
4 Encoder
5 Transmitter
6 Power amplifier
7 Receiver
8 Monitoring unit
9 Keyset
10 Monitoring relay
11 Bell
12 Pneumatic valve
13 Siren
14 Battery

group position of the selector unit, the pulse being sent successively to those of the relays in the encoder (4) register which correspond to the transmitted code.

Corresponding audio frequencies modulate the signal from the transmitter (5), possibly with power amplifier (6), and start the group alarm devices (red light and intermittent buzzer signal) in the receiver (7) concerned.

When the relay set starts, the holding current is removed from the monitoring relay (10) but, being delayed in release about 10 seconds, the monitoring unit (8), the receiver of which starts in response to each of the six codes, has time to set up a holding circuit on another path. On starting of the monitoring receiver, a bell (11) or other signalling device operates as acknowledgement that the alarm has been executed.

If the signal is not transmitted, and is therefore not recorded by the monitoring receiver, the monitoring relay releases after about 10 seconds and then opens the pneumatic valve (12) which connects the siren into circuit (13). The siren signal can be interrupted after a given time and the signal character varied by means of a code signal transmitter. On release of the monitoring relay the fault lamp on the selector unit also lights.

The monitoring equipment is supplied from a 24 V battery (14).

Range

The range is dependent on several factors and varies from place to place. The most important factors are:

Type of aerial

Height of aerial

Power output

Receiver sensitivity

Terrain

Aerial

There is very little possibility of amplification in the horizontal plane with the frequency used. Aerials with amplification arrangements are bulky and expensive.

Height of Aerial

The wave propagation at 29 Mc/s within short ranges is practically linear, i.e. in principle one can attain the maximal visual range provided that the receiver sensitivity and transmitter efficiency are sufficient. The visual range is $\sqrt{2 \cdot rh}$, where h = height of aerial and r = radius of the earth. Doubling of the height of the aerial increases the visual range 1.4 times (40 %). The aerial should be placed as high as possible. On economic grounds one should make use of existing buildings, masts or the like.

Power Output

One means of obtaining a larger range, better coverage within a desired area, and stronger signal in shadow areas, is an increase of the aerial power. The normal power output is 5 W. On an increase to 50 W the field strength will be $\sqrt{10}$, i.e. rather more than three times as great. A further increase of the power involves unduly large and expensive transmitters. A power level of 50 W has therefore been found to be suitable for coverage of large areas.

Receiver Sensitivity

The ERICALL receiver needs a field strength of at least 50 μV/m in order to function. By way of comparison a car radio receiver needs a field strength of about 1 μV/m. The sensitivity of the receiver was selected on the basis of price and dimensions.

Terrain

The terrain affects the propagation of radio waves to a high degree and the range therefore varies from case to case. Over wet ground or water the range is greater than over dry ground. Elevations in the terrain cause radio shadows.

Summary

As appears from the foregoing account it is difficult to give general figures of range, but in practice it has been found that the following approximate ranges can be reckoned on (out-of-doors at street level):

Power	Aerial	In area of multi-storey buildings	In area of low buildings
5 W	30 m	1.5 km	3.5 km
50 W	30 m	6.0 km	12.0 km

Concluding Remarks

Among the advantages of radio alarm compared with the other systems mentioned, the foremost is the lower cost for municipal fire brigades. Then comes the fact that the individual member of a fire brigade can move freely within the duty area, whereas earlier he was forced to remain within hearing distance of a telephone or alarm bell. Experience from Oxelösund and the ten other places which today use the ERICALL system has shown, too, that the personnel are very much in favour of the method.

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

Subscriber-Dialled Trunk Traffic in Tunisia

From the ceremony in the presidential palace at Skanès in conjunction with the opening of the Sousse exchange: (from right) President Bourguiba, M. Salah Bezzaouia, M. Abdallah Farhat, Minister of Communications, and Mr. Malte Patricks, Executive Vice President of L M Ericsson.

The automatization of the Tunisian telephone network is advancing rapidly. Since the opening of the exchanges in Tunis and Sfax, referred to in the last number of Ericsson Review, two further trunk exchanges have been opened at Sousse and Bizerte. These four ARM exchanges together have a multiple capacity of 1380 lines.

The opening of these new exchanges implies that the four largest towns in Tunisia—Tunis, Sousse, Sfax and Bizerte—have been linked together via the all-automatic trunk network. All subscribers connected to automatic exchanges can now dial trunk calls to all other automatic subscribers in the country.

During the ceremony at the presidential palace at Skanès in conjunction with the opening of the new ARM exchange at Sousse, President Bourguiba, in his address to Mr. Malte Patricks of L M Ericsson, said:

"I am satisfied with the work that L M Ericsson has done in Tunisia. It was a happy inspiration to choose this Swedish company. – – – The cooperation established between Tunisia and Swedish technicians has been very fruitful."

LM Ericsson Deliveries to Colombia for 21 Million Kronor

L M Ericsson has completed three major contracts in Colombia for the delivery and installation of telephone exchanges in conjunction with the expansion of the telephone networks of Bogotá, Medellín and Cartagena. These contracts amount to some 21 million kronor.

L M Ericsson's two main customers in Colombia are the two municipal telephone companies, Empresa de Teléfonos de Bogotá and Empresas Públicas de Medellín, which bought their first automatic telephone exchanges from L M Ericsson in 1946 and 1937, respectively. Since the installation of the equipment on these last contracts the total telephone exchange capacity of Bogotá is 171,000 and of Medellín 112,600 lines.

L M Ericsson is also main supplier of telephone equipment to many other municipal telephone enterprises in Colombia and in recent years has also made large deliveries to the national telephone company, Empresa Nacional de Telecomunicaciones, which is responsible for the national trunk traffic.

Through its work on the Colombian market L M Ericsson has in recent years been the largest Swedish exporter to that country. In 1964 L M Ericsson accounted for about 50 per cent of Swedish exports to Colombia.

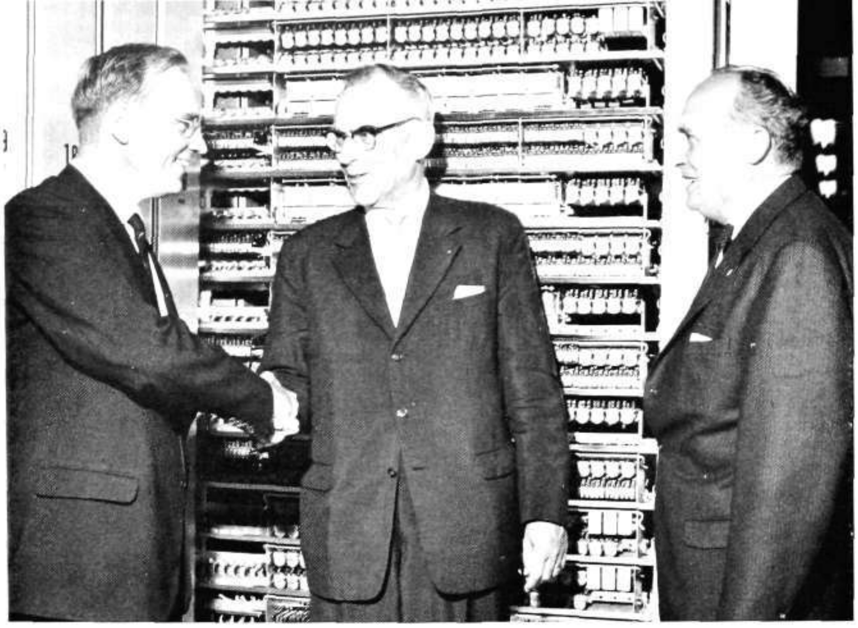
LM Ericsson Telemateriel AB — New Sales Company

On September 1, 1965, L M Ericssons Svenska Försäljnings AB (Swedish sales company) altered its style to L M Ericsson Telemateriel AB. The reason for this change of name is that, having hitherto worked exclusively on the Swedish market, the company will in future sell on foreign markets as well.

L M Ericsson Telemateriel AB will, as before, sell internal telephone systems, industrial signalling equipments such as fire alarm, time control systems and data collection systems. Others of its products are telecommunication components, telecommunication cable and outside plant.

In conjunction with these broadened sales activities a design department is being created for dealing with technical problems and development of new products.

The head of L M Ericsson Telemateriel AB is Mr. Per-Bertil Janson, who will be assisted by Mr. Anders Jörgensen as head of technical activities and Mr. Sven Österlund as head of sales.



From the opening of Sweden's first code switch exchange at Drevviksstrand: Director General Håkan Sterky is seen between Mr. Björn Lundvall (left), President of L M Ericsson, and Mr. Malte Patricks, Executive Vice President.

First Swedish Code Switch Exchange

In September 1965 the new automatic exchange of the Swedish Telecommunications Administration at Drevviksstrand, Stockholm, was cut over. This exchange is the first exchange operating on the L M Ericsson code switch system (described in Ericsson Review No. 3, 1964) to be installed in Sweden and the second in the world after the Nørregade exchange in Copenhagen.

The new exchange, an AKF 10 system with initial capacity of 4000 subscriber lines, is housed in a building which will permit expansion up to 30,000 lines.

The most striking feature of the code switch is its compact structure. A comparison with the 6-horizontal crossbar switch shows that the code switch has 70 per cent more contacts within a smaller volume. The front area of the code switch is about one-third that of the crossbar switch.

In his opening address Mr. Håkan Sterky, Director General of the Board of Telecommunications, stated that Sweden today has the highest per capita telephone density in the world counted on the number of direct exchange lines, and second after the United States on the basis of number of telephone sets, which in Sweden is now about 3.5 million. At the present rapid rate of expansion Mr. Sterky forecast that by 1980 Sweden will have 6 million telephones.

Among other representatives of the Telecommunications Administration at the opening ceremony were Mr. Bertil Bjurel, Deputy Director General, and Mr. Torsten Larsson, Technical Director. Among L M Ericsson representatives were the President, Mr. Björn Lundvall, and Executive Vice President, Mr. Malte Patricks.

Telephone Jubilee at Ericsson do Brasil

The production of telephone sets at Ericsson do Brasil recently passed the half-million mark and is rising as a rapid rate of about 80,000 per annum. To celebrate this jubilee in the history of the factory, invitations were extended to General Amaury Kruel and Dr. José Mech, Secretary of Public Works in São Paulo, and a number of other prominent personages from São Paulo, to visit the plant at São José dos Campos.

The General arrived in a helicopter and was greeted with applause by the factory workers. The Swedish Consul General at São Paulo, Erik Svedelius, Chairman of the Board of Ericsson do Brasil, spoke at the ceremony and presented General Kruel with a white DBH 15 telephone with a commemorative medallion embossed on it.

The event was shown on television and at short-film cinemas, and was reported extensively in the press. In the São Paulo parliament Ericsson do Brasil was specially mentioned for its important contributions to the manufacture of telephone equipment.

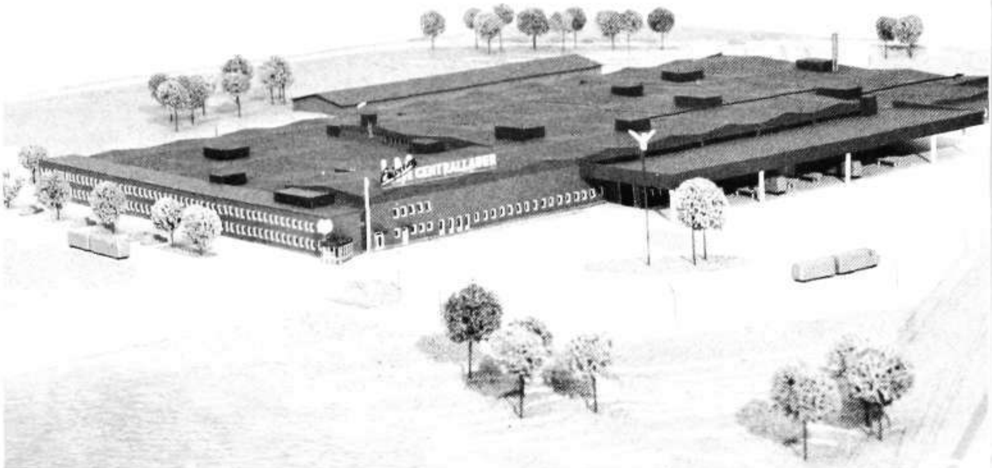
From the telephone jubilee at Ericsson do Brasil (EDB): (from left) Mr. Ragnar Hallberg, EDB, Sr. José Marcondes Pereira, Mayor of São José dos Campos, Sr. Geraldo Nobrega, EDB, General Amaury Kruel with the 500,000th telephone, Robert Brunn, Manager of São José dos Campos factory, Consul General Erik Svedelius, and Dr. José Mech, Secretary of Public Works at São Paulo.

LM Ericsson Acquires New Central Warehouse

In the middle of July the erection of a new central warehouse started on a 670,000 sq. ft. site at Flemingsberg about 16 miles south of Stockholm. The gross floor area will be about 290,000 sq. ft. and the building is expected to be completed by the middle of 1967.

Reception, storage, packing and dispatch of goods from the new warehouse will be rationalized as far as possible. New systems will be employed to some extent and in point of fact it would be more correct to call the installation a packaging factory.

Some 150 workers are expected to be employed at the warehouse. The entire installation is calculated to cost 21 million kronor.



Model of L M Ericsson's new central warehouse at Flemingsberg

Mr. Gunnar Sträng, Swedish Minister of Finance, on a visit to L M Ericsson, was shown round the exhibition room by the President, Mr. Björn Lundvall. (From left) Mr. Hugo Lindberg, Mr. Björn Lundvall, the Minister of Finance, and Mr. Arne Stein.

Some seventy factory and office staff from L M Ericsson's subsidiary, FATME, in Italy were on a trip to Sweden during the summer to make a more intimate acquaintance with the Ericsson group. During their visit to Midsommarkransen they made a tour of the factory and were shown over the exhibition room. The visit ended with a lunch and a showing of the new PR film "Four Ericofons".

The Chilean Ambassador in Stockholm, Sr. Eduarde Hamilton, in happy mood during his visit to L M Ericsson. On his left is Mr. Bengt Looström, L M Ericsson (photograph left).

The Brazilian ambassadors to the United States, Juracy Magalhães, and to Sweden, Luis Bastian Pinto, recently visited L M Ericsson's Midsommarkransen factory. In the exhibition room they saw, among other things, a model of the offices and factory. (From right) Sres. Pinto and Magalhães, and Mr. Arne Stein, L M Ericsson.

G. H. Wieneke in Memoriam

After a brief period of severe illness G. H. Wieneke died on August 30 at an age of 68 years. After graduating as an engineer he was taken on by the municipal telephone administration in Rotterdam on February 1, 1921, where the automatization of telephone operations was then planned. With his great technical ability he had an active part in the realization of these plans and the choice fell on L M Ericsson's then recently developed 500-switch ssytem. He thereafter devoted his entire interest and efforts to the complicated problems of telephone operation.

When, in 1961, he celebrated his fortieth anniversary in the service of telephony, he was greeted with many expressions of appreciation of his work and he could look back on a successful accomplishment. He rapidly advanced within the local telephone administration and had the pleasure of seeing a rapid subscriber growth, but he also lived through the 1940 catastrophe when Rotterdam was bombed and the largest telephone terminal completely destroyed by fire. With unwearying energy he organized the rebuilding and succeeded in a remarkably short time in getting the service operating again on a limited scale.

With the exception of two short periods during the wars and during reconstruction of the war-damaged Dutch telephone network, his work was in Rotterdam where he was head of the government-operated telephone network until his retirement on pension in 1962.

A keenly interested and prominent technician, he followed from the start and, with his colleagues, contributed to the development of L M Ericsson's 500-switch system and, after the war, to the introduction of the new crossbar systems in Holland. L M Ericsson sets a high value on this fruitful technical co-operation.

In the course of the years many L M Ericsson engineers have had the advantage of working in Rotterdam and, thanks very much to his efforts, have gained an insight into the practical problems of telephone operation which have been of inestimable value to us in our work. We shall remember G. H. Wieneke as the farsighted friend and technician who was always ready to discuss and analyse problems large and small. *Requiescat in pace!*

G. H. Ericsson

Opening of New Exchanges in Lebanon

On July 15 a new crossbar exchange was opened at Bhamdoun about 12 miles from Beirut in the presence of, among others, the PTT Minister, M. Sehnaoui, and the Governor of Mont Liban, M. Fawzi Bardawil.

The new exchange building at Reyfoun

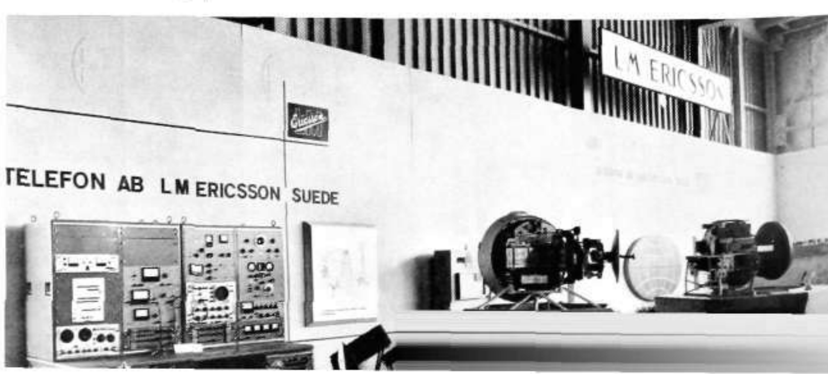
The new exchange has an initial capacity of 2000 ARF lines and handles fully automatic traffic, via the Aley exchange, to Beirut, Tripoli and Jounieh.

The work on the automatization of the remainder of the national network is proceeding according to plan. Altogether five rural exchanges are now in operation, the last of which, at Reyfoun, was inaugurated by the PTT Minister, M. Sehnaoui, in the presence of, among others, Bishop Sfeir, of Reyfoun.

During the year orders have been received for extensions of some 20 larger and smaller Ericsson exchanges.

The Minister of the Lebanese PTT, M. Antoine Sehnaoui, cuts the symbolic tape at the opening of the Bhamdoun exchange. Beside the Minister (right) is Emir Magid Arslan and (left) Director General Antoine Chemali and, behind the latter, M. Fawzi Bardawill.

From the year's International Aviation and Space Exhibition in Paris the radar equipment developed within the Military Electronics Division of L M Ericsson for the VIGGEN aircraft (right), was shown for the first time. Beside it will be seen the DRAKEN radar and, partly concealed, an equipment for digital transmission of radar pictures on ordinary telephone circuits; at the far left is a radar test equipment.



UDC 621.395.455/457
LME 8424

TRONSLI, S.: *L M Ericsson's H. F. Line Equipment for Small-Diameter Coaxial Cable.* Ericsson Rev. *42*(1965) 3, pp. 78—89.

This article presents briefly the economic arguments in favour of the smalldiameter coaxial cable systems and describes L M Ericsson's repeater equipments with 1.3 and 4 Mc/s bandwidth for this type of cable. These equipments, and the methods for their connection to the cable, have been developed in consultation with the Swedish Board of Telecommunications.

UDC 621.395.25
LME 8372

GUDMARK, A. ROMARE, B.: *AKD 735, Code Switch P. A. B. X. for 30 Extensions.* Ericsson Rev. *42*(1965) 3, pp. 90—99.

This article presents a Code Switch P.A.B.X. designed to cover requirements up to 30 extensions and 7 exchange lines. The new P.A.B.X., AKD 735, is a register-controlled code switch unit working on the bypath principle.

UDC 621.396.9
614.842
LME 861 852

ANDERSSON, GUNNAR: *Radio Alarming of Fire Brigade.* Ericsson Rev. *42*(1965) 3, pp. 100—104.

Of the systems used hitherto for alarming of part-time staff within a fire defence organization there have been three main types, namely sirens, signals issued to the firemen's telephones via a signal distributor, or bells installed in the firemen's homes and connected in series to an alarm loop.

None of these systems has been considered to meet the demands of today, and therefore L M Ericsson Telemateriel AB, in close co-operation with Svenska Radioaktiebolaget, have adapted the ERICALL radio paging system, designed by the latter company, for fire alarm purposes.

The result of this team project is reported in this article.

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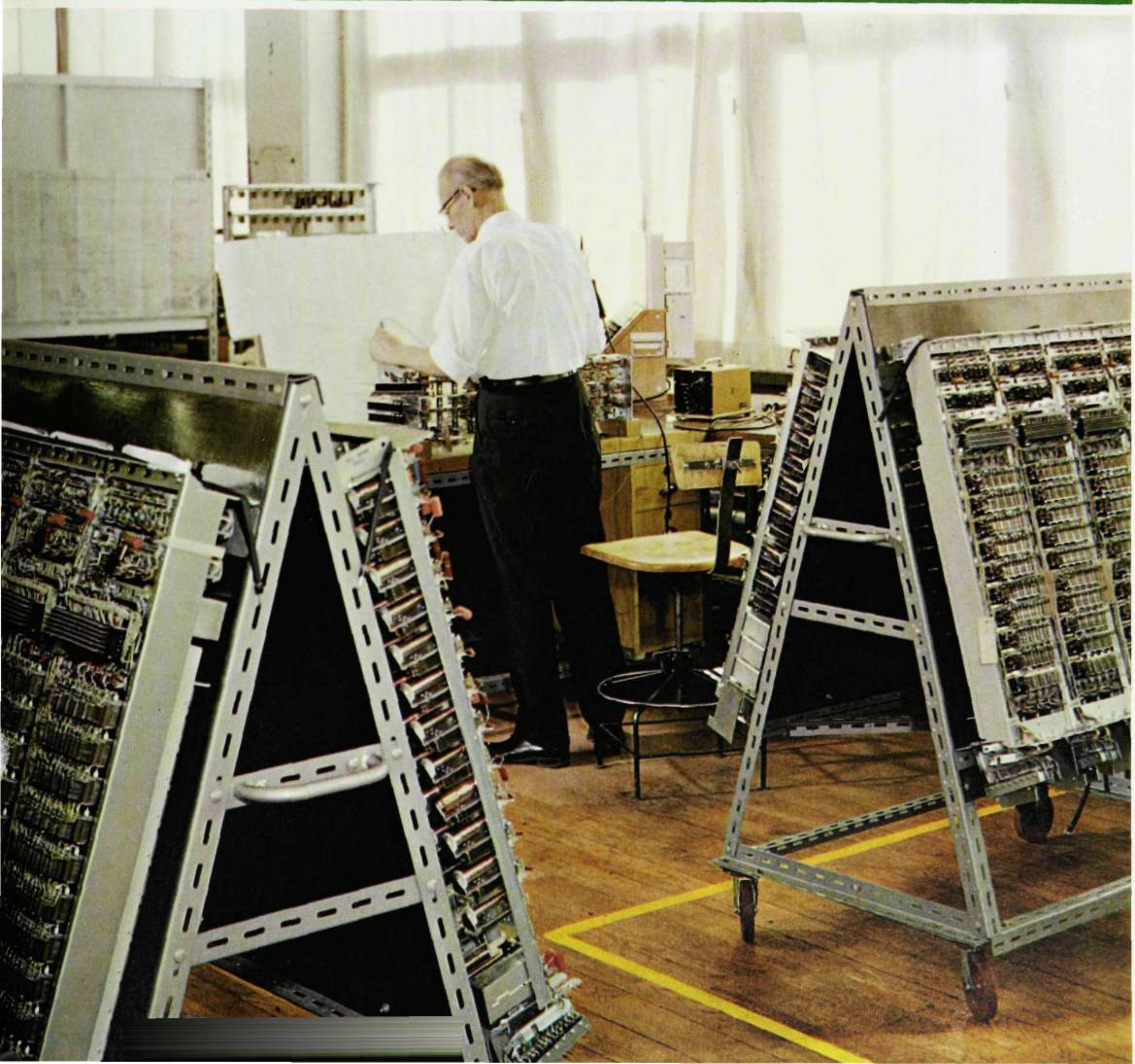

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CONTENTS

On cover: Quality evaluation of relay sets. Samples are taken from current manufacture in order to establish the quality level.

Signal Conversion Equipment for Parallel Data Transmission on Telephone Lines

W. WIDL, TELEFONAKTIEBOLAGET L M ERICSSON, STOCKHOLM

UDC 621.391
LME 81

Information which is to be transmitted exists at the sending side as a rule stored, for example as holes punched in a tape or card, as magnetic markings on a magnetic tape or ferrite store, as contact closures in a mechanical counter. At the receiving side the information is again fed into a store for further processing in a subsequent data processing equipment.

So far, serial data transmission has been predominant in the case of data transfer between sets of terminal equipment. The signal elements carrying information are in this case sent after each other in time, and the data flow occupies a single but relatively wide channel. L M Ericsson's equipment for serial transmission is described in Ericsson Review No. 3, 1962 and in TELE No. 1, 1965.

Recently, yet another type of transmission, viz. parallel transmission of data, has come into use. The signal elements carrying information are compressed into short blocks. In this method, the elements are transmitted in parallel in time and each signal element in a block uses its own relatively narrow band channel. Parallel transmission offers an economical transmission alternative which is resistant to interference, particularly when operating together with terminal equipment which has parallel input and output of data.

It can therefore be appropriate to illustrate the most important differences between serial and parallel transmission. In this article, both methods of transmission are compared, and in addition a description is given of a signal conversion equipment for parallel data transmission.

Some Comparisons of Serial and Parallel Data Transmission

In the case of binary data flow, information occurs at the data transmitter in the form of two direct voltage levels which are converted in the transmitter to voice frequency signals. These occupy a certain frequency band on the line depending on the modulation rate, method of modulation and type of filtration. At the receiver the two data voltage levels are restored. The effect of distortion and noise in the transmission channel can be reduced by suitable design of the equipment. The transmission system under discussion transmits the data levels in turn; the system uses serial transmission. If a number of serial systems are connected in parallel, the data levels are transferred simultaneously to a number of inputs and outputs in parallel; the arrangement giving rise to parallel transmission. The line frequency band available for transmission is used in its entirety for a single data channel when using serial data transmission. In the case of parallel data transmission, the frequency band is divided up into a number of narrower channels.

For economic reasons the data channels in a parallel system cannot be as expensively equipped as the single channel of the serial system. The simpler construction of the parallel channel associated with the necessity of separating the parallel channels leads to a poorer utilization of the transmitter channel bandwidth compared with the serial system (fig. 1). Thus a serial system with phase shift modulation and single sideband transmission attains a bandwidth effectiveness of almost 1.9 (bits/s.)/Hz. On the other hand an 8-channel parallel system with frequency modulation only attains about 0.6 (bit/s.)/Hz.

Fig. 1

Bandwidth usage for serial and parallel transmission

Δf_s Bandwidth for 1 serial channel

Δf_p Bandwidth for 1 parallel channel

The channel bandwidth requirements are directly proportional to the modulation rate and are thereby also inversely proportional to the signal element length. At the same data transfer rate (bit/s.) the parallel system works at a lower modulation rate than the serial system. The signal power on the line is furthermore divided among a number of parallel data channels when there is parallel transmission. The signal power in each parallel channel is therefore less than the signal power in the single channel of the serial system. To illustrate this, a comparison between a binary serial system and different parallel systems is shown in table 1.

Table 1

Data transmission equipment	Data transfer rate bits/s.	Number of channels	Information per signal element and channel (bits)	Modulation rate (bauds)	Signal element length (s.)	Transmitter power per channel (dbm)
serial	f_b	1	1	f_b	$\frac{1}{f_b}$	−6
parallel	f_b	8	1	$\frac{f_b}{8}$	$\frac{8}{f_b}$	−15
parallel	f_b	4	2	$\frac{f_b}{4}$	$\frac{4}{f_b}$	−12

The data signals are subject to interference and distortion in the transmission channel. The influence of interference depends to a large extent on the spectral distribution of the interference. A short spike impulse, for example, leads to an approximately constant amplitude spectrum. The amplitude of the intereference pulse obtained after demodulation is proportional to the channel bandwidth while the interference pulse width is inversely proportional to the channel bandwidth. The greatest risk of interference occurs when the interference pulse amplitude occurs at the instant of sampling. The interference risk is assumed to be proportional to the relationship $K = A/U$, where U = data voltage, and A = the interference amplitude when sampling. An n-channel parallel system and a serial system with the same type of demodulator are compared, assuming that

$$n = \frac{\Delta f_s}{\Delta f_p} = \frac{A_s}{A_p} = \frac{U_s^2}{U_p^2}$$

(Δf = channel bandwidth, s = index for serial channel, p = index for parallel channel).

Then $K_p = 1/\sqrt{n} \cdot K_s$, i.e. the simplified method of consideration leads to the conclusion that the parallel system is subject to less interference due to short duration pulses or breakdowns than the serial system.

If the transmission channel is subjected to white noise and with the same assumptions as mentioned above, irrespective of the bandwidth, the signal-to-noise power ratio is the same for each channel, i.e. the serial and parallel systems are influenced by white noise to the same extent.

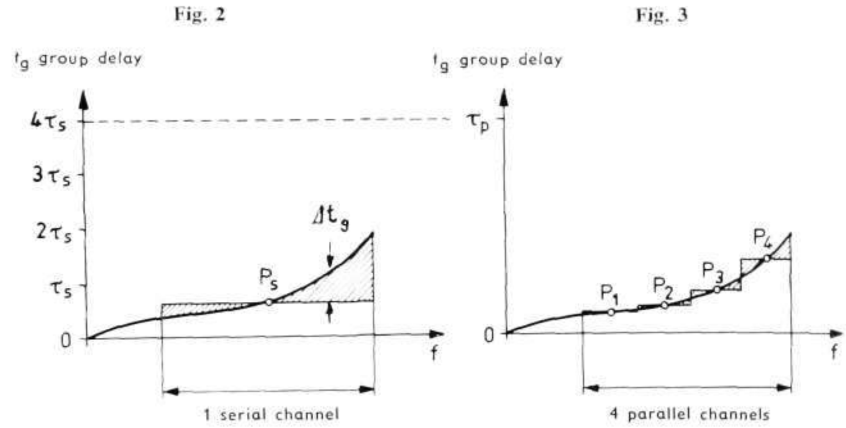
In the case of practical systems is is not possible for economic reasons to obtain optimum design of the channels of the parallel system, as mentioned earlier, in the same way as in the case of the single channel in a serial system. The parallel system is therefore more sensitive to white noise interference than the serial system. However, this is not an inconvenience as the noise occurring in a telephone network is primarily of pulse character and not noise interference.

The possibilities of transmission by the most important media, loaded circuits or carrier circuits, are limited by the delay distortion. Suitably designed data conversion equipment tolerates delay distortions of up to a time corre-

Fig. 2
Delay distortion for serial transmission

Fig. 3
Delay distortion for parallel transmission

τ_s Signal element length for serial transmission
τ_p Signal element length for parallel transmission
Δt_g Delay distortion



sponding to the length of a signal element ($\pm \tau$). The group delay graph t_g for the same loaded circuits is shown in figs. 2 and 3. The delay distortion Δt_g is the difference between the group delay graph of the loaded circuit and a horizontal line through the group delay at the channel centre frequency. The circuit is used for a serial channel in fig. 2 and for four parallel channels in fig. 3. The delay axis is graduated in multiples of signal element lengths. Comparing figs. 2 and 3 shows that due to the relatively long signal elements and narrow channel bandwidths of the parallel system, the signal elements in each parallel channel are distorted much less than in the case of serial transmission. The total delay distortion of the serial channel throughout the band is about 1.5 τ_s, the maximum delay distortion of the parallel channels is about 0.2 τ_p! Signal elements in each channel are sent out simultaneously from the sending side of the parallel system, the signal elements received in parallel, however, have mutual time differences as seen in fig. 3 if there is delay distortion. Provided that the maximum time difference (between P_1 and P_4 in fig. 3) is τ_p, the time differences can be eliminated by sampling in synchronism with the modulation rate. The parallel system according to fig. 3 thereby tolerates approximately twice as much delay distortion as the serial system according to fig. 2. The delay distortion is compensated in serial transmission by connecting phase shifting networks (equalizing in frequency domain) or combinations of delay networks and pads (equalizing in time domain) in tandem with the line. Automatic equalization of serial channels thereby leads to relatively complex equipment.

In addition to the analogue equalizing methods discussed above, digital equalization can be used in parallel transmission—e.g. by individual delay of the sampling pulses of the channels, a method permitting relatively simple automatic equalization.

When data communication occurs, the information to be transmitted is as a rule quantized in blocks, e.g. $n = 8$ binary signal elements are combined to form a character. A serial system with a modulation rate of f_s (bauds) thereby permits a data transfer rate of $f_t = f_s/n$ characters per second.

In the case of parallel data transfer, i.e. the signal elements constituting a character are transmitted in parallel and each signal element uses its own channel, the modulation rate in each channel is identical with the data transfer rate $f_t = f_p$ characters/s.

Many simple data terminal equipments such as punched tape readers and punched card readers and punches generate and receive the characters respectively in parallel form. For interworking with serial conversion equipment, the terminal equipment requires parallel/serial and serial/parallel converters; data conversion using parallel data equipment operates without these converters, thereby offering a simpler data communication system. Character-by-character transfer furthermore requires transfer of timing information for regeneration of modulation and data transfer rate on the receiving side.

If the same transmission channel is used for data and timing information the permissible signal power is shared between the two types of information. An attempt is made to have a low signal power for transmission of timing information and simple equipment for regeneration of data transfer rates at the receiver. For regeneration of the modulation rate, the serial systems with high band effectiveness use the timing information which is transferred by the level changes between different signal elements of the data flow. It is true that the method requires no signal power at all for transfer of timing information, but in return more or less complicated timing regeneration circuits are required, depending on the code restriction in the data flow. The modulation rate which is essential for timing regeneration can be transferred with the help of the $(n+1)$st channel in the case of the parallel data system. The relatively low band effectiveness is thereby reduced somewhat further, but with a suitable code in the timing pulse channel a simpler timing regeneration equipment is obtained.

With suitable design, parallel transmission offers a relatively economic and robust (i.e. resistant to interference and distortion) method of transferring data up to about 800 bits/s. on telephone channels. As an example of parallel transmission L M Ericsson's signal conversion equipment *ZAT 03* is now decribed.

Signal Conversion Equipment for Parallel Data Transmission

As mentioned earlier, parallel transmission together with parallel operating terminal equipment requires no serial-parallel converters. Simple and economic matching to a large number of different terminal equipments with parallel inputs and outputs is made easier by having flexible transmission equipment. The flexibility is obtained by using, for example, "the building brick principle". This principle is applied in L M Ericsson's signal conversion equipment *ZAT 03* for parallel data transmission so that it will cater for a large number of different types of operation. By simply exchanging plug-in units, equipment is obtained with or without

- code translation,
- timing channel,
- timing pulse regeneration with flywheel effect,
- supervisory channel in the backward direction,
- error detection equipment,

with a transmission capacity of 4, 6 or 8 binary channels.

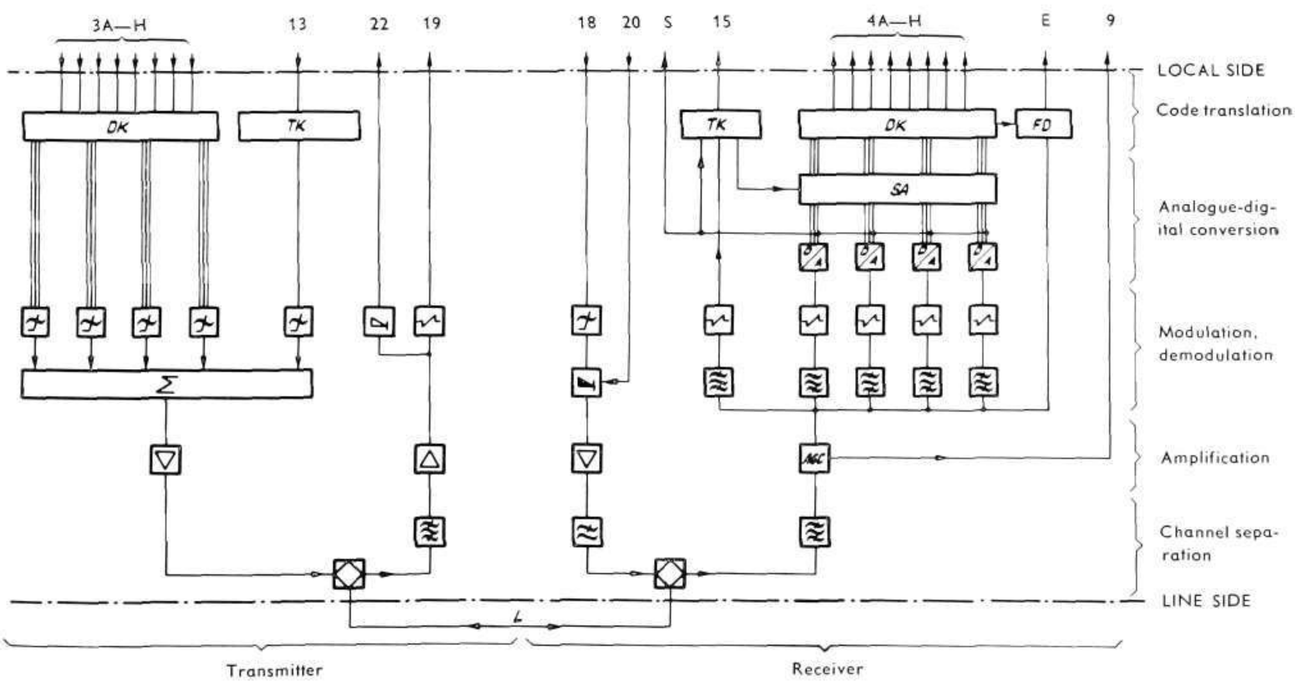


Fig. 4
Block schematic

3A—H	Transmitted data
4A—H	Received data
9	Data carrier detector
13	Transmitter signal element timing
15	Receiver signal element timing
18	Transmitted supervisory channel data
19	Received supervisory channel data
20	Transmit supervisory channel carrier
22	Supervisory channel carrier detector
E	Character error detector
S	All-zero detector
L	Line
AGC	AGC amplifier

FM modulator
ON-OFF modulator
SA Sampling circuits
Σ Summing amplifier
FM demodulator
Analogue-digital converter
ON-OFF demodulator
Hybrid
DK Encoder, decoder
TK Timing pulse encoder, decoder
FD Error detector

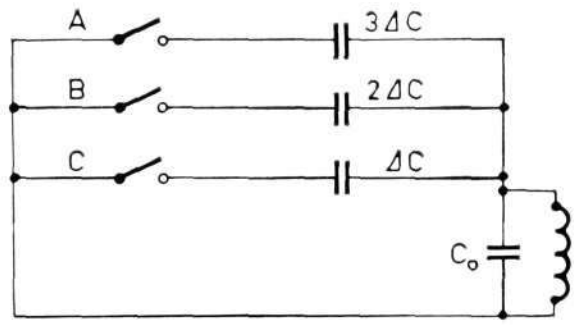


Fig. 5
Control of group oscillator

Equipment shown in fig. 4 is fully built out for transmission of an 8-column punched tape in the forward direction and including the supervisory channel in the backward direction. The numbers given on the local side interface refer to CCITT recommendations for serial systems.

Code Translation

At the output of the data terminal equipment there is information in a code intended for data processing: a machine code. In many cases the machine code is not optimum for transmission purposes and adaptation to the transmission channel requires recoding from the machine code to the transmission code. Usually the risk of errors with electronic data transmission is greater than the risk when processing data. Error detection and correction of transmission errors are simplified when the transmission code shows greater redundancy than the machine code. The transmission code redundancy is limited by the transmission capacity of the parallel channels, i.e. 8 binary channels. At the input of the encoder, an incoming character is characterized by n mechanical or electrical contacts. If 2^n characters possible, a maximum of 256 different characters can thus be transmitted.

At the output of the receiver decoder a character appears again at a number of binary outlets. The number of binary outlets of the decoder need not be identical with the number of binary inputs of the encoder. The encoder and decoder can easily be replaced so as to adapt the signal conversion equipment to different communications systems. The data flow appears once again at the decoder in the form of electrical or mechanical contact functions. The example in fig. 4 shows a code translation for a punched tape copying system.

Modulation and Demodulation of the Forward Channels

The data flow occurs at the encoder output in the form of d.c. levels channelled into a maximum of 4 groups of 3 conductors. The potential of the conductors, symbolized in fig. 5 by mechanical contacts forming a group, influences the frequency determining circuit of an oscillator. Closure of contact A thus gives rise to the lowest frequency f_1 in the frequency group, closure of contact B results in f_2, closure of contact C results in f_3, and no contact closure results in the rest frequency f_4. For the above-mentioned method of signalling the data

Fig. 6
Channel frequency positions
G_1—G_4 Frequency groups 1—4
G_B Backward channel
G_T Timing channel

flow enters 3 binary inputs with a code restriction permitting a maximum of one contact closure for each signal element. Instead of one contact closure of A, f_1 can be generated by 2 simultaneous closures of B and C. In this case the signalling method uses 2 binary inputs without code restriction. The possibility of selection of the signalling method simplifies the design of the encoder. The contact closures shown in fig. 5 are generated in the encoder; capacitances in the lines between terminal and transmission equipment thus do not influence the data signal frequencies of the oscillatory circuit.

A fully built-out data transmitter shown in fig. 4 contains 4 data signal oscillators and one timing signal oscillator. Each oscillator generates one of several possible frequencies. The signal frequencies are combined, amplified and fed out to the line via a hybrid transformer.

Table 2 shows the relationship between the signal state, contact function and data signal frequencies; fig. 6 shows the frequency position of the groups.

Table 2

Signal state	Contact closure at inputs	Data signal frequency per group
1 0	A or $B + C$	f_1
1 1	B	f_2
0 1	C	f_3
0 0	—	f_4

At the data receiver the line frequency signals pass through a hybrid transformer, a band-pass filter and an a.g.c. amplifier. The frequency groups are separated in band-pass filters. Each frequency group is demodulated by its f.m. discriminator. An analogue signal is obtained at the output of each data discriminator, having one of four possible levels corresponding to the signal frequency at the discriminator input.

As an illustration, fig. 7 shows the four level positions within a frequency group for an arbitrary data flow with a modulation rate of 75 bauds (eye pattern).

The levels are separated by 3 voltage thresholds. The discriminator design is particularly simple if both voltage thresholds and signal frequencies in a frequency group have been arranged to be equidistant. (Choice of capacitor according to fig. 5 gives practically equidistant frequencies and adjacent signal frequencies, provided that $\Delta C \ll C_0$.) Small frequency intervals reduce the bandwidth requirements of the group when transferring data and moreover permit larger frequency separations between the groups. In this way, the transmitting filters have been eliminated and requirements of the receiver

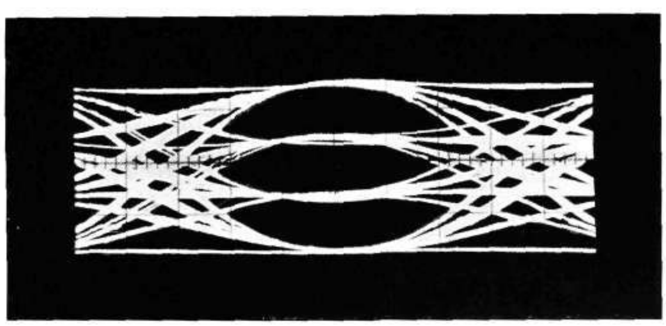


Fig. 7
Level positions for an arbitrary data flow, modulation rate 75 bauds

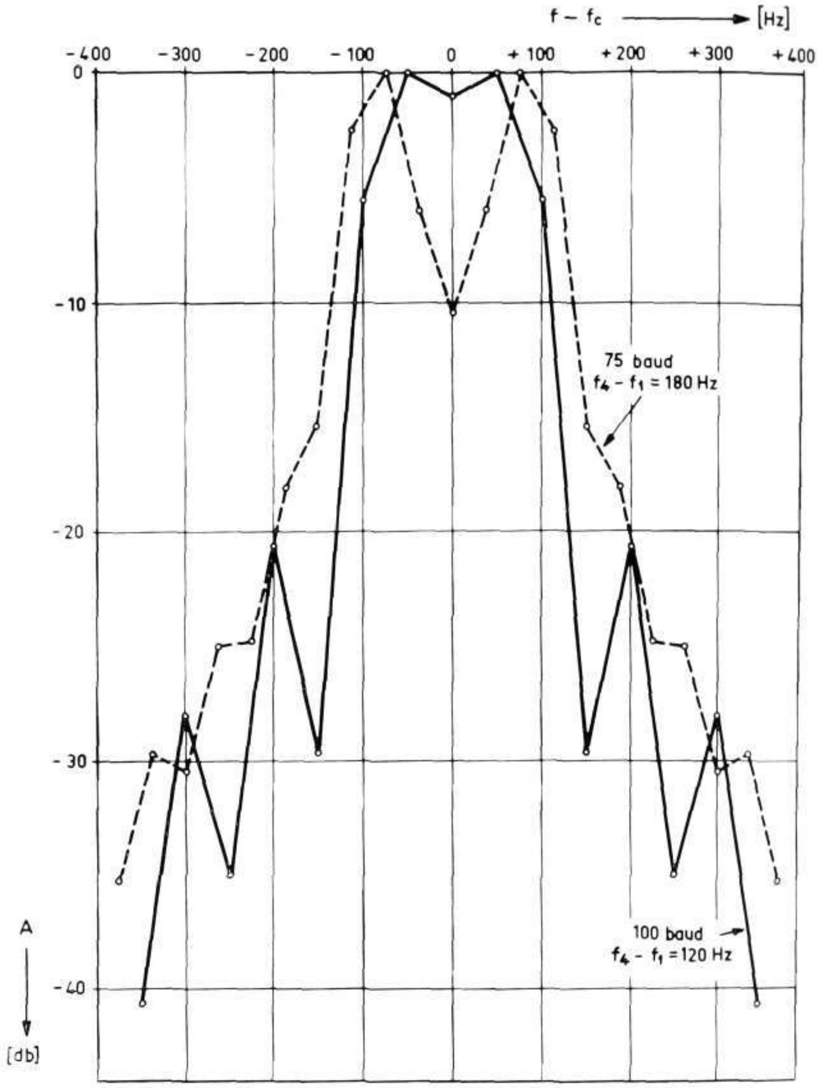


Fig. 8
Envelope of distinct spectral lines of amplitude spectrum occurring when signals alternately change from f_1 to f_4
A Amplitude spectrum

filters for channel separation have been made less stringent. As an illustration, fig. 8 shows the envelope of the distinct spectral lines of the amplitude spectrum occurring when signals alternately change from the extreme group frequencies f_1 and f_4. The line drawn in full applies to 100 bauds and 120 Hz between extreme frequencies, the dashed line shows the case for 75 bauds and 180 Hz frequency difference.

Analogue-digital Conversion

The baseband signal obtained after demodulation of each group—four possible voltage levels—is converted to digital data signals which in turn are fed via 3 lines to the decoder (corresponding to contact closures A, B and C in fig. 5). When converting, the baseband voltages are sampled in synchronism with the data transfer rate which is either sent via a separate timing channel or is recovered from the data flow. Using a timing pulse channel, a synchronous character regeneration is obtained up to the maximum system transfer rate of 100 characters/s. If there is no timing channel, the data frequencies (f_1, f_2, f_3) and the rest frequency f_4 are sent out alternately in each group. The idle position in each group is detected as "All zero". After about 25 ms. "All zero" indication, signal sampling starts and thereby permits a rate of up to 20 characters/s.

Timing Pulse Channel

The timing signals are generated in the data processing sender in synchronism with the data transfer rate. The timing signals entering the data transmitter timing pulse encoder are for example converted into a series of voltage level changes, which in turn give rise to alternate transmission of the two voice frequencies in the timing channel. The timing channel has been located between groups 2 and 3 (fig. 6) so as to reduce the influence of delay distortion when sampling.

After demodulation in the receiver a square wave is obtained having a fundamental frequency of half the data transfer rate. At the output of the timing pulse decoder, one sampling pulse is obtained for each character.

Interference to transmission changes the time interval between sampling pulses, the pulse series showing jitter which leads to telegraph distortion when regenerating characters. Greater interference can even result in the addition or elimination of characters. In many applications, use is made of a predetermined data transfer rate with a maximum tolerance of 10 %. In such cases a timing pulse oscillator with flywheel effect has been developed which reduces the jitter effect. After synchronism has been obtained, the timing pulse oscillator for the terminal equipment generates a square wave signal having a fundamental frequency corresponding to the data transfer rate.

By suitable choice of timing pulse encoder and decoder the timing pulse channel can also bear supervisory signals in the forward direction in addition to the timing pulse information.

Error Detection

The equipment can be provided with two different types of error detection: digital or analogue. On detecting a digital error, either the machine or transmission code is checked. Error indication by the parity method has been made easier by the relationship between data signal frequencies and signal states (Gray code) given in table 2. It will be seen that the signal states corresponding to two adjacent frequencies differ by a binary one. Owing to the effect of interference, instead of a certain data signal frequency the adjacent frequency is detected. The incorrect frequency group can thus be discovered by a parity check.

Error indication can also occur when non-permissible characters are received. For example, when transmitting an 8-column tape using a 4-out-of-8 machine code, only 70 characters of 256 possible giving 4 holes per character are used. If a character having more or less than 4 holes appears in the decoder, an error is indicated. In analogue error detection, the changes in level of the received frequencies occurring when there is interference can be indicated.

Backward Channel

Information in the backward direction is mainly used for control functions for error correction. The backward channel consists of a binary f.m. channel with the possibility of breaking each frequency independently. In this way three different states can be transmitted, frequency f_{R1}, frequency f_{R2} or no frequency. The signals pass through an output amplifier, pass through a hybrid when the data flow in the forward channel is separated, and are fed out to the line. The received signals pass through a band-pass filter, a limiting amplifier and are finally demodulated in an f.m. discriminator. An amplitude detector is used to detect signal-free periods and when this occurs the output signal from the discriminator is locked in a predetermined position. The backward channel operates at a maximum rate of 75 bauds and is located in the frequency range 350—500 Hz, see fig. 6.

Technical Data

Modulation rate
up to 100 bauds

Frequencies

Forward channel:	group 1	960	1000	1040	1080	Hz
	group 2	1230	1270	1310	1350	Hz
	group 3	1650	1690	1730	1770	Hz
	group 4	1920	1960	2000	2040	Hz
	timing channel	1480	1520 Hz			
Backward channel:		390	450 Hz			

Line requirements
Temporarily or permanently connected telephone circuit

Line side

Forward channel:	transmitter output impedance	600 ohms
	output level per frequency	−12 dbm
	receiver input impedance	600 ohms
	input level per frequency (min.)	−52 dbm
Backward channel:	transmitter output impedance	600 ohms
	output level (adjustable in steps of 2 db)	0 to −6 dbm
	receiver input impedance	600 ohms
	input level (min.)	−40 dbm

Local side
Signals to transmitter:

input impedance	3 kilohms ± 10 %
mark	contact closed or voltage + 0.5 to − 12 V
space	contact open or voltage + 3 to + 12 V

Signals from transmitter:

	relay output	electronic output
output impedance	0	mark < 10 ohms space > 10 kilohms
mark	contact closed	< +0.25 V
space	contact open	+ 6 V ± 10 %

Ambient temperature
0–50° C

Power supply
220 V a.c. ± 10 %

Mechanical Design

The units are designed using silicon diodes and assembled on printed wiring boards. These can be mounted in a shelf on a 19-inch bay or in a cabinet.

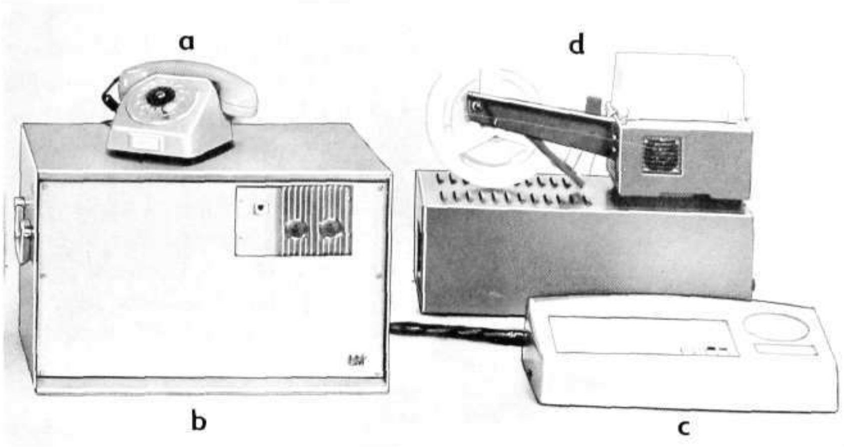


Fig. 9
Receiving terminal of punched tape transmission system

- a Telephone set
- b Signal conversion receiver
- c Control panel, error correction and control equipment
- d Tape punch

In many applications the data signal conversion equipment is connected to intermediate equipment, for example, for error correction, automatic disconnection etc. The mains supply units provided with the signal conversion equipment are also intended to supply power to simple intermediate equipment. In fig. 9 is shown a receiving terminal of a punched tape data transmission system consisting of a telephone set, signal conversion receiver, control panel, error correction and control equipment together with a tape punch.

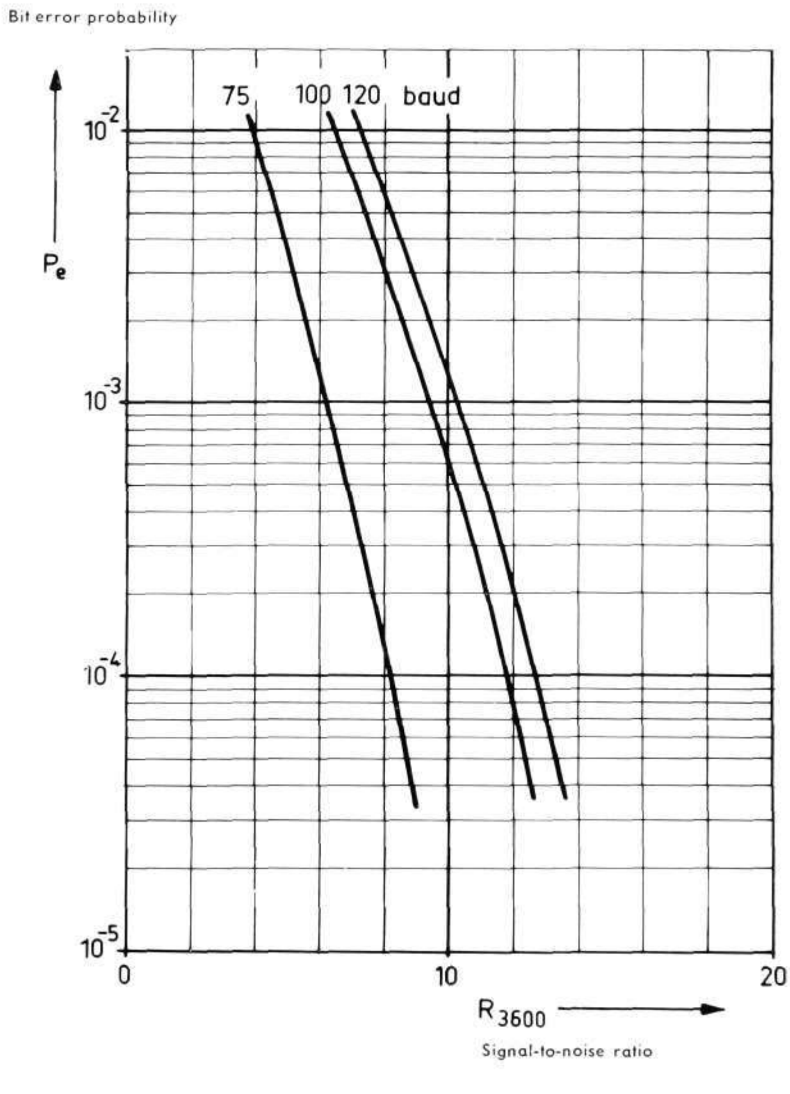


Fig. 10
Bit error probability as a function of the signal-to-noise ratio for different modulation rates (noise bandwidth 3600 Hz)

System Measurements

The measurements on the system have been made with a test circuit permitting white noise having a bandwidth of 3600 Hz to be injected at a certain signal-to-noise ratio into the data signal conversion receiver input (fig. 4). The test circuit consists of a data test transmitter generating a quasi-random information flow in serial form. The serial flow is converted into 8 parallel binary data flows in a serial/parallel converter. After passage through the data signal conversion equipment the new data flow in serial form is obtained once more. The bit error rate is calculated by comparing the serial data flows of the transmitter and the receiver. The bit error rate is shown in fig. 10 as a function of the signal-to-noise ratio for different modulation rates (The data transfer rate in bits/s. is 8 times the modulation rate in bauds).

As mentioned previously, 8 signal elements can form a character. If there is a sufficiently low bit error rate ($p_e < 10^{-2}$) the character error rate is obtained from the bit error rate $p_{character} = 8p_e$.

Summary

Parallel transmission offers a relatively economic and interference resistant alternative when operating with parallel data terminating equipment. The parallel signal conversion equipment developed by L M Ericsson employs a frequency range discussed by CCITT and should therefore be capable of being used on most telephone circuits. Measurements on switched circuits have given results for character error frequency of better than 10^{-5}. For data processes requiring more stringent requirements as regards error reliability e.g. character error probability of between 10^{-7} and 10^{-8}, error correction systems combined with the line units for automatic reply functions have been developed.

On the Dynamic Characteristics of the Electromagnetic Relay

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UDC 621.318.56
LME 7350

In the spring of 1965 C. Ahlberg presented a theory[1] for the motion of an electromagnetic relay. To simplify the solution of a time integral, the load characteristic of the relay is first converted to show the air gap flux as function of the permeance of the magnetic circuit instead of showing the load as function of the air gap. The "mechanical" load characteristic consists of straight lines which become slightly curved after conversion to "magnetic" coordinates. These curved lines are thereafter assumed to be straight. Formulae for velocity, acceleration and time of passage are deduced on the basis of this approximation.

Professor Stig Ekelöf of the Chalmer's University of Technology has made the same approximation after the conversion to a flux—magnetomotive force system of coordinates and has thereby radically simplified the formula for the time of passage.

Since Alf Lundin of the Chalmer's University of Technology has shown that velocity and acceleration formulae can be set up without using this approximation, being therefore more closely related to reality, the author has revised the formulae.*

This article presents a summary of the theory, using Ekelöf's time formula and the new velocity and acceleration formulae in place of the original ones. The basic ideas are the same as in the cited thesis[1]. The intermediate steps in the derivations are omitted from considerations of space.

A common formula for the operate time of a relay is

$$t = T \ln \frac{I_s}{I_s - I_t} \tag{1}$$

where I_s is the final value of the relay current, I_t its value when the armature assumes the critical position, and T is the "time constant" of the relay. The formula gives only an approximate value of the operate time. It would be exact if the relay current varied exponentially with time as in an inductor with constant inductance. Cf. (23) below.

The current does not vary exponentially, however, as will be seen from the well-known oscillograms in fig. 1. These show the growth of the current at five voltages with relative values 2, 3, 4, 5 and 6. The downward points in the curves mark the times of impact of the armature against the magnet. Prior thereto the armature moves at varying velocity and the inductance increases during the operate motion to two or more times its initial value. T can therefore not be predetermined but must be calculated from measured values of t with the aid of eq. (1). T varies with I_s, but remarkably little. This is because the increase of inductance takes place mainly during the last part of the operate time, when the armature performs the greater part of its movement, and which in relation to the entire operate time is usually short. It is not shorter, however, than that different operate times are measured on "early" and "late" contacts. T is therefore not unique for the relay.

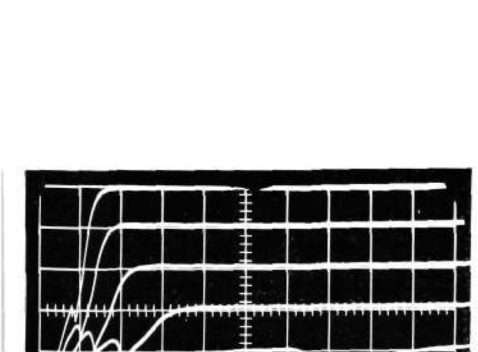


Fig. 1
Growth of relay current at five voltages with the relative values 2, 3, 4, 5 and 6

* Not yet published

Other formulae as well take the armature motion into account. But the number of contact springs taking part in the motion varies during the motion. Strictly speaking, therefore, it is not a single relay which performs the motion, but the motion may be likened to a "relay race" in which several relays succeed one another. The operate or release time is the sum of the "running times" of the different relays. Every formula for the total time in which the relay is considered as an unchangeable structural unit must therefore be a free construction based on arbitrary, although perhaps empirically verified, assumptions. A formula of this kind can nevertheless be very useful for calculation of operate times. Its disadvantage lies in the fact that it does not reflect how the design of the relay affects the time, and it is therefore of no value for the designer. In the worst case it may even mislead him.

Formulae for velocity and acceleration of the armature appear to be lacking in the relay literature. It is of great interest to control the velocity, however, since a high velocity, particularly immediately before the end positions of the armature, causes contact bounce and armature rebound, and accordingly wear both of contacts, impact surfaces and pivot.

Since the early forties great attention has been paid to wear on account of the rising demands for speed and long life of telephone and other switching systems. To reduce wear and increase velocity, the designers reduce the mass of moving parts to a minimum. As regards wear this measure appears obvious, but it is not clear whether the velocity increases when the mass is reduced and whether the increase can be carried to any desired length.

As regards acceleration, it is a commonly held view that it is positive during the entire armature motion. Certain time formulae are even based on this assumption. But if a relay is fed with rather too low a voltage, it is a well-known fact that the armature may stop in an intermediate position. The motion must thus have been retarded during its latter portion, so that the hypothesis of accelerated motion is at all events dubious.

To elucidate this and other questions concerning the motion of the armature, I contributed a theory for the dynamic properties of the electrodynamic relay. The theory is based on the approximation that the mass is negligible. One reason for this approximation is the experience that a small mass offers many advantages. The other reason is that earlier researchers have not succeeded in solving analytically the simultaneous differential equations governing the electrical and the mechanical motion without disregarding the mass. For further simplification friction is also disregarded.

To start with, we may look once again at fig. 1. From the oscillograms one cannot decide when the armature starts to move, but one can see when it ends its motion. It is in motion, however, before the current attains its first maximum.

As long as the armature is in motion, it will be seen from the diagram that the current is very much less dependent on the feed voltage than before and after the motion. The current appears to be stabilized within a given range. This appears obvious from the following argument. The current, and so the pull, grows from zero to a final value. At some instant the pull overcomes the counterforce acting on the armature and the armature changes position. This, of course, always takes place at the same pull and amperage irrespective of the feed voltage. But the argument is incomplete since it does not explain why the growth of the current is arrested.

The explanation must be that, when the armature moves, it generates an additional counter-e.m.f. in the coil which regulates the current, and hence the pull, to a value which both covers the counterforce of the contact springs and gives the armature the necessary velocity to generate once again the same additional counter-e.m.f. If the mass is not too great, accordingly, it is the spring force which determines the pull and the amperage. Since the mass is not zero, the current grows slightly with the armature acceleration, i.e. with the feed voltage, as in fig. 1.

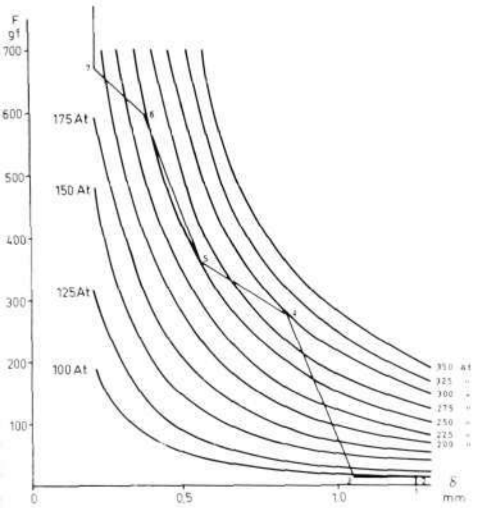


Fig. 2
Load and pull characteristics at different ampere-turns

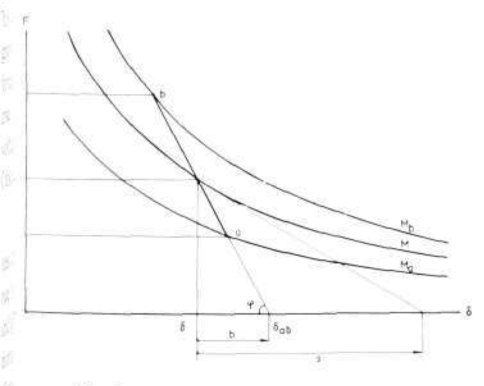


Fig. 3
Load line and pull curves with base *b* of triangle and subtangent *s*

Relation between Counter-e.m.f., Armature Motion and Impressed e.m.f.

During the armature motion there is constant equilibrium between, on the one hand, the instantaneous value of the pull and, on the other, the instantaneous values of the load, friction forces and mass forces. In the following presentation the mass and friction will be disregarded, as stated above.

The mode of variation of the pull of the relay with armature air gap and ampere-turns is assumed to be known through the static pull characteristics (cf. fig. 2). This diagram shows the lifting force F transmitted by the armature to the load at different magnetomotive forces as function of the length of air gap δ in the direction of the field. The mode of variation of the load with the air gap is assumed to be known from the load characteristic, an example of which is shown by the broken line 1 2 3 4 etc. in fig. 2.

The dynamic process in fig. 2 is composed of 7 sections. For a study of the motion we imagine a section limited by two arbitrary points a and b as in fig. 3. In this figure there is a "load line" ab and a lifting force curve corresponding to the instantaneous m.m.f., M. Under the influence of the load and lifting force the armature now takes up a position in which these forces are equal, i.e. the air gap δ being equal to the δ-coordinate for the point of intersection between the load line and the lifting force curve. When the latter moves upwards or downwards with time, the armature follows the movement of the point of intersection. How then is the counter-e.m.f. in the coil affected by this armature motion?

The counter-e.m.f. per turn of the winding is

$$\frac{d\Phi_{med}}{dt}$$

where Φ_{med} is the mean flux per turn in the core. Φ_{med} is governed by the relation[1]

$$\Phi_{med} = \Phi\left(k + \frac{l}{\Lambda}\right) \qquad (2)$$

where Φ is the tractive flux through the pole face,
k is a constant close to 1,
l is a permeance approximately equal to one third of the leakage permeance between the core and the return path for the flux, and
Λ is the permeance of the magnetic circuit defined by

$$\Lambda = \frac{\Phi}{M} \qquad (3)$$

where M is the m.m.f. of the coil.

For the air gap flux we convert Maxwell's formula for the pull between parallel surfaces to:

$$\Phi^2 = 2\mu_0 A f F \qquad (4)$$

where μ_0 is the permeability of free space,
A is the geometrical pole face area of the magnet,
f is the lever arm ratio between load and pull, and
F is the lifting force.

In fig. 3 the load line has been prolonged to the point of intersection δ_{ab} with the δ-axis, which it cuts at the angle φ. The load F at point F/δ is

$$F = b \operatorname{tg} \varphi \qquad (5)$$

where b is the base of the load triangle according to the diagram:

$$b = \delta_{ab} - \delta \qquad (6)$$

The permeance is governed by the relation[1]

$$\frac{1}{\Lambda} = \alpha + \beta\delta \qquad (7)$$

where α and β are characteristic constants of the magnetic circuit.

In fig. 3 the tangent of the lifting force curve M at point F/δ has also been drawn. The equation of the lifting force curve can be formed from (3), (4) and (7), and from it the following expression is derived:

$$s = \frac{1}{2}\left(\delta + \frac{\alpha}{\beta}\right) \tag{8}$$

where s is the length of the subtangent in fig. 3.

The counter-e.m.f. per turn is now obtained by derivation of (2). After combination with equations (3) – (8) or their derivatives the following expression can now be formed:

$$\frac{d\Phi_{med}}{dt} = \frac{Ml}{2\,bs}\left(\frac{k}{2\,\beta l} + s - b\right)\frac{db}{dt} \tag{9}$$

According to the explanation above, the counter-e.m.f. of the coil will now regulate the current which the impressed e.m.f. E drives through the resistance R, so that the m.m.f. will be M when the air gap is δ (see fig. 3). If the number of turns of the coil is N, the current will accordingly be

$$\frac{M}{N} = \frac{E - N\frac{d\Phi_{med}}{dt}}{R}$$

We introduce the final value of the operate m.m.f.

$$M_s = \frac{NE}{R}$$

and the "resistance constant" of the circuit

$$r = \frac{R}{N^2}$$

and obtain

$$\frac{d\Phi_{med}}{dt} = r\,(M_s - M) \tag{9a}$$

which is inserted in (9) and gives

$$\frac{db}{dt} = 2\,\frac{r}{l}\,\frac{M_s - M}{M}\,\frac{bs}{\frac{k}{2\,\beta l} + s - b} \tag{10}$$

Velocity of Armature

According to fig. 3, $\delta = \delta_{ab} - b$. The operate velocity is accordingly $v_t = -d\delta/dt = db/dt$ and the release velocity $v_f = d\delta/dt = -db/dt$.

From (10) we obtain directly

$$v_t = 2\,\frac{r}{l}\,\frac{M_s - M}{M}\,\frac{bs}{\frac{k}{2\,\beta l} + s - b} \tag{11}$$

In the release motion it is assumed that the circuit is closed and that its resistance is R. Since $M_s = 0$ the release velocity will be

$$v_f = 2\,\frac{r}{l}\,\frac{bs}{\frac{k}{2\,\beta l} + s - b} \tag{12}$$

Acceleration of Armature

The operate acceleration is $a_t = d^2b/dt^2$ and the release acceleration $a_f = -d^2b/dt^2$.

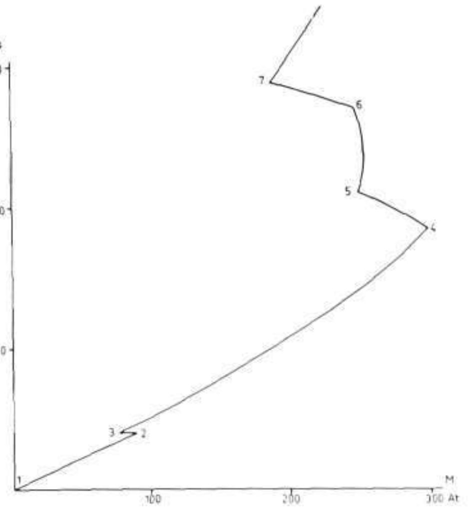


Fig. 4
The load characteristic in fig. 2 converted into magnetic system of coordinates Φ—M

Taking into account that M is variable, we derive (10) and after certain intermediate steps obtain

$$\frac{d^2b}{dt^2}=2\frac{r^2}{l^2}\frac{M_s-M}{M}\frac{bs}{\left(\frac{k}{2\beta l}+s-b\right)^2}\left(b+\frac{M_s-2M}{M}s+3\frac{M_s-M}{M}\frac{bs}{\frac{k}{2\beta l}+s-b}\right)\quad(13)$$

The operate acceleration we obtain directly from (13):

$$a_t=2\frac{r^2}{l^2}\frac{M_s-M}{M}\frac{bs}{\left(\frac{k}{2\beta l}+s-b\right)^2}\left(b+\frac{M_s-2M}{M}s+3\frac{M_s-M}{M}\frac{bs}{\frac{k}{2\beta l}+s-b}\right)\quad(14)$$

In the release motion $M_s=0$, so that the release acceleration will be

$$a_f=2\frac{r^2}{l^2}\frac{bs}{\left(\frac{k}{2\beta l}+s-b\right)^2}\left(b-2s-3\frac{bs}{\frac{k}{2\beta l}+s-b}\right)\quad(15)$$

Time of Passage of Armature from Position a to Position b or Vice Versa (Ekelöf's Formula)

The load characteristic is drawn in a system of coordinates with Φ as ordinate and M as abscissa (fig. 4). The load lines, which in fig. 2 are straight, become slightly curved after the conversion to magnetic coordinates. Ekelöf makes the approximation that the load lines are straight and deduces a formula for the time of passage between the end points a and b along an imaginary straight line ab in the following manner.

From (2), (3) and (9a) we get

$$dt=\frac{1}{r}\left(l+k\frac{d\Phi}{dM}\right)\frac{dM}{M_s-M}\quad(16)$$

But

$$\frac{d\Phi}{dM}=\frac{\Phi_b-\Phi_a}{M_b-M_a}$$

where Φ_a is the flux and M_a the m.m.f. at point a while Φ_b and M_b are the same quantities at point b. According to (4) $\Phi=\sqrt{2\mu_0 fAF}$ Vs if F is measured in Ws/mm. With F in gf, $\Phi=1.57\cdot10^{-7}\sqrt{fAF}$ Vs. The time of passage for operation is obtained by integration of (16):

$$t_{ab}=\frac{1}{r}\left(l+1.57\,k\,10^{-7}\sqrt{fA}\frac{\sqrt{F_b}-\sqrt{F_a}}{M_b-M_a}\right)\ln\frac{M_s-M_a}{M_s-M_b}\quad(17)$$

where F_a and F_b are the loads at points a and b.

Analogously the time of passage for release, when $M_s=0$, is

$$t_{ba}=\frac{1}{r}\left(l+1.57\,k\,10^{-7}\sqrt{fA}\frac{\sqrt{F_b}-\sqrt{F_a}}{M_b-M_a}\right)\ln\frac{M_b}{M_a}\quad(18)$$

In cases when $M_a=M_b=M$, formula (17) changes to

$$t_{ab}=1.57\frac{k}{r}10^{-7}\sqrt{fA}\frac{\sqrt{F_b}-\sqrt{F_a}}{M_s-M}\quad(19)$$

and formula (18) to

$$t_{ba} = 1.57 \frac{k}{r} 10^{-7} \sqrt{fA} \frac{\sqrt{F_b} - \sqrt{F_a}}{M} \tag{20}$$

If the load line in fig. 3 is vertical, then

$$t_{ab} = \frac{1}{r}\left(l + 1.57\,k\,10^{-7}\sqrt{fA}\,\frac{\sqrt{F_b}}{M_b}\right) \ln \frac{M_s - M_a}{M_s - M_b} \tag{21}$$

and

$$t_{ba} = \frac{1}{r}\left(l + 1.57\,k\,10^{-7}\sqrt{fA}\,\frac{\sqrt{F_b}}{M_b}\right) \ln \frac{M_b}{M_a} \tag{22}$$

In the special case when the vertical load line stands on the δ-axis, $M_a = 0$ and

$$t_{ab} = \frac{1}{r}\left(l + 1.57\,k\,10^{-7}\sqrt{fA}\,\frac{\sqrt{F_b}}{M_b}\right) \ln \frac{M_s}{M_s - M_b} \tag{23}$$

Formula (23) gives the time of growth of the pull of a relay with locked armature. By comparison with (1) we can form an idea of the composition of the "time-constant" T in this formula.

Effect of Eddy Currents

The eddy current circuits can be approximately replaced by an imaginary one-turn winding covering the entire magnetizing coil. If its resistance is denoted by r_v, the effect of the eddy currents will be expressed by formulae which include r if r is replaced by

$$\frac{r}{1 + \dfrac{r}{r_v}}$$

The resistance r_v can be determined from measurements of t when r is varied while, for example, M_s or the power in the entire relay circuit is kept constant. Unfortunately r_v is not constant at different powers or m.m.f.s and does not always provide a good correction for eddy currents. If r_v is large in relation to r, however, the approximation is acceptable.

Analysis of Velocity Formulae (11) and (12)

The operate and release velocities grow with r. They also grow with r_v. The operate velocity grows furthermore with M_s.

The dependence on the leakage and on the position and slope of the load line and the lifting force curve is more complicated. The velocity may both grow and diminish with growing s, but always grows with growing b with the following exception.

With growing b, the velocity is negative from a given value of b at which it changes from $+\infty$ to $-\infty$. The smaller the leakage, however, the greater is this value of b, which becomes infinite for $l = 0$. Physically this phenomenon is explained as follows.

During operation an e.m.f. is generated in the coil which, according to Lenz' law, constantly opposes the impressed e.m.f. and is the sum of two parts. One part is generated by the flux which leaks from the core over to the return path without passing through the working air gap. The other part is generated by the flux which passes both core and air gap. According to (2) and (3)

$$\Phi_{\text{med}} = kM\Lambda + Ml$$

The first term represents the share of the air gap flux and the second term the share of the leakage flux in Φ_{med}. If l is very much greater than Λ, the leakage flux will dominate. Φ_{med} and the counter-e.m.f. generated from it are then little dependent on Λ, i.e. on the armature motion. The current grows exponentially as in a fixed inductor. In fig. 3, accordingly, the instantaneous pull curve M will shift continuously upwards. If the load line then slopes more than the pull curve, the point of intersection between them moves towards smaller values of δ. If the slope is less than that of the pull curve, on the other hand, the point of intersection moves towards larger values of δ. To attain equilibrium, accordingly, the armature must move backwards in the latter case. But if l is of the same order of magnitude as Λ, the armature motion has a greater influence on Φ_{med} than in the former case, and so on the counter-e.m.f., and the latter now regulates the current to the lifting force requirements. The instaneous pull curve moves upwards or downwards (cf. fig. 1), with the result that the point of intersection with the load line always moves towards smaller values of δ.

During the release motion a corresponding process takes place, but in the reverse direction.

But a relay armature cannot move backwards—except in certain phases of superimposed transient oscillations—i.e. away from the magnet in operation and towards the magnet in release. The theory concerned with the motion of the equilibrium position can therefore be applied to the armature only so long as the velocity is positive. In the reverse case the theory can be replaced by the following physical considerations. Since the armature cannot move backwards in order to diminish the surplus force tending to drive it forwards, it moves forwards under the influence of the surplus force and the latter increases instead of diminishing. A real armature will then accelerate its motion and so continue into a section of motion which, according to the theory, has a positive velocity.

In a section of motion in which the counter-e.m.f. is able to regulate the current to the load, the motion may be called "controlled" or "stable"; otherwise it may be called "uncontrolled" or "unstable". According to (11) or (12) the stability condition is obviously

$$\frac{k}{2\beta l} + s - b > 0 \tag{24}$$

With a knowledge of the relay constants k, β and l, the first term in (24) can be easily calculated. The stability can then be examined in fig. 2 in all desired positions of the armature after measurement or calculation of the subtangents s and bases b.

The question we raised in the introduction as to whether the velocity can be increased unlimitedly by diminishing the mass can now be answered. *In controlled sections of the motion the velocity is finite even if the mass is zero. In uncontrolled sections it grows towards infinity when the mass falls towards zero.*

To obtain a numerical basis for the formulae a test relay was prepared, the pull and load characteristics of which are shown in fig. 2. A suitable number of associated values of F, M and δ can be read off in the diagram, after which the ratio $M/\sqrt{F}$ is calculated and drawn as a function of δ. All points lie with good approximation on the straight line

$$\frac{M}{\sqrt{F}} = a + c\delta$$

But

$$\frac{1}{\Lambda} = \frac{M}{\Phi} = \frac{1}{1.57 \cdot 10^{-7}\sqrt{fA}} \frac{M}{\sqrt{F}} = \frac{a + c\delta}{1.57 \cdot 10^{-7}\sqrt{fA}} = \alpha + \beta\delta$$

With a knowledge of a, c, f and A, the values for the test relay are found to be $\alpha = 3.6 \cdot 10^6$ At/Vs and $\beta = 15.6 \cdot 10^6$ At/Vs mm. From flux measurements it is found that $k = 1.15$ and $l = 9.81 \cdot 10^{-8}$ Vs/At. Time measurements at constant M_S show that $r_v = 59 \cdot 10^{-6}\ \Omega$. The relay coil has $N = 9000$ turns and $R = 509\ \Omega$, from which it is calculated that $r = 6.29 \cdot 10^{-6}\ \Omega/t^2$.

We may take as example line 3—4 in fig. 2. The data for the line are

at point 3	at point 4
$\delta = 1.05$ mm	$\delta = 0.84$ mm
$F = 13$ gf	$F = 275$ gf
$M = 77.6$ At	$M = 298$ At
$b = 0.0104$ mm	$b = 0.22$ mm
$s = 0.623$ mm	$s = 0.518$ mm

At the final ampere-turns, $M_S = 414$ At, the operate velocity is calculated at point 3 to be $v_{t3} = 3.3$ mm/s. At point 4 the velocity is calculated to be $v_{t4} = 7.6$ mm/s. On the assumption that the coil is short-circuited, the release velocity at point 3 will be $v_{f3} = 0.76$ mm/s and, at point 4, $v_{f4} = 1.75$ mm/s.

The velocity thus diminishes in section 4—3 during the release motion. Since all velocities are positive, the stability condition is fulfilled in both positions.

As a check of the calculations a mean velocity of 5.5 mm/s in section 3—4 was measured on an oscillogram for $\delta = f(t)$ at 414 At. The mean value of the calculated v_{t3} and v_{t4} is 5.45 mm/s!

Analysis of the Acceleration Formulae (14) and (15)

The acceleration formulae are rather complicated. To start with we calculate the acceleration, at $M_S = 414$ At, for the test relay at points 3 and 4 on the load line 3—4. We find, for position 3, $a_{t3} = 420$ mm/s^2 and $a_{f3} = -56$ mm/s^2 and, for point 4, $a_{t4} = 10$ mm/s^2 and $a_{f4} = -2130$ mm/s^2.

The release motion is thus retarded, as it should be since the velocity was found to be lower at point 3 than at point 4.

The operate motion is accelerated but the acceleration diminishes and is very small at point 4 which, for this relay, constitutes the "critical" position of the armature.

A question of great interest is under what conditions the motion can be retarded in accordance with (14) and (15). The first condition both in operation and release is that the motion is controlled, see (24). In operation, furthermore,

$$b + \frac{M_s - 2M}{M} s + 3 \frac{M_s - M}{M} \frac{b_s}{\frac{k}{2\beta l} + s - b} < 0 \qquad (25)$$

and in release

$$b - 2s - 3 \frac{bs}{\frac{k}{2\beta l} + s - b} < 0 \qquad (26)$$

In operation M_s must obviously not be greater than that the second term in (25) is negative and greater than the sum of the first and third terms. Solving M_S from inequality (25) gives

$$M_s < \frac{2\left(\frac{k}{2\beta l} + s\right) - \frac{b}{s}\left(\frac{k}{2\beta l} - b\right)}{\frac{k}{2\beta l} + s + 2b} M \qquad (27)$$

Another question of interest is how great at the most the disregarded mass forces may be in sections of motion that are controlled. We calculate them at points 3 and 4 of line 3—4 with a knowledge of the moment of inertia of the armature and of the lever arm of the pull.

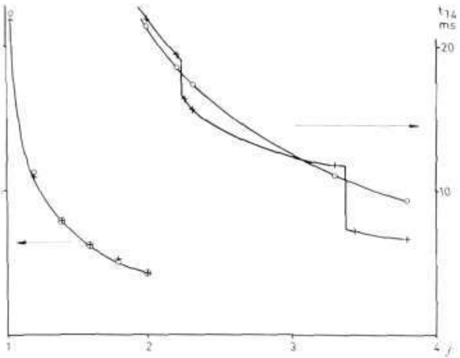


Fig. 5
Calculated (⊙) and measured (+) times of passage 1—4 at different ampere-turn safety factors $\gamma = M_s/M_4$

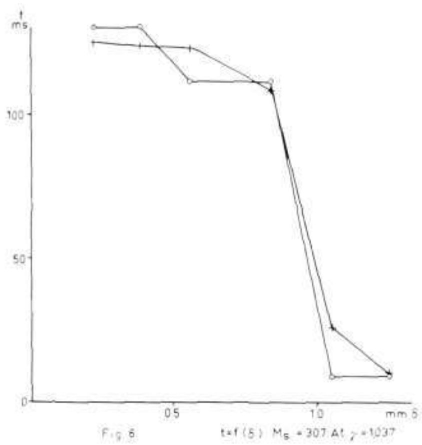
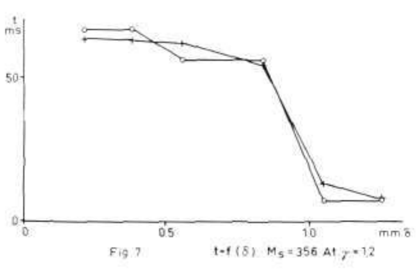
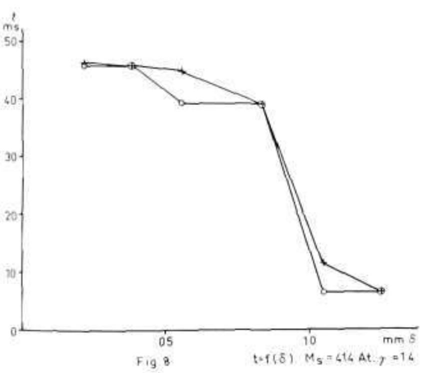


Fig. 6—15
Calculated (⊙) and measured (+) times of passage from position 1 onwards at different ampere-turn safety factors γ





Here the moment of inertia is $0.7 \cdot 10^{-6}$ ms² kgf and the lever arm $14 \cdot 10^{-3}$ m If a is measured in m/s², the mass force is found to be

$$F_m = \frac{0.7 \cdot 10^{-6}}{14^2 \cdot 10^{-6}} \frac{10^3}{9.81} a = 0.364\, a \text{ gf}$$

The calculated values for point 3 are +0.153 gf in operation and −0.002 gf in release. For point 4 the mass force in operation is +0.004 gf and in release −0.775 gf.

In all these cases the mass forces are negligible compared with the contact spring loads of 13 gf at point 3 and 275 gf at point 4.

In uncontrolled sections of motion the mass forces are, of course, greater.

Analysis of Formulae for Time of Passage

If the load line in fig. 3 slopes so little that M_b is smaller than M_a, both the logarithmic factor and the second term of the parenthesis in (17) and (18) will be negative. If then l is small, t_{ab} and t_{ba} will both be positive, but in the opposite case negative. In the latter case, as stated above, the theory for the motion of the equilibrium position cannot be applied to a relay armature. As the real velocity is very great, the time of passage through uncontrolled sections is very short and contributes little to the total time of passage.

To assess the extent to which the theory for the motion of the equilibrium position is applicable to the motion of a relay armature, a series of oscillograms was recorded showing the operate motion of the earlier mentioned test relay. The times from energization of the armature until it reaches the positions marked in fig. 2 have been both measured and calculated and inserted in figs. 5—15. In these diagrams γ signifies the ratio between M_s and the operate value $M_4 = 298$ At. The calculated times of passage for the uncontrolled sections 2—3, 4—5, and 6—7 have for the sake of simplicity been assumed to be zero, although this is not exact even for a massless armature.

Fig. 5 shows the times of passage from position 1 to position 4. The agreement between calculated and measured times is very good up to $\gamma = 2.2$. Above this value superimposed armature oscillations disturb the motion, so that the measured times show sudden changes. The oscillations arise as a result of the discontinuous change of load on the armature when in position 3 it comes into contact with the contact springs. These oscillations could not arise without mass of the armature and springs. They can, however, be almost entirely eliminated in a mass-loaded relay if the armature bears upon the contact springs with a light pressure from the start. This can be achieved by simple replacing of the helical spring which in most telephone relays holds the armature in position. No other change of the adjustment of the relay is required.

Figs. 6—15 show close agreement between calculated and measured times for sections of motion with low velocity, in which the mass has no appreciable effect. For section 1—2, in which the armature is stationary, the agreement is remarkably good.

The times which have been assumed to be zero do not, of course, agree with the measured times since these are prolonged by the mass. In sections in which the velocity is great on entry to the section, the time of passage is shortened since the armature makes use of its kinetic energy from the preceding section. The mass therefore has a smoothing effect on the velocity as, for example, during the passage from position 2 to position 4 or from position 4 to position 6. It seems as though the mass has no appreciable effect on the total time of passage from 1 to 7 but does have an influence on the times of passage through individual sections.

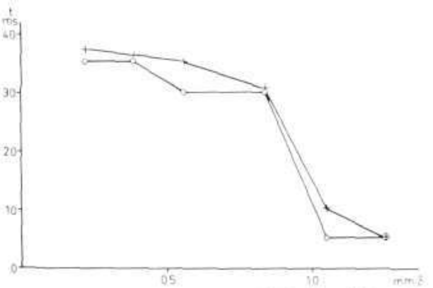


Fig 9 t=f(δ) M_s = 475 At γ = 1.6

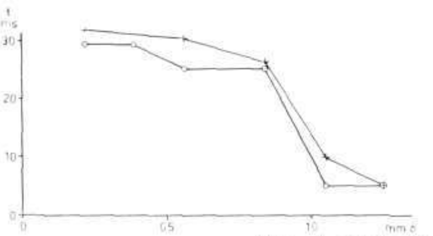


Fig 10 t=f(δ) M_s = 533 At γ = 1.8

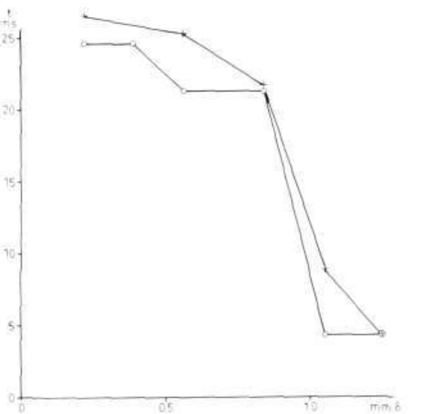


Fig 11 t=f(δ) M_s = 594 At γ = 2.0

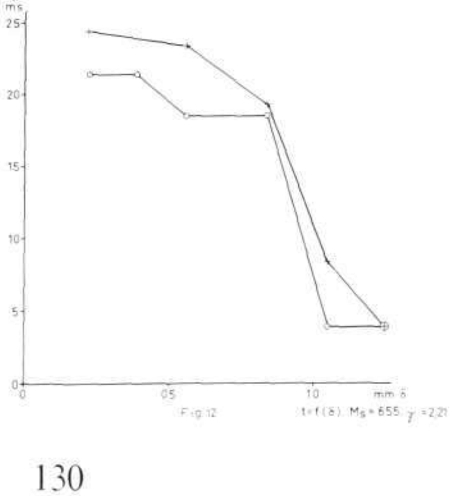


Fig 12 t=f(δ) M_s = 655 γ = 2.21

Means of Reducing Contact Bounce and Armature Rebound

A means of eliminating rebound of the armature against the contact springs in position 3 has been described above, namely to move the helical spring so that the armature bears against the contact springs in the idle condition. In the sequel we shall consider the spring vibrations and the armature rebound which arise on abrupt stopping of the motion in the end positions, and which grow with the kinetic energy of the armature and springs. Since the energy is proportional to the square of the velocity but only to the first power of the mass, it diminishes more with a lowering of velocity than with a reduction of mass.

According to the definition the operate time is completed when (in our case) position 5 is reached. The release time is completed when position 4 is reached. If a sufficient retarding of the armature could be achieved after these positions have been passed, the vibrations could be eliminated without reduction of mass and without change of the operate or release times. Is a retardation of this kind possible to achieve?

The motion from position 6 to position 7, or vice versa, is usually (and in our case definitely) uncontrolled, since b is large in (24). It will be both controlled and retarded if b is reduced by introducing between positions 6 and 7 an additional load which commences at a zero value and then rapidly grows when the armature approaches position 7.

The release motion from position 4 to position 3 is usually already controlled and retarded, since b is sufficiently small in the load triangle. But during its passage through the uncontrolled sections 7—6 and 5—4 a real armature has acquired so great a kinetic energy that the "natural" retardation in section 4–3 is not sufficient to lower the velocity to a value at which no rebound takes place. This is the reason why this retardation is not observed in relays. One remedy, obviously, is again the aforementioned load increment between 6 and 7 since this reduces the kinetic energy in position 6, and therefore in position 4, so much that the armature can be braked to the necessary extent during its passage from 4 to 3.

The additional load between 6 and 7 does not affect the operate time 1—5. It influences the release time by slightly prolonging the time of passage from 7 to 6, whereas the time for reduction of the pull from the initial value to the elevated value F_7 is shortened all the more. The total release time is thereby shortened.

Often this shortening of the release time is desirable, but in delayed relays the means of delay employed must be made more efficient if the delay is to be unchanged.

On closer thought the use of an additional load for retarding the motion is fairly obvious in respect of the operate motion, but the fact that it must start at a zero value may be readily overlooked. Such an additional load is used in a magnet in L M Ericsson's XY selector.

Another means of lowering the final velocity of the armature is to increase the lever arm ratio. The abscissa of the load characteristic is thereby shortened and all load lines become steeper. The armature velocity is lowered over the entire path of motion, but the lowering of the velocity is compensated by the fact that the path is shorter. In the formulae the change of leverage occurs as follows. When the pull end of the lever moves a distance b, the load end moves a distance which we denote b'. Obviously $b' = fb$. As the motion of the load is not affected

$$v_t = 2\frac{r}{l}\,\frac{M_s - M}{M}\,\frac{\frac{1}{f}b's}{\frac{k}{2\beta l} + s - \frac{b'}{f}} \tag{28}$$

$$v_f = 2\frac{r}{l}\,\frac{\frac{1}{f}b's}{\frac{k}{2\beta l} + s - \frac{b'}{f}} \tag{29}$$

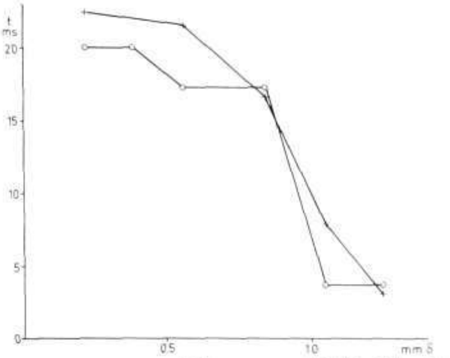


Fig 13 t=f(δ) M_s=687 At γ=2.32

by a change of the leverage, b' is constant and b changeable with f. On the other hand s, which is associated with the magnetic circuit, is independent of f. We introduce b' in the velocity formulae and find

An initially negative denominator in the formulae can become positive and an uncontrolled motion thus become controlled by increase of the leverage ratio. If the motion is already controlled, the increase of leverage reduces the release velocity. If M_s is matched to M after the increase of the leverage ratio, so that M_s/M is unchanged, the operate velocity is also reduced.

We introduce b' also in the retardation conditions (25) and (26):

$$\frac{b'}{f} + \frac{M_s - 2M}{M}\, s + 3\,\frac{M_s - M}{M}\,\frac{\frac{1}{f}\, b' s}{\frac{k}{2\beta l} + s - \frac{b'}{f}} < 0 \qquad (30)$$

$$\frac{b'}{f} - 2s - 3\,\frac{\frac{1}{f}\, b' s}{\frac{k}{2\beta l} + s - \frac{b'}{f}} < 0 \qquad (31)$$

We see that once the aforementioned denominator has become positive by increase of f, the release acceleration is negative as revealed by (31) and, if $M_s < 2M$, according to (30) the operate acceleration can also be negative or become negative through further increase of f.

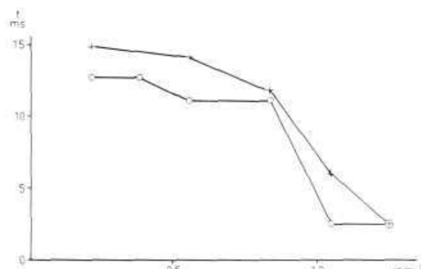


Fig. 14 t=f(δ) M_s=977 γ=3.3

A third method of lowering the final velocity of the armature is to enlarge the pole face. The constant β can be written[1] β'/A, where β' remains around the value $1/\mu_0 = 795 \cdot 10^6$ At mm/Vs.

The length of the subtangent can be written

$$s = \frac{1}{2}\left(\delta + \frac{\alpha}{\beta'} A\right)$$

An enlargement of the pole face thus increases s, and an examination of the stability condition (24) and of the retardation conditions (25) and (26) shows that the enlargement can change an uncontrolled and therefore accelerated motion to a both controlled and retarded motion. The new expression for s is introduced in the velocity formulae:

$$v_t = 2\,\frac{r}{l}\,\frac{M_s - M}{M}\,\frac{b\left(\delta + \frac{\alpha}{\beta'} A\right)}{\left(\frac{k}{l} + \alpha\right)\frac{A}{\beta'} + \delta - 2b} \qquad (34)$$

$$v_f = 2\,\frac{r}{l}\,\frac{b\left(\delta + \frac{\alpha}{\beta'} A\right)}{\left(\frac{k}{l} + \alpha\right)\frac{A}{\beta'} + \delta - 2b} \qquad (35)$$

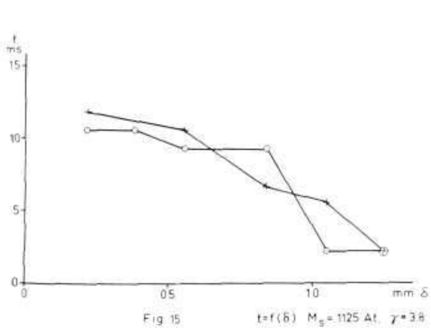


Fig 15 t=f(δ) M_s= 1125 At γ=3.8

How the velocity in an already controlled section is affected by the enlargement of the pole face is not easy to see from (34) or (35). The effect is very dependent on δ, i.e. on the armature position in which the velocity is analysed. The enlargement of the pole face may either increase or diminish the velocity or, in a given armature position, leave it unchanged. Its effect is therefore essentially to stabilize and retard uncontrolled sections of motion.

Still another measure may be taken to reduce the final velocity. The leakage constant l can be reduced by shortening the coil so that the winding is concentrated towards the working air gap.

The significance of l for the velocity and acceleration is immediately apparent from the formulae. An uncontrolled motion can be made controlled and retarded by diminishing l. If the motion is already controlled, this measure increases the velocity if $b < s$ and diminishes it if $b > s$ both in operation and release. M is little affected by the change.

Quicker Relays with Longer Life

It is well-known to all who use relays as components in rapid switching systems that contact bounce and armature rebound reduce the speed of the system. For, in order to operate reliably, the relay should preferably come to rest in the new position before it changes position again. The more the designer attempts to shorten the operate and release times of the relay by known means, the more is the gain of time eaten up by the vibrations. It is also well-known that contact bounce and armature rebound cause wear and so limit the life of moving parts. There has long been a desire, therefore, for inexpensive means of reducing or eliminating these disturbing effects of the kinetic energy. Examples of such means have been described above, which enable the relay user to speed up the relays and at the same time increase their life.

Summary

Observed properties in a family of curves of relay current growth indicate that, when the armature is in motion, the relay seems to regulate the current so that momentary equilibrium exists between pull, load, friction forces and mass forces. If the friction and mass are disregarded, laws can be set up which state where the armature should be at every instant in order that equilibrium shall prevail. Formulae for velocity, acceleration and time of passage for a given section of motion can be derived.

An analysis of the formulae shows that the armature would need to move backwards during certain parts of its motion in order to maintain equilibrium. Since the armature of a neutral relay can only move forwards, equilibrium cannot be achieved during those parts of its motion but the armature performs an accelerated "uncontrolled" or "unstable" movement forwards. In the operate motion "forward" signifies towards the magnet and, in the release motion, away from the magnet.

Along sections where equilibrium is maintained during forward motion, the motion is said to be "controlled". Controlled motion may be either accelerated or retarded.

Analysis of the formulae gives the designer information about how the design of the relay is related to velocity, acceleration and time of passage.

The mass has no significance in "controlled" sections but causes transient armature oscillations and spring vibrations at the end positions or when contact springs are added to or eliminated from the motion. In uncontrolled sections the mass reduces the acceleration. The motion is often alternatively accelerated and retarded, in which case the mass has a smoothing effect on the theoretically jerky motion. It appears as though the mass has only an insignificant effect on the overall time of passage.

The leakage has a great significance in producing uncontrolled sections of motion.

Accelerated sections of motion can be shortened by different means or even converted into retarded sections. There is reason to retard the motion if the contact bounce and armature rebound are injurious to the function or life of the relay. In such cases it is not necessary to make all sections retarded. It may suffice to retard the sections subsequent to that in which the last contact operates.

Vibrationless relays can be given shorter operate and release times than other relays. They also have a longer life.

Reference

1. AHLBERG, C.: *On the Dynamic Behaviour of Electromagnetic Relays. A Theoretical and Practical Study.* Ericsson Tech. *21*(1965): *1*, pp. 3—110.

TELEALARM—Equipment for Issue of Alarm on Automatic Telephone Network

U. NILSSON, L M ERICSSON TELEMATERIEL AB, STOCKHOLM

UDC 654.924
LME 861

There is today a very great need for supervision of various forms of equipment, the more so as increasingly advanced automatic equipments come into use. Too late action after a fault has occurred may result in serious financial losses.

Telectronic SA, of Switzerland, make two alarm signal transmitters for this purpose, types TA 104 and TA 104 B. L M Ericsson Telemateriel AB are the general agents of this firm.

The transmitters have been approved by the Swedish Board of Telecommunications for connection to the public telephone network.

Operation

The alarm signal transmitter (fig. 1) rings up the persons responsible for the maintenance of the equipment. The transmitter contains a tape recorder unit and a relay unit with transistorized amplifier. Both the number dialled and the actual message are recorded on tape, the total running time of which is about 11 minutes. This means that messages can be sent to up to 8 telephone subscribers. The tape is placed in a magazine which is easily changed.

Automatic alarm units of thermal indicator type, current and voltage relays etc., are normally employed for equipment supervision. In system *TA 104* the alarm units can be placed on two alarm circuits. For the supervision of larger plants an alarm transmitter type *TA 104 B* can be connected to four alarm circuits.

During transmission of alarm a green lamp lights on the transmitter. At the end of the alarm the green lamp goes out and a red lamp lights instead. This indicates that the alarm signal has been transmitted and that the apparatus must be restored before a new alarm signal can be sent.

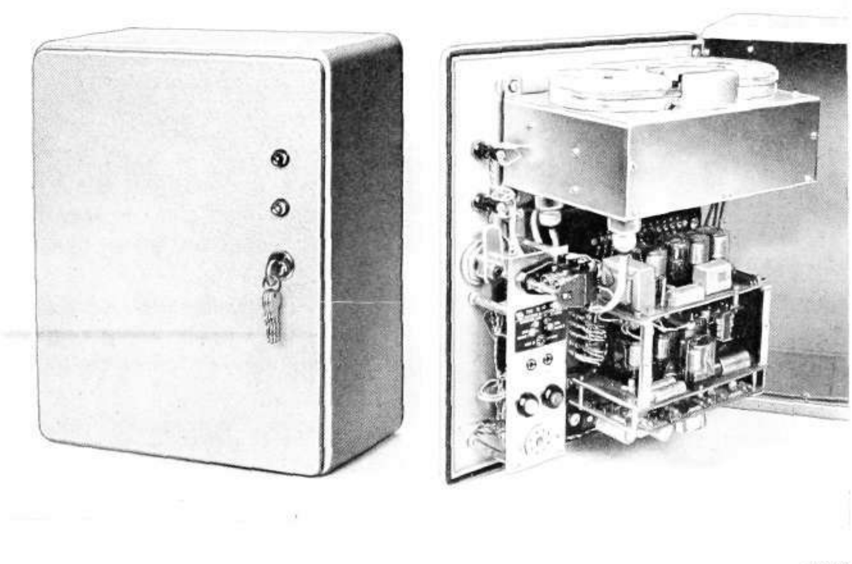
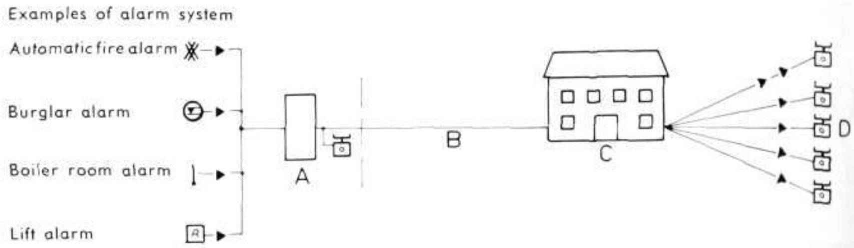


Fig. 1
Alarm signal transmitter TA 104
(Right) with cover removed

Fig. 2

Block schematic

A Alarm signal transmitter
B 2-wire telephone line
C Telephone exchange
D Subscribers



The transmission of alarms can be interrupted by call-back from the called subscriber. To do this, the subscriber replaces his handset momentarily at the end of the message. He then rings up the number to which TELEALARM is connected and replaces his handset again after hearing ringing tone.

Different means of remote control are possible through different strapping arrangements:

- After call-back from the subscriber the alarm is interrupted and the tape returns to the starting position.
- The ringing signal and transmission of the message continue after the subscriber has rung back until the tape has run out. The alarm is thereafter cut off.
- After the subscriber has rung back, the alarm is interrupted and the tape stops without returning to the starting position.
- The alarm signal transmitter can be wired for non-reception of a call-back signal. The receiver of the alarm must then proceed to the supervisory point to stop the alarm.

TELEALARM can be wired for manual or automatic resetting to supervisory condition.

Manual resetting is done with a key fitting the door of the alarm transmitter.

The various alternatives are arranged by strapping of the relay unit.

If the subscribers' numbers are engaged when an alarm is transmitted, repeated calls are made until the transmitter gets through to one of the subscribers.

A block schematic of TELEALARM is shown in fig. 2.

Alarm Transmitter

TA 104 is enclosed in a metal case sized 350×285×171 mm and weighing 8 kg. The terminal block is placed on the baseplate. Telephone line, telephone set, power supply and alarm units are connected to the terminal block.

The tape recorder and amplifier unit are placed inside the door. The units are easily replaceable, being connected by plug and jack. On the door there are push-buttons for testing the transmitter alarm circuits (fig. 1).

The door lock actuates the restoring keys of the transmitter.

The electrical and mechanical design of the apparatus comply with the high requirements that must be placed on equipment of this type.

Fig. 3
Recorder TAZ 104

Applications for TELEALARM

The applications of TELEALARM for supervisory purposes are practically unlimited. Some examples of its use are described below.

Industrial Supervision

TELEALARM permits efficient rationalization of the supervision of industrial equipment by reducing the need for manual supervision. Through the use of appropriate alarm units values such as temperatures, pressures, fluid levels, current and voltage, can be reported when they reach critical limits. The operating personnel are thereby enabled to take quick action for the prevention of damage and interruption of service.

Supervision of Property

Residential properties are now often combined into large units with a single caretaker. The caretaker has not usually time to keep the various installations under continuous supervision. There is therefore a great need for automatic alarm.

An alarm transmitter in each block provides quick advice of voltage failure, too low temperature, emergency signals from lifts, etc. The messages, transmitted to the caretaker's telephone, may be of the following nature: "Automatic warning from Telealarm. An emergency signal has come from lift 3 in the property at High Street 15" — the message being repeated twice.

Protection against Burglary and Hold-up

TELEALARM can be used in conjuction with an alarm installation against burglary and hold-ups in banks, cash offices, shops etc.

As the alarm transmitter presents a verbal message, the receiver need not keep in mind different identification signals in order to decide where the alarm comes from. The receiver understands immediately what action should be taken.

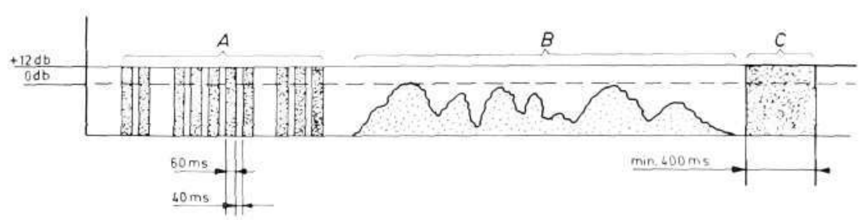
Protection against Fire Damage

When a fire alarm installation cannot be connected directly to the fire brigade, TELEALARM offers a good solution of the fire supervision problem. Flame detectors, smoke detectors or thermal detectors can be used as alarm generators.

Programming

Tape recording for TELEALARM is done with recorder *TAZ 104* (fig. 3).

The telephone numbers and messages with which the alarm transmitter is to be programmed are recorded on the tape. An example is shown in fig. 4, the impulse ratio being 60/40. *TAZ 104* can also be supplied for other impulse ratios.



ig. 4
iagram of programmed tape
Telephone number
Message
Clearing signal

The recorder has a visual counter for checking telephone numbers and clearing signals. A timer supervises automatically that the recording time is not exceeded. Scotch tape 150 is used for the recording.

Power Equipment

The alarm transmitter requires a 12 V DC supply. The voltage may vary by ± 20 %.

The power equipment consists of
- a charging rectifier *BMA 202X01*, 12 V, 0.5 A
- a lead acid accumulator type *6 SPg*, 12 V, 20 Ah
- a fuse set type *FÖB 8352*.

Installation and Maintenance

The alarm transmitter is designed for wall mounting and should be placed on a vibrationless base. It should be set up in dry premises, the temperature of which may vary between − 5 and + 40° C.

Using *TA 104* with a burglary alarm installation the transmitter should, of course, be placed within the protected premises.

Normally TELEALARM requires no maintenance apart from testing of the installation and checking of the acid level of the battery.

Patents

TELEALARM is patented in Australia, Austria, Brazil, Britain, France, Germany, Japan, Sweden, Switzerland and the United States.

Electrical Data

Type	Number of alarm circuits	Max. recording time per alarm circuit*	Idle power consumption	Power consumption during alarm	Working voltage
A 104	2	5.5 min.	0	600 mA	12 V
A 104 B	4	5.5 min.	0	600 mA	12 V

*For normal length of messages 3—4 subscribers can be called per alarm circuit. If only one alarm circuit is used (for *TA 104 B* two alarm circuits) the total recording time of about 11 minutes can be used for that circuit. In such case 6—8 subscribers can be rung.

NEWS *from* *All Quarters of the World*

Richard J. Anderson (left), editor and publisher of Financial World Magazine, congratulates Carl O. Lennmalm, resident director of L M Ericsson, New York, on the company's prize for the 1964 Annual Report.

New Telephone System for Finnish Railways with MFC Signalling

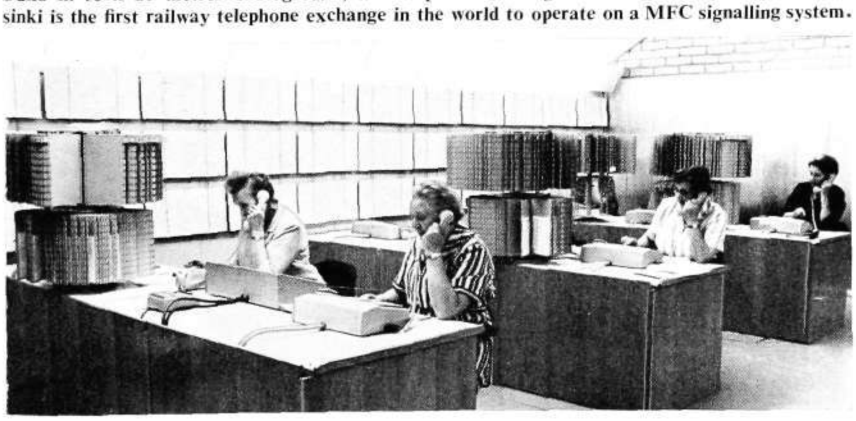
The Finnish railway telephone network is at present undergoing extensive modernization. The first change is the conversion from impulsing to the technically more advanced and very much quicker MFC signalling method. The conversion took place according to plan at the end of August this year, and without appreciable interference with the traffic. Only one fourth of the Finnish railway network now lacks an automatic telephone system.

At the same time a new transit centre was opened in Helsinki. It is extremely well protected, being built 25 metres below ground in granite, so that such important requirements as dustfree environment, uniform temperature and humidity are well satisfied. The underground environment has been made as "human" as possible. The staff even have pot-plants in the very neat and attractive premises.

The Helsinki exchange consists of a P.A.B.X. of type ARD 331 and of a transit exchange type ARM 301. It has at present 1 200 extension, 58 exchange and 60 trunk circuits. The exchange has automatic trunk circuits to Turku, Tampere, Oulu, Pieksämäki and Kouvola. From these places connections can be extended to a large number of group and terminal exchanges and selective calling circuits. Automatic alternative routing arrangements exist between the exchanges, i.e. a call is not stopped by a blocked route but the system allows automatic selection of a free route up to the subscriber.

A demonstration for representatives of the Finnish Communications Administration, press and L M Ericsson was arranged by the Finnish Railways Board a week or so after the commissioning of the new telephone system. The Director General of the Railways Board, Mr. E. Aalto, presented an address of welcome in which he spoke, among other things, of the development of Finnish railway telephony. Mr. K. Toivola, also of the Railways Board, thanked L M Ericsson's representatives for a sound job and good teamwork with the railway staff.

Build in rock 25 metres underground, the telephone exchange of the Finnish Railways at Helsinki is the first railway telephone exchange in the world to operate on a MFC signalling system.

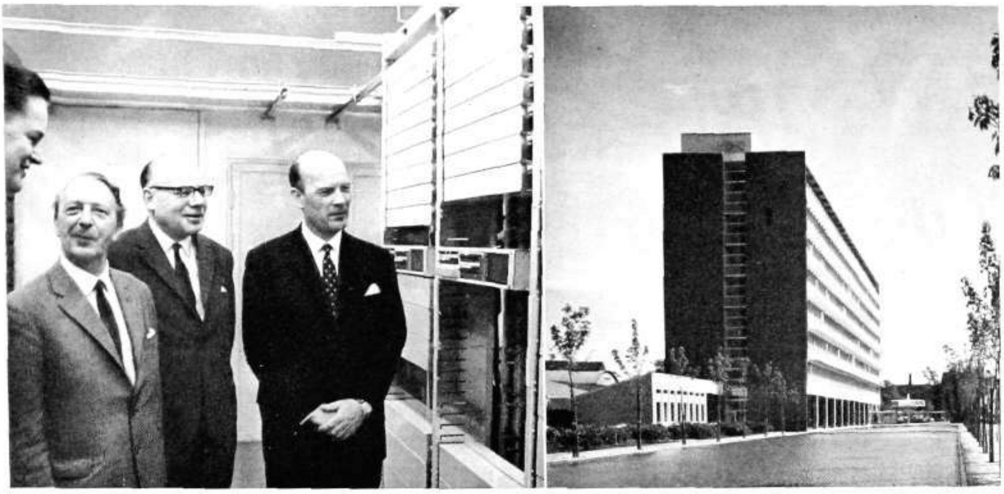


American Award for L M Ericsson's Annual Report

L M Ericsson's Annual Report for 1964 won Second Prize in the annual appraisal made by the American "Financial World Magazine". For the first time non-American companies formed a class of their own. The First Prize in this class was awarded to the Rank Organization in Britain.

Some 5 000 annual reports were reviewed. The awards were presented at a banquet at New York Hilton Hotel, at which the President of the New York Stock Exchange, Mr. G. Keith Funston, was main speaker.

L M Ericsson's annual reports have earlier gained recognition for their content, design and typography, and the 1963 report won a Merit Award in a competition which included American corporations as well.



From the inauguration of the new Code Switch P.A.B.X. at Tuborg Breweries. (From right) Mr. Gunnar Thomsen, Tuborg Breweries, Mr. Otto Siewert, L M Ericsson, Stockholm, Mr. Gelmark Sörensen, KTAS, and Mr. Frants Liisberg, L M Ericsson A/S, Copenhagen. The photograph on the right shows Tuborg's new administration building in which the P.A.B.X. is installed.

First AKD 791 P.A.B.X. Installed Abroad

The first large P.A.B.X. of L M Ericsson's new type AKD 791 based on the code switch was recently installed in Denmark.

This P.A.B.X. had been bought by the Copenhagen Telephone Company (KTAS) for the Tuborg Breweries and is initially equipped for 600 extensions, 40 exchange lines, 30 internal connecting circuits and 3 operators' positions.

After the cut-over the exchange was inspected by Mr. Thomsen, Managing Director of Tuborg Breweries, in the presence of representatives of KTAS and of L M Ericsson's Danish subsidiary and the parent company in Stockholm. Mr. Thomsen expressed his great satisfaction with the operation of the exchange and at being L M Ericsson's first customer for this new system which he wished success in all countries of the world.

Relay Interlocking for India

Ericsson Telephone Sales Corporation AB, New Delhi, has signed a contract with the Eastern Railway, India, for the supply of equipment for a relay interlocking for the large Howrah Station at Calcutta. The main part of the equipment will be supplied by L M Ericssons Signalaktiebolag.

Howrah Station is one of the largest in India and carries a heavy volume of long-distance and local traffic. The area to be controlled by signals includes 160 points, 130 signals, including 65 dwarf signals, and 170 track circuits. The relay interlocking will be equipped with a train describer system.

The contract amounts to around 4 million kronor.

Appointments

The Swedish Academy of Engineering Sciences (IVA) has elected Dr. Yngve Rapp, of Telefonaktiebolaget L M Ericsson's Research and Development Division, member of the Academy and Mr. Björn Lundvall, president of L M Ericsson, member of the Industrial Council of the Academy, with Dr. Christian Jacobæus, Executive Vice President of L M Ericsson and member of the Academy since 1957, as his deputy.

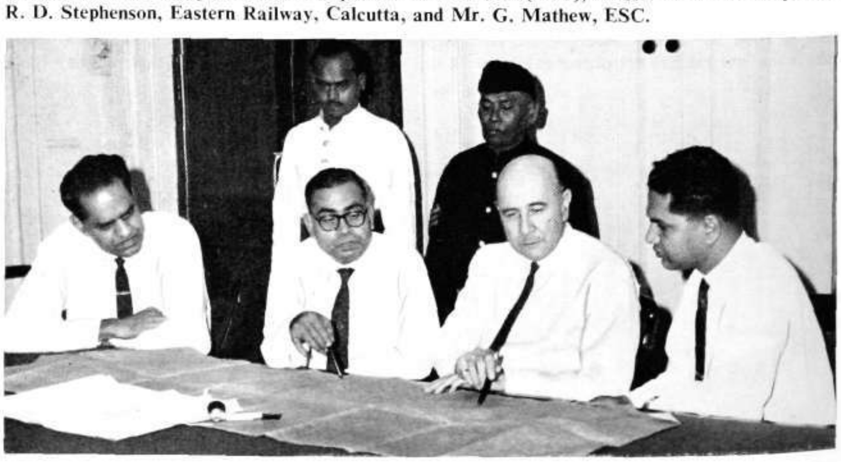
Dr. Rapp has elaborated principles and methods for planning of urban and trunk networks, using an electronic computer for the most demanding numerical calculations. These methods are intended to provide telephone administrations with a means and a framework for deciding on longterm investments. In recent years Dr. Rapp has read a number of papers which have aroused wide interest at conferences inside and outside Europe. A large number of projects have already been worked out in different countries and others are under preparation.

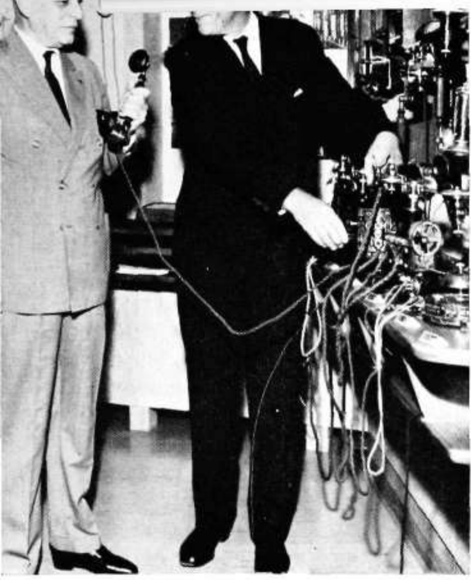
The Academy of Engineering Sciences, with was founded in 1919 for the promotion of technological and scientific research, was the first academy of engineering sciences in the world. Similar institutions have been created in the other Scandinavian countries. In the United States an academy of engineering sciences was founded in 1964.

Organizational Change

On September 1, 1965, Mr. Hans Sund became Manager of the Military Electronics Division of the parent company and at the same time was appointed Vice President of the Company.

The track and signal diagram of Howrah Station is here being discussed by (from left) Mr. M. K. Menon, Ericsson Telephone Sales Corporation in Calcutta (ESC), Messrs. S. K. Chatterjee and R. D. Stephenson, Eastern Railway, Calcutta, and Mr. G. Mathew, ESC.

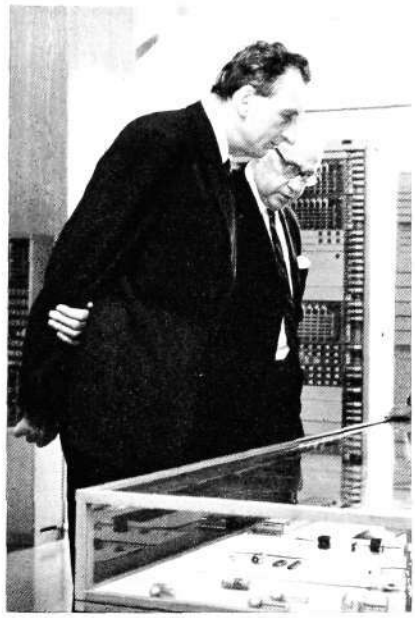




Mr. Björn Lundvall, President of L M Ericsson, demonstrates old models of Ericsson telephones to Sr. Carlos Reis Filho (left), head of Companhia Telefônica Brasileira, the largest telephone company in Brazil.

The Venezuelan Ambassador to Sweden, Sr. Aquilles Benitez S, and the Swedish Ambassador to Venezuela, Mr. Knut Bernström (second and third from left), recently visited L M Ericsson's main factory. They were taken on a tour of the factory by Mr. E. Lundqvist. Here they are studying an automatic test equipment for relay sets.

The Minister of Communications of Saudi Arabia, Ahmed Zaidan (left), met some of his fellow-countrymen, among whom his son, during a recent visit to L M Ericsson's head factory. Three of them are employees of the Saudi Arabian Ministry of Communications and are in Sweden to learn telephony.



The 1964 Nobel Prize Winner in Physics, Professor Alexander Prochorov, of the Soviet Union, was in Sweden in November and paid a visit to L M Ericsson. He was shown over the exhibition room by the Technical Director of the Company, C. Jacobæus (right).

Elsa Andersson and Viola Engström, employed in the grid winding division of AB Svenska Elektronrör (SER), have been awarded altogether 1216 kronor by the company management. In SER's manufacture of long-life tubes it is essential that the tolerances for the grids are as small as possible. These two women, seen behind one of the grid winding machines, had come on the idea that the grids would have a very much more uniform quality and that many machine resetting operations could be saved if the braking motors on the winding machine were started so long in advance of the actual winding of the grids that thermal stability had been attained.

Mr. Beheiry of the African Development Bank, Abidjan, Ivory Coast, in conversation with Mr. Thisell during a visit he paid in the autumn to L M Ericsson at Midsommarkransen.

Aircraft undergoing tests.

L M Ericsson Automatic Test Equipments for Swedish Air Force

Telefonaktiebolaget L M Ericsson has received an order from the Swedish Air Force for automatic test equipments to be used, among other purposes, for control of and tracing of faults in the electronic equipment of the new Swedish combat plane, the "37 Viggen".

It is anticipated that altogether 44 test equipments will be delivered over a period of 10 years, valued at a total of 44 mill. kronor. The first delivery, comprising 4 equipments, is scheduled to take place as from August 1, 1966.

In the past 10 years L M Ericsson has used automatic test equipments of different kinds for its own production control with extremely good results.

This experience has been of great value in the design of L M Ericsson's new test equipment for automatic control and fault testing of aircraft electronics. With this equipment thousands of tests of the various electronic equipment in a modern ground attack or fighter aircraft can be made within a few minutes.

When the vehicle carrying the test equipment has been driven up to the aircraft–which may have landed just before–the technical staff need merely make sure that the cables have been correctly connected to the aircraft test terminals and that the test equipment has been programmed for the type of aircraft concerned. The programme is recorded on magnetic tape. The actual tests and the presentation of the results are performed automatically by the test equipment.

The equipment may be compared with an electronic computer. The correct test values with their tolerances are stored on programming tape. The test equipment sends signals to the various electronic units in the aircraft. The answering signals from the latter are automatically compared with the tolerance limits recorded on the programming tape. In the event of deviation outside the tolerance limits or other fault, the test equipment indicates the exact nature and location of the fault.

L M Ericsson's new test equipment will greatly reduce the time spent on inspection of aircraft between missions.

The test equipment is self-checking in order to preclude a wrong test result on account of a fault in the test equipment itself. This self-checking feature comes automatically into play, for instance, as soon as the equipment has discovered any fault in the controlled equipment.

The change from manual to automatic testing reduces the risk of human error. There is therefore a greater probability that all electronic equipments of the aircraft are in optimum condition before the craft starts on a mission. This increased safety for pilots is an important factor.

The switching devices which connect the test points to the stimuli and measuring circuits of the test equipment, like many other of its circuits and components, were developed in an extensive research programme conducted by L M Ericsson on telephone exchanges of the future. Their reliability has thus been extremely thoroughly tested, since the environmental and functional requirements on telephone exchange equipments are also very severe.

The digital data processing unit in the test equipment is also based on many years of experience. In 1956 L M Ericsson started to develop a fully electronic type of telephone exchange. A model of this exchange was exported and has been in continuous operation for several years. A complete computer was designed for control of this exchange. The work in this field has since continued, and the data processing unit in L M Ericsson's automatic test equipment is based on the technique used in the digital computers controlling the electronic telephone exchanges now being developed and made by L M Ericsson.

Telex Contract with Chile

On October 28 L M Ericsson signed a contract with the government purchasing authority in Chile—La Dirección de Aprovisionamiento del Estado—for the delivery of telex equipment to the national telephone authority, El Servicio de Correos y Telégrafos de Chile.

The contract comprises 13 automatic terminal exchanges for altogether 660 subscribers, 2 manual exchanges and 4 trunk exchanges with a total capacity of 500 lines for automatic transiting of telex calls between the capital, Santiago, and Valparaiso, Talca and Concepción.

This order constitutes the first step in the automatization of the Chilean telex network and provides for future international traffic via radio and cable.

The delivery is expected to be completed during the second half of 1967.

The order was obtained in hard competition with most of the international manufacturers of telex equipment and is the largest yet received by L M Ericsson in South America.

From the signing of the telex contract are seen (from left) the Swedish Ambassador, Count Gustav Bonde, Sr. Luis Azócar, Notary Public, Mr. Lars Silfverling, L M Ericsson, the Chilean Vice President, Sr. Bernardo Leighton, the Director of the Government Purchasing Authority in Chile, Sr. Mario Araos, and the Director General of the Chilean PTT, Sr. Mario Parada.

Two cards–card 1

UDC 621.391
LME 81

WIDL, W.: *Signal Conversion Equipment for Parallel Data Transmission on Telephone Lines*. Ericsson Rev. *42*(1965): 4, pp. 110—120.

Information which is to be transmitted exists at the sending side as a rule stored, for exemple as holes punched in a tape or card, as magnetic markings on a magnetic tape or ferrite store, as contact closures in a mechanical counter. At the receiving side the information is again fed into a store for further processing in a subsequent data processing equipment.

So far, serial data transmission has been predominant in the case of data transfer between sets of terminal equipment. The signal elements carrying information are in this case sent after each other in time, and the data flow occupies a single but relatively wide channel. L M Ericsson's equipment for serial transmission is described in Ericsson Review No. 3, 1962 and in TELE No. 1, 1965.

Two cards–card 1

UDC 621.318.56
LME 7350

AHLBERG, C.: *On the Dynamic Characterstics of the Electromagnetic Relay*. Ericsson Rev. *42*(1965): 4, pp. 121—132.

In the spring of 1965 C. Ahlberg presented a theory for the motion of an electromagnetic relay. To simplify solution of a time integral, the load characteristic of the relay is first converted to show the air gap flux as function of the permeance of the magnetic circuit instead of showing the load as function of the air gap. The "mechanical" load characteristic consists of straight lines which become slightly curved after conversion to "magnetic" coordinates. These curved lines are thereafter assumed to be straight. Formulae for velocity, acceleration and time of passage are deduced on the basis of this approximation.

UDC 654.924
LME 861

NILSSON, U.: *TELEALARM—Equipment for Issue of Alarm on Automatic Telephone Network*. Ericsson Rev. *42*(1965): 4, pp. 133—135

There is today a very great need for supervision of various forms of equipment, the more so as increasingly advanced automatic equipments come into use. Too late action after a fault has occurred may result in serious financial losses.

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Card 2

UDC 621.318.56
LME 7350

AHLBERG, C.: *On the Dynamic Characteristics of the Electromagnetic Relay*. Ericsson Rev. *43*(1965): 4, pp. 121—132.

Professor Stig Ekelöf of the Chalmer's University of Technology has made the same approximation after the conversion to a flux-magnetomotive force system of coordinates and has thereby radically simplified the formula for the time of passage.

Since Alf Lundin of the Chalmer's University of Technology has shown (not yet published) that velocity and acceleration formulae can be set up without using this approximation, being therefore more closely related to reality, the author has revised the formulae.

The article presents a summary of the theory, using Ekelöf's time formula and the new velocity and acceleration formulae in place of the original ones. The basic ideas are the same as in the cited thesis. The intermediate steps in the derivations are omitted from considerations of space.

Card 2

UDC 621.391
LME 81

WIDL, W.: *Signal Conversion Equipment for Parallel Transmission on Telephone Lines*. Ericsson Rev. *42*(1965): 4, pp. 110—120.

Recently, yet another type of transmission, viz. parallel transmission of data has come into use. The signal elements carrying information are compressed into short blocks. In this method, the elements are transmitted in parallel in time and each signal element in a block uses its own relatively narrow band channel. Parallel transmission offers an economical transmission alternative which is resistant to interference, particularly when operating together with terminal equipment which has parellel injection and extraction of data.

It can therefore be appropriate to illustrate the most important differences between serial and parallel transmission. In this article, both methods of transmission are compared, and in addition a description is given of a signal conversion equipment for parellel data transmission.

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A/S Industrikontroll *Oslo 6*, Grenseveien 86/88 tel: Centralbord 68 34 64, tgm: indtroll, telex: 1117 A/S Norsk Kabelfabrik *Drammen*, P.B. 205, tel: 83 76 50, tgm: kabel A/S Norsk Signalindustri *Oslo 3*, P.B. 5055, tel: 46 18 20, tgm: signalindustri

Portugal

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

Spain

Cia Española Ericsson, S. A. *Madrid 8*, Torre de Madrid, Princesa 1, tel: 241 14 00, tgm: ericsson

Sweden

Telefonaktiebolaget L M Ericsson *Stockholm 32*, tel: 08/19 00 00, tgm: telefonbolaget, telex: 19910

AB Alpha *Sundbyberg*, tel: 08/28 26 00, tgm: aktiealpha, telex: 10082

AB Ermi *Karlskrona 1*, tel: 0455/23010, tgm: ermibolag

AB Rifa *Bromma 11*, tel: 08/26 26 10, tgm: elrifa, telex: 10308

AB Svenska Elektronrör *Stockholm-Tyresö 1*, tel: 08/712 01 20, tgm: electronics, telex: 1275

Instruktionsteknik AB *Stockholm 44*, tel: 08/68 08 70, tgm: instruktec

L M Ericssons Driftkontrollaktiebolag *Solna*, tel: 08/83 07 00, tgm: ericdata

L M Ericssons Signalaktiebolag *Stockholm Sv*, tel: 08/68 0700, tgm: signalbolaget

L M Ericsson Telemateriel AB, *Stockholm-Tyresö 1*, Fack, tel: 08/712 00 00, tgm: ellem, telex: 1275

Sieverts Kabelverk AB *Sundbyberg*, tel: 08/28 28 60, tgm: sievertsfabrik

Svenska Radioaktiebolaget *Stockholm 12*, tel: 08/22 31 40, tgm: svenskradio

Switzerland

Ericsson Telephone Sales Corp. AB, Stockholm, Zweigniederlassung *Zürich 8032 Zürich*, Postfach, tel: 32 51 84, tgm: telericsson telex: 52 669

Turkey

Ericsson Türk Ticaret Ltd. Şirketi *Ankara*, Rumeli Han, Ziya Gökalp Cad., tel: 12 31 70, tgm: ellem *Istanbul*, Istanbul Bürosu, Liman Han, Kat 5, No. 75, Bahçekapi, tel: 22 81 02, tgm: ellemist *Izmir*, Izmir Bürosu, Kisilkaya Han, Kat 3, No. 13, Halif Ziya Bulvari, tel: 27832, tgm: ellemir

West Germany

Ericsson Verkaufsgesellschaft m. b. H. *4 Düsseldorf-Rath*, Postfack 88, tel: (0211)63 30 31, tgm: erictel, telex: DSSD 8 58 6871

• ASIA •

India

Ericsson Telephone Sales Corporation AB *Calcutta 22*, P.O.B. 2324, tel: 45 44 94, tgm: inderic *New Delhi 1*, P.O.B. 669, tel: 27 23 12, tgm: inderic

Indonesia

Ericsson Telephone Sales Corporation AB *Bandung*, Djalan Ir. H. Djuanda 151—153, tel: 8294, tgm: javeric *Djakarta*, Djalan Gunung Sahari 26, tel: OG 48531, tgm: javeric

Iraq

Telefonaktiebolaget LM Ericsson, Technical office *Baghdad*, P. O. B. 493, tel: 87033, tgm: ellemco

Lebanon

Telefonaktiebolaget LM Ericsson, Technical office *Beyrouth*, Rue du Parlement, Immeuble Bisharat, tel: 25 26 27, tgm: ellem

Thailand

Ericsson Telephone Corp. (Far East) AB *Bankok*, P.O.B. 824, tel: 55511, tgm: ericsson

Egypt

Telefonaktiebolaget LM Ericsson, Technical office Egypt Branch *Cairo*, P.O.B. 2084, tel: 46 581, tgm: elleme

Morocco

Société Marocaine des Téléphones Ericsson *Casablanca*, 38, rue Mohamed Sedki, tel: 288-75, tgm: teluni

Rhodesia, Bechuanaland and Malawi

Ericsson Telephone Sales Corporation Ltd. *Salisbury, Rhodesia*, P.O.B. 2891, tel: 25737, tgm: ericofon

Tunisia

Telefonaktiebolaget LM Ericsson, Technical offiice *Tunis*, Boite Postale 780, tel: 24 05 20, tgm: ericsson

Zambia

Ericsson Telephone Sales Corp. AB. *Ndola*, P.O.B. 2256, tel: 3885, tgm: ericofon

• AMERICA •

Argentine

Cía Ericsson S. A. C. I. *Buenos Aires*, Casilla de Correo 3550, tel: 33 20 71, tgm: ericsson

Cía Argentina de Teléfonos S.A. *Buenos Aires*, Belgrano 894, tel: 33 20 76, tgm: catel

Cía Entrerriana de Teléfonos S.A. *Buenos Aires*, Belgrano 894, tel: 33 20 76, tgm: catel

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

Brazil

Ericsson do Brasil Comércio e Indústria S.A. *Rio de Janerio*, C.P. 3601, tel: 43-0990, tgm: ericsson, telex: rio 310

Canada

LM Ericsson Ltd. *Montreal 9, P.Q.*, 2300 Laurentian Boulevard, City of St. Laurent, tel: 331—3310, tgm: caneric, telex: 1-2307

Chile

Cía Ericsson de Chile, S.A. *Santiago de Chile*, Casilla 101 43, tel: 825 55, tgm: ericsson

Colombia

Cía Ericsson Ltda. *Bogotá*, Apartado Aéreo 4052, tel: 41 11 00, tgm: ericsson

...on, ...*Apartado* L. M. E.

Ecuador

Teléfonos Ericsson C.A. *Quito*, Casilla 2138, tel: 16100, tgm: ericsson

Guayaquil, Casilla 376, tel: 16892, tgm: ericsson

Mexico

Teléfonos Ericsson S.A. *México D.F.*, Apartado M-9958, tel: 46 46 40, tgm: coeric

Teleindustria, S.A. de C.V. *Naucalpan*, Est. de Mexico, Apartado 297

Peru

Cia Ericsson S. A. *Lima*, Apartado 2982, tel: 34941, tgm: ericsson, telex: 3540202

Soc. Telefónica del Perú, S.A. *Arequipa*, Apartado 112-1012, tel: 60 60, tgm: telefonica

El Salvador

Telefonaktiebolaget LM Ericsson, Technical office *San Salvador*, Apartado 188, tel: 4989, tgm: ericsson

Uruguay

Cia Ericsson S.A. *Montevideo*, Casilla de Correo 575, tel: 92611, tgm: ericsson

USA

The Ericsson Corporation *New York, N.Y.*, 10017, 100 Park Avenue, tel: MUrrayhill 5-4030 tgm: erictel, telex: etelsac 620149 North Electric Co. *Galion, Ohio*, P.O.B. 688, tel: (419-) 468-2420, tgm: northphone-galionohio, telex: 419-464-4860

Venezuela

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

• AUSTRALIA & OCEANIA •

Australia

L M Ericsson Pty. Ltd. *Broadmeadows (Victoria)*, P.O.B. 41, tel: 307-2341, tgm: ericmel *North Sydney (NSW)*, 182 Blue's Point Road, tel: 92 11 47, tgm: ericsyd

Teleric Pty. Ltd. *Broadmeadows (Victoria)*, P.O.B. 41, tel: 307-2341, tgm: teleric *North Sydney (NSW)*, 182 Blue's Point Road, tel: 92 11 47, tgm: teleric

Representatives

• EUROPE •

Austria

Telecom G. m. b. H. *Wien XI*, Geiereckstrasse 6, tel: 74 15 81, tgm: teleric, telex: electrodiesel wn 2436

Belgium

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

Greece

"ETEP" S.A. Commerciale & Technique *Athens 143*, 57, Akadimias Street, tel: 62 99 71 tgm: aeter athinai, telex: 5708

Iceland

Johan Rönning H/F *Reykjavik*, P.O.B. 883, tel: 10632, tgm: rönning

Yugoslavia

Merkantile Inozemna zastupstva *Zagreb*, Pošt pretinac 23, tel: 36941, tgm: merkantile, telex: 21139

• ASIA •

Burma

Myanma Export Import Corp. Import Agency Division *Rangoon*, P.O.B. 400, tel: 10999, tgm: myaceico

Cambodia

The East Asiatic Company Ltd. *Phnom-Penh* P.O.B. 625, tel: 3334, tgm: pyramide

Ceylon

Vulcan-Laval Ltd. *Colombo 1*, 40, Church Street, tel: 36-36, tgm: vultra

Cyprus

Zeno D. Pierides *Larnaca*, P.O.B. 25, tel: 2033, tgm: pierides

Hong Kong & Macao

Swedish Trading Co. Ltd. *Hongkong*, P.O.B. 108, tel: 23 10 91, tgm: swedetrade

Iran

Irano Swedish Company AB, *Teheran*, Khiabane Sevom Esfand 29, tel: 310 66, tgm: iranoswed

Iraq

Usam Sharif Company W.L.L. *Baghdad*, P.O.B. 493, tel: 870 31, tgm: alhamra

Japan

Gadelius & Co. Ltd. *Tokyo C*, P.O.B. 1284, tel: 403-2141, tgm: goticus, telex: 22-675

Jordan

The Arab Trading & Development Co., Ltd. *Amman*, P.O.B. 1, tel: 259 81, tgm: aradeve

Korea

Gadelius & Co. Ltd. *Seoul*, I.P.O. B. 1421, tel: 22—9866, tgm: gadeliusco

Kuwait

Morad Yousuf Behbehani *Kuwait, State of Kuwait*, P.O.B. 146, tel: 32251, tgm: barakat

Lebanon

Swedish Levant Trading (Elié B. Hélou) *Beyrouth*, P.O.B. 931, tel: 23 16 24, tgm: skefko

Malaysia and Brunei

Swedish Trading Co. Ltd. *Kuala Lumpur*, P.O.B. 2298, tel: 25316, tgm: swedtrade

Pakistan

Vulcan Industries Ltd. *Karachi 2, West Pakistan*, P.O.B. 4776, tel: 23 58 28, 22 85 66, tgm: vulcan

Philippines

U.S. Industries Philippines Inc. *Manila*, P.O.B. 125, tel: 88 93 51, tgm: usiphil, telex: 344

Saudi Arabia

Engineering Projects & Products Co. *Riyadh*, P.O.B. 987, tel: 271, tgm: eppcol

Singapore

Swedish Trading Co. Ltd. *Singapore 1*, 42 Chartered Bank Chambers, Battery Road, tel: 94362, tgm: swedtrade

Syria

Constantin Georgiades *Damas*, Rue Ghassan, Harika, tel: 1-02-89, tgm: georgiades

Vietnam

Vo Tuyen Dien-Thoai Viet-Nam, *Saigon*, P.O.B. 10 49, tel: 22 660, tgm: telerad

• AFRICA •

Congo

I.P.T.C. (Congo) *Léopoldville 1*, P.O.B. 8922, tel: 5345, tgm: induexpan

Ethiopia

Mosvold Company (Ethiopia) Ltd. *Addis Abeba*, P.O.B. 1371, tel: 14567, tgm: mosvold

Ghana

The Standard Electric Company *Accrá*, P.O.B. 17, tel: 646 15, tgm: standard

Kenya, Tanzania, Uganda

Transcandia Telecommunication Sales Ltd. *Nairobi, Kenya*, P.O.B. 7296, tel: 25941, tgm: trantel

Liberia

Post & Communications Telephone Exchange, *Monrovia*, Corner Ashmun & Lynch Street, tel: 22222, tgm: radiolibe

Mauritius

Mauritius Trading Co. Ltd. *Port Louis*, P.O.B. 201, tgm: agentou

Morocco (Tangier)

Elmar S. A.—SEYRE *Tetuan*, Apartado 440, tel: 3701, tgm: elmar

Mozambique

J. Martins Marques & Co Lda. *Lourenço Marques*, P.O.B. 2409, tel: 5953, tgm: marquesco

Nigeria

I.P.T.C. (West Africa) Ltd. *Lagos*, P.O.B. 2037, tel: 2653, tgm: consult, telex: shell pb 35

South Africa, South-West Africa, telex: pb 35

Dryden Communications (Pty.) Ltd. *Johannesburg*, P.O.B. 2440, tel: 838-5454, tgm: qualsteels

Sudan

TECOMA Technical Consulting and Machinery Co. Ltd. *Khartoum*, P.O.B. 866, tel: 72224, ext. 27, tgm: sutecoma

Tunisia

Ateliers Mécaniques du SAHEL, *Sousse*, Route de Monastir/Djemmal, tel: 21.011, tgm: amesa

• AMERICA •

Bahama Islands

Anglo American Electrical Company Ltd., *Freeport, Grand Bahama*, P.O.B. 104

Bolivia

Johansson & Cía, S.A. *La Paz*, Casilla 678, tel: 22700, tgm: johansson

British Guiana

General Supplies Agency *Georgetown*, P.O.B. 375, tgm: benwlks

Costa Rica

Tropical Commission Co. Ltd. *San José*, Apartado 661, tel: 3432, tgm: troco, telex: CR-126

Dominican Republic

García & Gautier, C. por A. *Santo Domingo*, Apartado 771, tel: 3645, tgm: gartier

Guatemala

Nils Pira *Ciudad de Guatemala*, Apartado 36, tel: 62258, tgm: nilspira

Hon...

Qui... *galpa*, Apartado 85, tel: 2-5171, tgm: quinchon

Jamaica and Brit. Honduras

Morris E. Parkin *Kingston*, P.O.B. 354, tel: 24077, tgm: morrispark

Netherlands Antilles

S.E.L. Maduro&Sons, Inc. *Willemstad, Curaçao*, P.O.B. 304, tel: 11200, tgm: madurosons

Nicaragua

Sonitel Centroamerica S.A. *Managua*, Apartado 1271, tel: 4476, tgm: sonitel

Panama

Sonitel, S.A. *Panama, RP.*, Apartado 4349, tel: 5-3640, tgm: sonitel

Paraguay

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

Puerto Rico

Novae Electronics Inc. *San Juan*, F 17, Park Lane *Bayamón*, tel: 782-1054, tgm: novaelec

El Salvador

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

Surinam

C. Kersten & Co. NV. *Paramaribo*, P.O.B. 1808, tel: 4444, tgm: kersten

Trinidad, W. I.

Leon J. Aché Ltd. *Port-of-Spain*, 100 Frederick Street, tel: 32357, tgm: achegram

USA

State Labs. Inc. *New York, N.Y.*, 10003, 215 Park Avenue South, tel: (212) 677-8400, tgm: statelabs, telex: (212) 867-6996 (For electron tubes)

• AUSTRALIA & OCEANIA •

New Zealand

ASEA Electric (N Z) Ltd. *Wellington*, ... tel: 70-614

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