

# ERICSSON

1  
1973

# Review





# ERICSSON REVIEW

Vol. 50

1973

RESPONSIBLE PUBLISHER: CHRISTIAN JACOBÆUS, DR. TECHN.

EDITOR: GUSTAF O. DOUGLAS

EDITORIAL STAFF: FOLKE BERG,

BO SEIJMER (ERICSSON NEWS)

EDITOR'S OFFICE: S-12625 STOCKHOLM

SUBSCRIPTIONS: ONE YEAR \$1.80; ONE COPY \$0.60

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On cover: The PABX operators' room  
at L M Ericsson's head office in Stock-  
holm.



# Sixth International Symposium on Human Factors

NORMAN GLEISS, SWEDISH TELECOMMUNICATIONS ADMINISTRATION, STOCKHOLM

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UDC 621.395:658.3.041  
007.51  
LME 5811

*During the week June 26—30, 1972, the Sixth International Symposium on Human Factors in Telecommunications was held in Stockholm. According to the directives for the symposium the following subject fields were to be dealt with:*

*“Man-machine problems of users of the Telecommunications Services (customers, operating and maintenance personnel) as they are affected by human communication capabilities, limitations, preferences, needs and wants. Problems concerning the international network are of special concern. Contributions need not be restricted to audio telephony but may also cover visual communications and the transmission of data.”*

## Background and Organization

The term *human factors* is used chiefly in the USA, whereas in Europe and Sweden the term *ergonomics* is preferred. The latter term was introduced after the second world war when attempts to establish interdisciplinary research were made on a major scale. Ergonomics signifies the application to practical problems within industry, communications etc. of the knowledge about man derived from experimental psychology and physiology. It is thus a question of interplay between behavioural sciences and the engineering art, with the aim of attaining satisfactory adaptation between man and machine.

The first symposium of this kind was held in 1961 at Cambridge, England, and was followed by others at two-year intervals at Copenhagen, the Hague, Bad-Wiessee and London. The Stockholm meeting was the first in Sweden. The Swedish Telecommunications Administration and L M Ericsson<sup>1</sup> acted as joint hosts for the symposium.

The working week consisted of four days with sessions and discussions and one day for excursions. Altogether some fifty papers were presented at the sessions, dealing chiefly with the following subjects:

- The telephone subscriber's behaviour
- Communication man-machine
- New telecommunications services
- Public telephones
- Instructions to users
- Dialling and data transmission
- Telephone directories
- Legibility of visual displays
- Videotelephones
- Sound transmission quality

## The Sessions

Among the papers may be mentioned one group dealing with the significance of telecommunications for the social structure. A practical study has been made of the possibility of discussion and negotiation between parties in different parts of the country via a conference telephone system with or without video transmission. Problems arise particularly in conjunction with decentralization of enterprises. The most active group within this field is the *Joint Unit for Planning Research* in London. Methods deriving from this unit were used in the investigation carried out by the National Swedish Civil Service Department on the frequency of contact between government administrations, "KOMM 71", in the autumn of 1971. Research within this field may have practical consequences for the conference telephone services which telephone administrations are expected to offer in the future.

In conjunction with the introduction of new telephone services, such as call-back and call transfer, there is reason to question to what extent services of this kind, which today exist in certain PABX, are in fact used. It is found that seldom utilized functions, for example alarm or special services, are forgotten so completely that in reality they never come into use. The remedy for this situation is a problem of instruction.

Easily understood instructions, for example in the form of symbols for users of coin box telephones, are also of great importance.<sup>2</sup> The problem arises not only for foreign visitors, but also for users within the country who have no telephone of their own and whose lack of familiarity with the telephone deters them from using a complicated coin box telephone. The same applies to emergency telephones along main roads.

Another problem dealt with in several papers is the long numbers which must be dialled for setting up international calls. A suitable division into digital groups may simplify dialling, as also may the replacement of the dial by a keyset. The keyset can be used also for transmission of data, which also permits bank transactions, ordering of goods etc. to be done via the telephone network in direct communication with computers. Speech communication between man and computer is also conceivable and was dealt with during the symposium.

Another subject field was *Human engineering*, which is concerned with how telephones and systems should be designed for convenient handling and quick



Fig. 1  
The Human Factors Symposium in Stockholm 1972

service. This applies not least to equipment which is used on a professional basis by telephone and telex operators.

Of particular interest at the present time is the videophone and the advantages it may bring. This formed an important part of a special discussion on *Interpersonal Communication* (which is a different subject than *Man/machine communication*). Other papers dealt with the legibility of digits and symbols shown on visual displays. The use of such displays is already of interest, among other things for directory assistance service.

Almost a whole day was devoted to speech transmission problems. This includes questions of sound quality both technically and as experienced by the subscriber. Experiments are being made in the replacement of the old carbon microphone by a stable element which provides a better sound quality. The results of such tests, on which the Telecommunications Administration and L M Ericsson are engaged, were presented. It has proved difficult, as also in conjunction with other technical changes in the properties of a telephone connection, to find a reliable measure of listeners' reactions to the change. It is not economical to introduce quality changes which are unnoticed by subscribers.

Another field which was discussed was voice-switched loudspeaking telephones. Computers were used for this purpose, both for study of the time structure of speech during actual telephone conversations and for simulation of the properties of voice switching circuits. The properties could at the same time be judged by listening tests controlled by the computer instead of the experimenter.

Within the speech transmission field there were also a number of papers on more conventional problems such as measuring methods for telephone receivers and microphones, the effect of bandwidth on sound quality, crosstalk criteria etc. These problems normally fall within the field of activities of Study Group XII of CCITT, whereas human factors in other respects are chiefly dealt with by Study Group II, Working Party 5.

All papers and discussions from the symposium are now available in the form of a book which is being distributed by the Swedish secretariat.

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# Transmission and Grade of Service — Are Our Present Norms Correct?

CHRISTIAN JACOBÆUS, TELEFONAKTIEBOLAGET LM ERICSSON, STOCKHOLM

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UDC 621.391.8  
621.395.31  
LME 8408  
8071  
8077  
5811

*This paper is a revised version of the opening address at the International Symposium on Human Factors in Telecommunications in Stockholm, June 1972.*

*The author poses the fundamental question whether our telephone plants are properly dimensioned. Have we a reasonable balance between transmitted bandwidth and grade of service (congestion) in the network? The article also illustrates some fundamental difficulties encountered by the researcher in this field.*

The reason why transmission and grade of service (or the reverse concept of congestion) are taken together, and also contrasted, is that these two parameters largely determine the dimensioning of telephone plants. Both parameters are directed to the quality of the plant — viewed from the users'/subscribers' aspect. Grade of service is a parameter which has a direct influence on quantity — i.e. the number of switching devices and trunks — while the quality of transmission determines how much each circuit will cost (at least as a first approximation). Within the framework of a given total cost, accordingly, one can vary the plant in different ways depending on how quality of transmission and grade of service are weighed against one another.

How should this weighing be done? Is the present practice the right one? We shall return to this matter after we have had a closer look at the two concepts.

## Quality of Transmission

The main concern of transmission is to attain intelligibility of transmitted speech and, secondarily, naturalness of transmitted speech. The quality of transmission is determined, as is known, by a number of parameters such as attenuation, crosstalk, return loss, transmission time, noise, bandwidth. The point which is chiefly open to debate is bandwidth. The other parameters are, of course, very important, but the possibilities of variation appear, purely technically, to be better in respect of bandwidth.

As regards the perhaps most important factor, attenuation, it is primarily determined by the local networks up to the 4-wire point. The attenuation on the actual trunk circuits is close to 0. Gain on trunk circuits can hardly be allowed in view of the risk of singing on certain connections. In other cases the values of return loss that can be obtained require a positive attenuation in the trunk area.

It has proved to be rather difficult to get a grip on why a total bandwidth of 4,000 Hz with speech transmission within the range 300—3,400 Hz has been adopted. In the course of time the frequency range has been pressed upwards. The loadings that were common in earlier periods had cut-off frequencies as low as 1,800 Hz, which was clearly too little. But why was it decided to adopt 3,400 Hz? The reason probably was that at this cut-off frequency one gets very good intelligibility and that the carrier terminals had reasonable types of filter. At the same time telephone receivers could be made which functioned well up to this frequency. We may draw the conclusion that, as intelligibility was practically perfect, there was no reason to raise the bandwidth any higher, especially as there would probably be certain difficulties in the design of telephone instruments. We can now recognize, however, that the technical conditions have changed in a drastic manner. We can now design telephone instruments with semiconductor amplifiers which, without being too expensive, cover a larger frequency range. There is also the possibility of compensating the higher attenuation in local networks at high frequencies. When it comes to the carrier networks the bandwidth has, as one says, become cheaper through the advent of new systems with a larger transmitted bandwidth. In a coaxial carrier system, for instance, the terminal cost per channel during the last 20 years has fallen in current monetary values to half, while the circuit cost including amplifiers has gone down to one-sixth. And this is so although the cost of cable has risen on account of the higher price of copper. These terminal costs relate to the actual multiplex costs. If the exchange portion is included, the cost comparison will be even more to the disadvantage of the terminal equipment, as the exchange cost has risen rather than fallen. The result, as seen from the table, is a total change of the cost relations by a factor of 4 to 5.

The automatic exchanges of ordinary type, i.e. electromechanical, and also electronic with space division, have no difficulty in passing a higher frequency. In some cases, however, one must be careful about crosstalk at higher frequencies. An alternative to raising the upper cut-off frequency is to reduce the lower cut-off frequency. Several investigations have indicated that this would have considerable benefits from the point of view of transmission. But unfortunately it would involve rebuilding of all old exchanges, as the current feed bridges would have to be redimensioned. In the frequency division carrier systems a

Terminal cost/channel			HF line cost/channel								
			per km		per 100 km		per 300 km		per 1 000 km		
			1952	1972	1952	1972	1952	1972	1952	1972	
Multiplex		3 000	1 200	25	4	2 500	400	7 500	1 200	25 000	4 000
	Exchange	2 000	2 500								
Total		5 000	3 700			5 000	3 700	5 000	3 700	5 000	3 700
HF line cost/terminal cost				0.5	0.11	1.5	0.32	5.0	1.1		

The table shows the relation between HF line cost and terminal cost per channel in a coaxial system. The costs are calculated in Swedish crowns.

reduction to 200 Hz also seems to involve problems in conjunction with outband signalling. In the long run as well, therefore, a reduction of the lower cut-off frequency will be a less attractive alternative.

It would be natural that, if bandwidth has become cheaper in relation to other parts of the plant, a greater use should be made of it at the expense of other characteristics. If it is considered that the present bandwidth is the most favourable in the situation today, one must conclude that we have earlier used too great a bandwidth!

Probably, however, there will be reason to depart from the present standard if one wishes something over and above intelligibility. This would be naturalness of speech, i.e. what is heard in a receiver should resemble more closely what is heard in a conversation between the same two persons in a room. This would, of course, have subjective advantages, be more pleasant, less tiring and, in the case of a loudspeaker telephone for example, would yield also objectively measurable improvements.

These ideas have also been confirmed to some extent by investigations in other fields. Norman Gleiss of the Swedish Telecommunications Administration has published the results of an investigation of the significance of bandwidth, among other factors, for the quality of radio transmission<sup>1</sup>. He found a very pronounced subjective improvement of the relative quality on raising of the upper cut-off frequency. ATT have also found an increasing preference for higher bandwidths.

We see here an example of two common difficulties encountered in research in this field. One is the habituation in subscribers' evaluations through their familiarity with the telephone as it has been and as it is. Force of habit differs in different people, and one can also trace a difference of general attitude to innovations in different countries. Habituation introduces a conservative feature. Within telephony it will reinforce the "conservatism of capital" due to the large investments in existing plants with which all innovations must be compatible. On economicotechnical grounds therefore, changes take place slowly and are never radical.

The second difficulty is the subjective evaluation itself. How should the subscriber/experimental subject grade his judgement? What are his points of reference? One must also expect subjective evaluations to be subject to change. We do not know whether the investigations made today will be relevant in 10 or 20 years' time. To take a drastic example, in 20 years' time a guarantee of secrecy of conversation against unauthorized listening will perhaps be more important for many people than better transmission.

These difficulties presumably exist within almost all spheres where the human factor enters into the picture. It is therefore no new problem for the sociologists, for example; but for the engineers, who usually work with measurable, reproducible and unchangeable magnitudes, this is a new feature which for some may be felt to be frustrating.

Through very widely organized experiments it would be possible to find out what subscribers are willing to pay for an increased bandwidth, but it is questionable whether this possibility is not entirely theoretical. The experimental area would have to be divided into subareas, each of which would have a given bandwidth and corresponding subscription and call charges. From time to time

a permutation would be made between areas in respect of bandwidths and charges. At the end of the series of experiments the subscribers could state which alternative they consider most desirable. There is hardly any other organization in the world than ATT with the resources to carry out such an investigation; but it is extremely doubtful whether, on policy grounds, they would be willing to do so. If one carries out investigations without varying the charges, one gets a wrong result. Subscribers will always say yes to improvements which do not cost them anything. (An example of this is pushbutton dialling, which in all investigations has met with an enthusiastic response. When, thereafter, its introduction was associated with a rise of charges, it was treated with great hesitation.) As regards bandwidth, as also other measures of quality, one may be sure that the evaluations tend toward higher quality. In 10 years, perhaps, the present channel division of 4,000 Hz will be felt to be as antiquated as we now consider the bandwidth of 1,800 Hz for loaded circuits.

Most of our circuits in the world today, apart from urban areas, have a 4,000 Hz channel division. But we have very much larger investments ahead. Take, for example, telephone instruments, which today do not reproduce higher frequencies than 3,400 Hz. Should we not consider whether it is really correct to bind ourselves to the present standard for all future time? When we start to have integrated exchanges and transmission on a PCM basis, it will probably be too late to do anything about it.

## Grade of Service

If we now pass on to grade of service, or its reverse concept of congestion, we find the conditions to be different from many points of view. Here there are no general congestion norms, but each administration has followed its own standard. The congestion between two subscribers in a national network is generally kept low — in the busy hour perhaps one or two per cent of calls between two arbitrary subscribers are rejected. It has been remarked that this is really a good standard — the main reasons for unsuccessful calls being that the called subscriber is engaged or does not answer; perhaps up to 15 % of the calls are lost in this way. But it must be noted that there must be a certain overcapacity in the network to meet unusual peaks of traffic. These occur in conjunction with different events in a community, pseudo or real events. It is especially important in critical situations that the telephone network should have an adequate capacity, as otherwise the community cannot function as it should. It should also be pointed out that in a fully automatic system the subscribers must have an adequate grade of service, as in a multiexchange network the queuing arrangements hardly function.

Here, too, of course, there is the question of habituation of the subscribers to a certain quality of service. Impairment of the service initially results in complaints from the subscribers, but after some time they become accustomed to it and the complaints disappear. There is hardly a trend to a higher level of grade of service — but rather to an increase of congestion.

It may be worthwhile to mention a contribution by the pioneering Swedish traffic researcher Conny Palm. In a posthumous paper published in TELE 1952<sup>2</sup> — for that matter one of the first in which a traffic researcher seriously considered the effect of “human factors” — Palm discussed the subscriber’s reaction on encountering congestion in a loss system and in a delay system. For delay systems Palm introduced the subscriber’s irritation at any moment as a magnitude increasing with time. The inconvenience is defined as the sum of the

irritations experienced up to the moment in question. The inconvenience can be written

$$I(t) = \frac{c}{1 + \lambda} f^{1 + \lambda}$$

Palm succeeded in determining the magnitude  $\lambda$  by analysing measurements of the delay in replacement of the handset by a subscriber who had dialled an unobtainable number. (The earlier Swedish systems did not return a "number unobtainable" tone.)  $\lambda$  was found to be close to 1, which means that the irritation felt at any moment is proportional to the delay.

Palm did not, however, discuss how the subscribers' experience of the service affected their irritation, nor what trend may be expected in subscribers' evaluations.

In contradiction to bandwidth, it is fairly easy to change the congestion in a network. As the traffic constantly increases, congestion can be increased by somewhat postponing the extensions of junction and trunk lines, and in the same way it can be reduced by installing additional circuits. The problem is simple from the technical aspect and the economic consequences are entirely surveyable.

## Transmission Versus Grade of Service

Now that we have had a closer look at our parameters of transmission and grade of service we come back to the original question: How to weigh the two parameters against one another? First it may be said that no such weighing has taken place in a conscious manner. As will have appeared, a certain practice has developed which, however, is rooted in a technique which in several respects is now ripe for discarding. It is also coloured by the valuations — which in themselves need not be antiquated — which existed 30-40 years ago.

It should be mentioned that some 10 years ago Yngve Rapp of L M Ericsson made an attempt to obtain a point of comparison between congestion and quality of transmission. He based his approach on the fact that, under conditions of poor transmission, conversations tend to be longer owing to questioning, and perhaps because it is necessary to speak more slowly and clearly. This approach led to certain results, but a number of assumptions had in such case to be made as to how much the subscriber's time was worth, etc., which must be regarded as entirely uncertain. Also it was not possible to take into account the costs due to possible misunderstandings between subscribers. Furthermore, it was not considered that such poor transmission could be offered to subscribers that any measurable results could be gained within a reasonable time.

As far as is known, no other studies have been published which have thrown light on this question. We are presumably faced with a question of "policy". Its decision must be a matter of judgement on the part of administrations. There are very many such questions of priority in our society, which are usually decided at a political level. Telephone administrations undoubtedly have many other similar questions, for example tariffs for different services, the quality of service for the network, how quickly faults should be repaired etc. The question of quality of transmission versus grade of service is perhaps more closely associated with *technology than most other such questions. These questions, and especially people's attitude to them, however, are to a large extent a grey area. If these remarks can stimulate to increased research within this very important sphere,*

administrations would have a more solid ground on which to base their decisions. One may also hope that the decisions made on the basis of this extended knowledge will have a greater length of life. It should be an attractive sphere also for researchers, as it concerns the very heart of telephony. For all too long a time the multitude of detailed investigations has pushed fundamental problems aside.

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# In-dialling

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UDC 621.395.5.21:  
621.395.25  
LME 8372  
8350  
8325

*By in-dialling is meant that the public subscriber can directly dial an extension of a PABX without the assistance of an operator. In-dialling can be used both on local, long-distance and international calls. It results in a shorter setting-up time and is more convenient than conventional connection via an operator. The introduction of in-dialling reduces the operator's work by up to 80 %.*

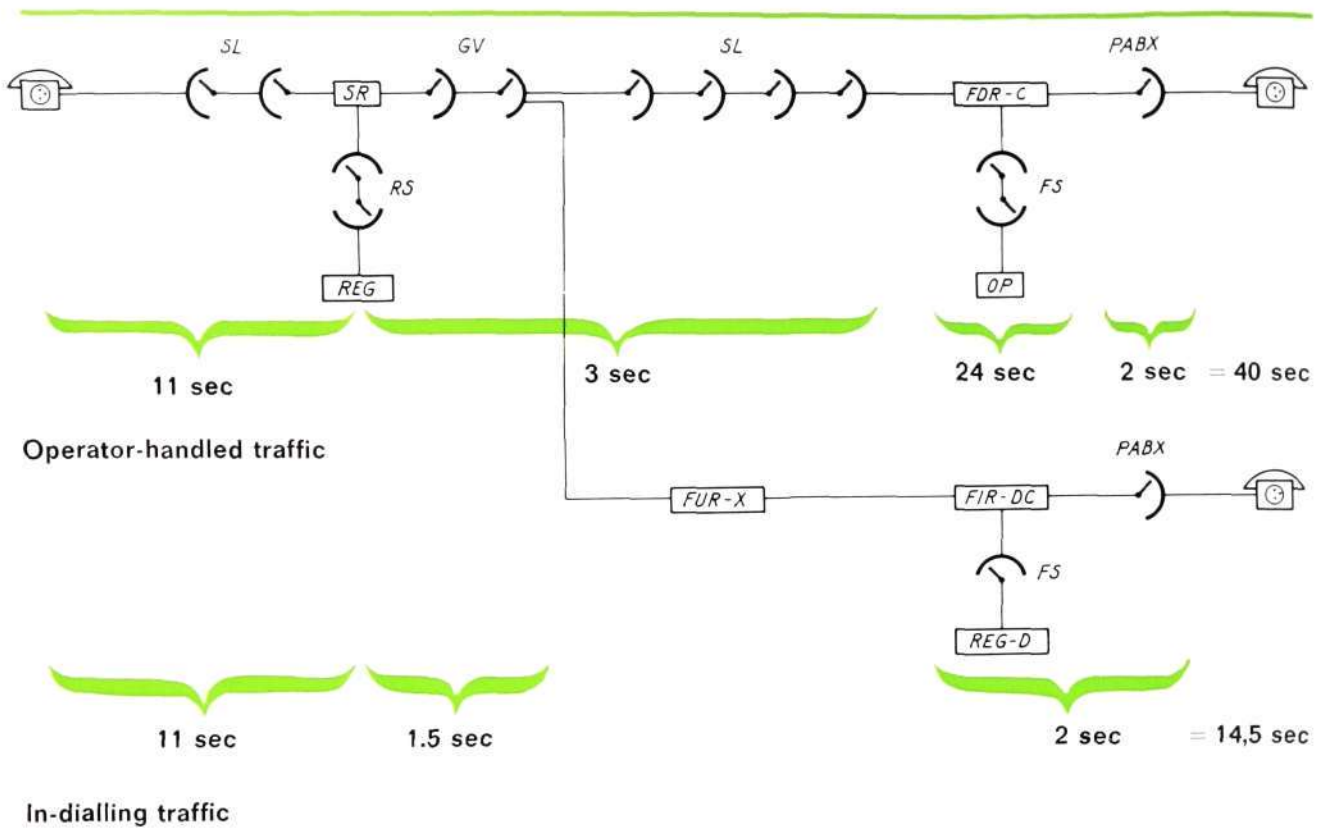
*It is estimated that for a large or medium-sized city about 40 % of all telephone traffic terminates on PABX's. When in-dialling becomes more common, accordingly, a large part of the total telephone traffic of a city will be affected.*

*This article deals with questions of principle and general solutions to problems in conjunction with in-dialling.*

## Advantages of In-dialling

In-dialling offers the following essential advantages:

- *Convenient procedure* and gain of time for the public subscriber, who can dial or key the wanted extension's number direct.
- *Fewer PABX operators* are required since all in-dialled calls are set up automatically.
- *Fairer charging*, as metering does not start until an answer is received from the called extension. On operator-handled traffic, on the other hand, metering starts when the operator answers, irrespective of whether an answer is received from the wanted extension or not.
- *Shorter setting-up time* as the connection is obtained direct. The gain in time is about 25 sec (fig. 1). The load on the public network is naturally reduced to a corresponding extent, so that more paid traffic can be carried over the same equipment.
- *Increased call rate* as, owing to the quicker and more convenient procedure, the subscribers are encouraged to use the telephone to a greater extent.



**Fig. 1**  
**Comparison between setting-up times for operator-handled and in-dialled calls**

SL	Subscriber's stage
GV	Group selector stage
PABX	Private automatic branch exchange
SR	Cord circuit
RS	Register finder
REG	Register
FUR-X	Line equipment for in-dialling route
FDR-C	Two-way line equipment in PABX
OP	Operator's position equipment in PABX
FS	Register finder
REG-D	In-dialling register
FIR-DC	One-way in-dialling line equipment

### Fixed-length or Optional-length Numbering

On the introduction of in-dialling a choice has to be made between fixed-length and optional-length numbering.

With fixed-length numbering the in-dialling numbers of the PABX extensions form part of the normal numbering scheme of the public network. They contain the same number of digits as a normal subscriber's number.

The advantages of fixed-length numbering are:

- Convenient for subscribers.
- Minimum risk of wrong dialling.
- Number of digits to be transmitted forward in a network can easily be accommodated to CCITT's recommendations<sup>1</sup>, according to which max. 12 digits may be transmitted on international circuits. Administrations should, however, attempt to reduce this number as far as possible.
- Shortest possible setting-up time.
- The numbering principle is well adapted to register- or computer-controlled telephone systems, which are the chief systems being installed today.

When in-dialling is introduced on a major scale and with fixed-length numbering, the numbers in present numbering schemes will be more quickly used up.

which means that new numbering schemes must be introduced or a change must be made to numbering schemes with larger number of digits. For the PABX owner, therefore, the introduction of in-dialling may mean that the number must be extended by an additional first digit or in some cases that the entire number must be changed.

In the planning of in-dialling numbering schemes attention should be paid to the fact that the last part of the in-dialling number is at the same time the internal number within the PABX owner's numbering scheme.

The in-dialling number consists normally of 5-7 digits. The required number of digits (the first digits of the in-dialling number) are used to control one or more selector stages in the public exchange, whereas the remaining 2—5 digits (depending on the size of the PABX) are used to control the PABX selector stages.

As register-controlled systems are not directly tied to a specific number of digits for operation of the various selector stages, in-dialling routes to exchanges with different lengths of number can be inserted in the same selector stages without departing from the fixed-length numbering principle. This is of interest when PABX's with different lengths of number are to be connected to the same selector stage.

With optional-length numbering, which is often used in networks with step-by-step systems, the caller dials the PABX in-dialling number followed by the internal number of the wanted extension. The length of number will thus vary according to the size of the PABX. Generally this form of numbering scheme results in different lengths of number for in-dialling subscribers and other subscribers directly connected to public exchanges. The in-dialling subscribers will then have the longer numbers.

## How Can In-dialling Numbers be made known to the Public?

As it is impossible to record all in-dialling numbers in public telephone directories, other methods must be adopted in order to get people to use these numbers. Large companies usually draw up internal telephone directories, and these can of course be distributed to people who have frequent contact with the company. Information concerning in-dialling numbers can also be given, for example, by indicating on the company's letter paper the name and in-dialling number of the person responsible for a given matter<sup>2</sup>. The staff should also be encouraged to inform people outside the company concerning their in-dialling numbers.

After introduction of the in-dialling facility the load on the switchboard operators is successively reduced, as subscribers fairly soon learn to use the much more convenient in-dialling method.

## Application of In-dialling

The most interesting application for in-dialling from the economic aspect should be large PABX's, in view of the gain both to the PABX owner and to the telephone administration.

The routes to such PABX's are inserted in the group selector multiple at the public exchange (fig. 2). The introduction of many in-dialling groups often necessitates a larger group selector multiple. In ARF 102 this problem can suitably be solved by using the three-stage group selector with a capacity up to 1,600 outlets<sup>3</sup> (fig. 3). In some cases it may be better to insert an extra group selector stage to cater for the larger number of routes (fig. 4).

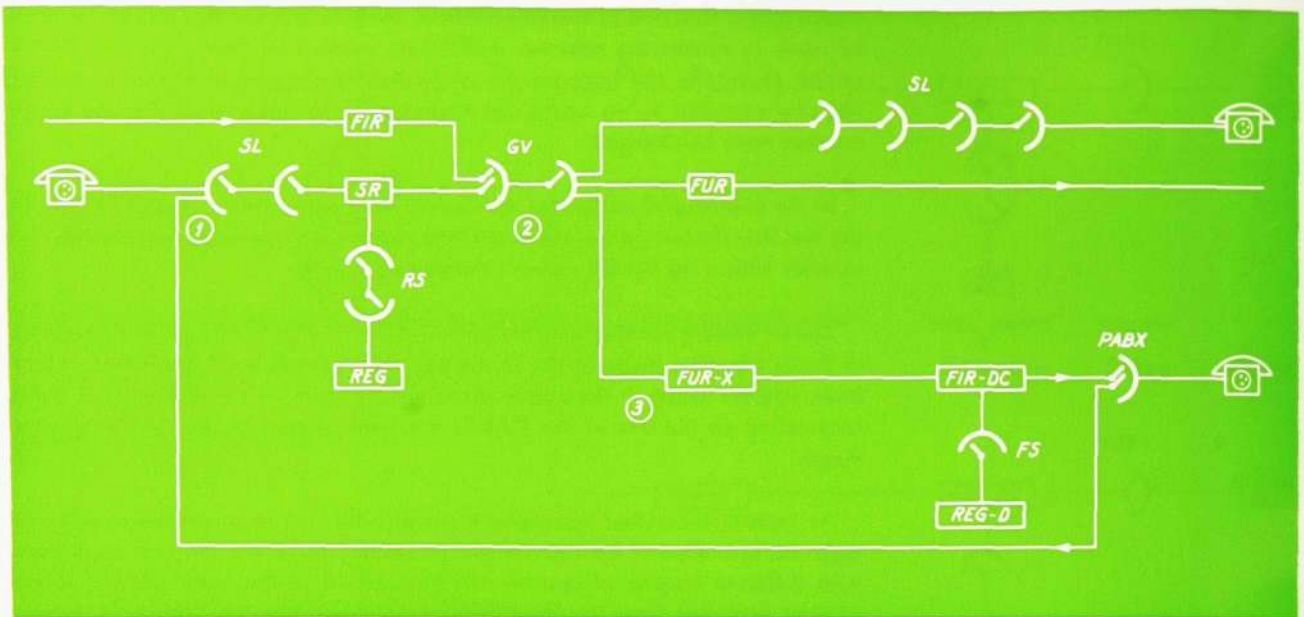


Fig. 2

Trunking diagram for ARF 102 exchange with in-dialling route to PABX

FUR, FIR line equipments for outgoing and incoming calls to and from other exchanges

- (1) Incoming traffic from PABX can also be in-dialled as per (1A) in fig. 5
- (2) The in-dialling route can also be connected as per (2A) and (2B) in figs. 3 and 4
- (3) The line equipment may be one-way or two-way with or without signal conversion, see (3A), (3B) and (3C) in figs. 6, 7 and 8

On the introduction of in-dialling the PABX's concerned will be integrated in the local network, in which case the normal signalling principles of the local network should preferably be used also on the in-dialling routes. This leads to greater speed and efficiency, and the requirement of equipment is reduced.

MFC (Multi Frequency Code) is today being increasingly introduced as register signal system in local networks and should in such case be the first choice for in-dialling routes. Other signalling systems as well exist to a greater or lesser extent in local networks, but in these cases the question of introducing in-dialling must be the subject of special study.

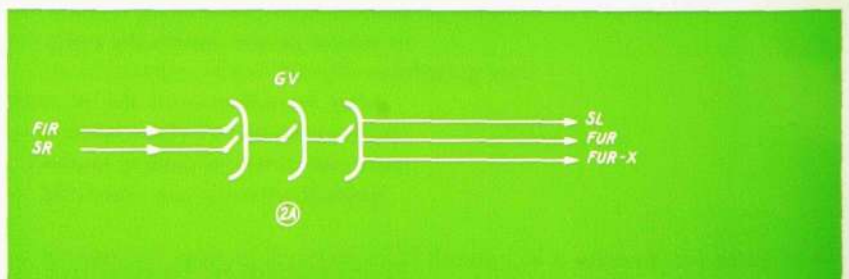


Fig. 3

To permit connection of a large number of in-dialling routes 3-stage GV are used in an ARF 102 exchange

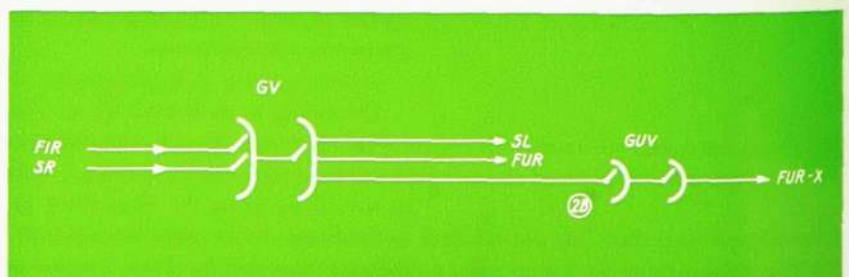


Fig. 4

A separate outgoing GV stage for in-dialling routes may be a satisfactory alternative for extension of the multiple capacity of an existing GV stage

GUV Group selector stage for outgoing traffic

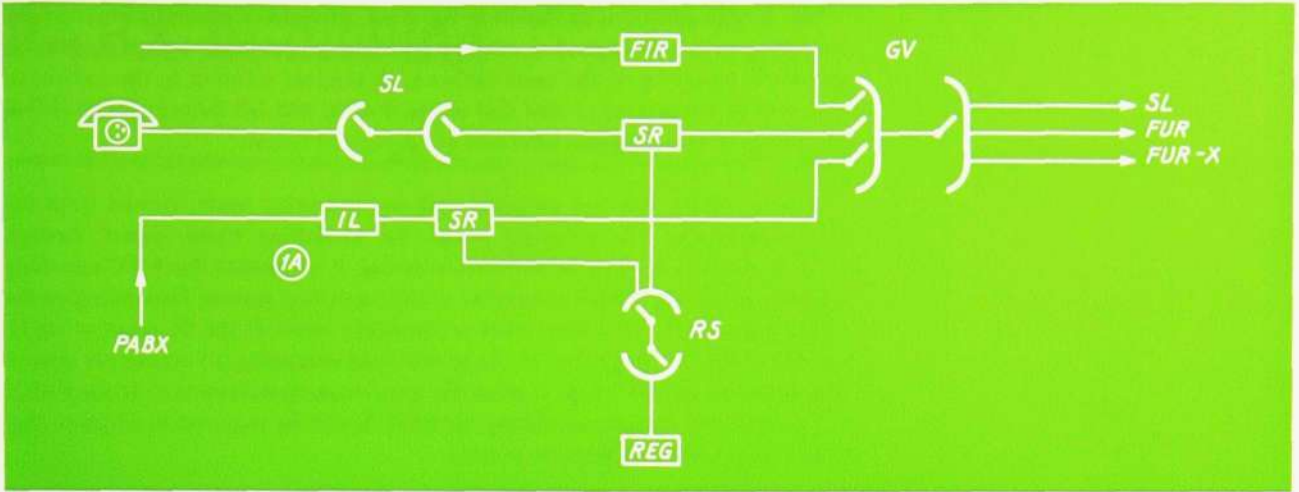


Fig. 5  
With high traffic per line, incoming traffic from PABX is connected directly to the GV stage via IL and SR

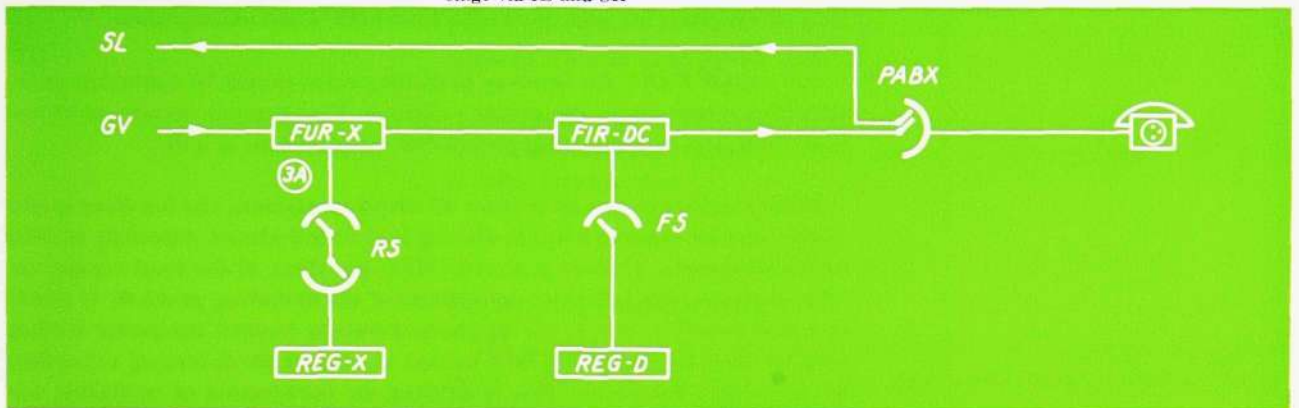


Fig. 6  
If signal conversion is required on the in-dialling route, FUR-X is connected via RS to the signal conversion equipment REG-X

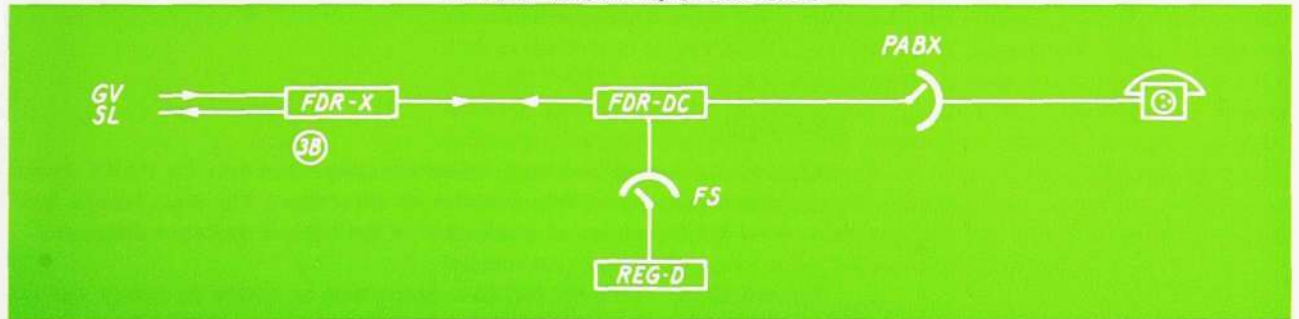


Fig. 7  
With moderate traffic between PABX and ARF 102 it may be most economical to use two-way circuits as shown in the figure

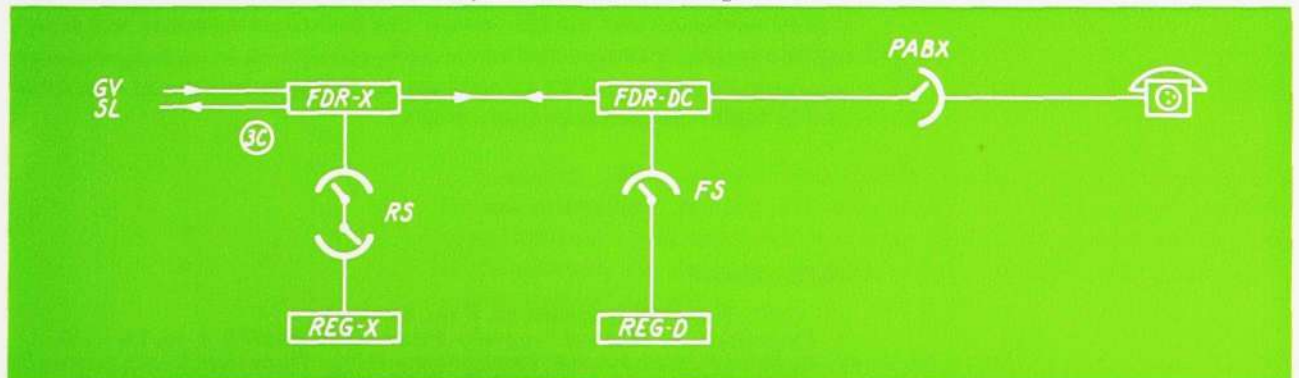


Fig. 8  
If signal conversion is required on an in-dialling route with two-way circuits, FDR-X is connected via RS to the signal conversion equipment REG-X

Fig. 2, with additions as shown in fig. 3—8, provides a general picture of the in-dialling principle applied to crossbar exchanges with fixed-length numbering and MFC signalling in the local network. A suitable solution in the individual case will be dependent on the size of the PABX and on the signalling system employed. A few common solutions are presented below.

*A large PABX* has one outgoing and one incoming route, viewed from the public exchange. The outgoing route, the in-dialling route, passes through FUR-X. As there is no signal conversion device, it is assumed that MFC signalling is used and that the PABX is adapted to this signalling system. Depending on the traffic intensity the incoming route is connected either to the SL stage or via IL and SR to the GV stage (fig. 5). At an overload exceeding 0.5 erlang per circuit, connection to the GV stage is often the most economical solution. If the PABX can accept only decadic signalling, an REG-X will be required in addition (fig. 6) to convert MFC to decadic pulsing.

*For a medium-sized PABX* a two-way route, connected to the GV and SL stages, is advantageous (fig. 7). MFC signalling is assumed. Fig. 8 shows the same arrangement but with conversion from MFC to decadic signalling.

*For a small PABX* the two-way in-dialling route should be connected to the subscriber's multiple in the public exchange. This requires certain additional equipment, and in older exchanges involves modifications as well.

These solutions cannot be used for all telephone systems, and therefore special studies may be required when in-dialling is to be introduced, especially in older telephone systems. If there is already MFC signalling in the local register for other purposes, this facilitates the solution of the in-dialling problem. It should be noted, however, that in old telephone networks modern equipment is often used for their extension. It is then natural to connect the in-dialling subscribers to the modern equipment, thus facilitating the introduction of in-dialling and reducing its cost. This can be done, for example, when there is old and modern equipment in the same building.

## Summary

The introduction of in-dialling brings advantages not only for PABX owners and telephone administrations, but also for subscribers. The main benefit, however, is for PABX owners, as a large part of the work of operators disappears.

The remaining operators will have more time to devote to callers and can give an even better service, which should increase the goodwill of the company.

With in-dialling, accordingly, telephone administrations can offer the public a more convenient and quicker service. The investment necessary will bring a satisfactory return, as more paid traffic can be carried with an unchanged quantity of equipment. The charge for a PABX with in-dialling facility should reasonably also be higher than for an ordinary PABX.

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# PABX In-dialling

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*The introduction of in-dialling in PABX's means that a large proportion — perhaps 75 % or more — of the incoming calls to an organization are put through fully automatically, that is without the assistance of a PABX operator. The organization can make considerable savings, as fewer operators will be required. Time is saved for the caller, as calls are set up more quickly.*

*The article deals with the technical prerequisites for the introduction of in-dialling and with the questions of a technical and economical nature which must be taken into account.*

## Technical Prerequisites

The in-dialling equipment needed in a PABX will depend on the type of public exchange to which it is connected. The public exchange may be of step-by-step or register-controlled type.

In a step-by-step public exchange the in-dialling lines are usually connected to a suitable group selector stage, and the PABX replaces the final selector stage and, in the case of large PABX's, one or more group selector stages. In the case of small PABX's connection can be made to a final selector stage with PBX hunting. The last digits of the in-dialling number, which may be longer than an ordinary subscriber's number, are the same as the PABX extension number. The digits are transmitted decadicly in the form of DC pulses to the PABX without check of transmission, and the receiving devices on the PABX must therefore be set up quickly when a call appears. The first digit of the extension number may have to be stored in line repeaters of the PABX.

At register-controlled public exchanges the in-dialling lines are connected to a suitable selector stage. The in-dialling numbers usually form part of the public number series and have the same length as ordinary subscriber numbers.

The digit transmission can be effected by decimal DC signalling. Often, however, the digital information from the public exchange registers is not decimal but must be translated in the PABX equipment.

In modern public automatic systems MFC signalling from the registers has become increasingly common. The advantage is that the signalling is entirely controlled and is very quick, which reduces the number of registers. The cost of the necessary v.f. signalling receivers, however, is higher than for pulse receivers with DC signalling.

The lines to the public exchange may be one-way or two-way. The latter cost more but are used for small groups of circuits as they provide better circuit utilization. The in-dialling lines, however, should be one-way, as this allows optimal utilization of the in-dialling equipment.

For the choice of suitable PABX equipment for in-dialling the following data are required:

- type of public exchange
- type of line signalling
- resistances, voltages and time conditions for different line signals

A complete line signalling schedule is also needed, which should contain the instructions which must be transmitted from the PABX to the public exchange concerning the state of extension lines.

## Matters for Consideration when Introducing In-dialling

From the dialling aspect there is no difference between in-dialled and ordinary calls; the caller has merely to dial the required number of digits. On grounds of space, however, the in-dialling numbers cannot be included in the public telephone directory but must be notified to the public by other means.<sup>1</sup>

Calls to an ordinary subscriber fail if they are not answered or if the subscriber is engaged, and must be repeated later. The same applies to in-dialling; but here the risk of failures is greater. The wanted person may be out of his room or engaged in a long telephone conversation and the result may be a large number of unsuccessful calls which load the public network with unpaid traffic.

The situation differs if a call is placed through a PABX operator. The operator can inform an engaged extension that a call is waiting and can park the call on the engaged line. As long as conversation has not started, the operator is reconnected to the line at regular intervals. If desired, she can also transfer the call to another extension. An unanswered call to an unengaged extension is supervised in the same way, but in this case, after a given time, it is automatically transferred to another person — for example a secretary — who takes it over and relieves the load on the operator. But on grounds of cost only a limited number of extensions are equipped with this facility.

With in-dialling, accordingly, the calls will fail which meet engaged condition or which are not answered, possibly after transfer. The disadvantage of repeated unsuccessful in-dialled calls can, however, be eliminated by redirecting them to a PABX operator. The calls can then be dealt with in the same way as if an operator were called direct.

The following solutions are conceivable:

- calls which are not answered within a given time are diverted to an operator
- calls which meet engaged condition or calls to vacant or restricted service extension numbers are diverted direct to an operator and ringing tone is sent to the calling party.

The PABX equipments are so designed that the operator is informed of the desired extension number and the reason for failure — no answer, engaged, vacant number or restricted number. The operator can then notify the caller of the reason for the failure.

The extent to which this service — which need not apply to all extensions — should be used depends upon the attitude of the telephone administration and of the PABX owner and must be established from case to case. The caller's desires should also be considered.

The service has both advantages and disadvantages:

- for the telephone administration the number of unsuccessful calls is reduced, and therefore also the unpaid load on the public network
- for the PABX owner the need for operators increases, but in return a better telephone service is provided for customers, which may be of significance
- the caller avoids the irritation of repeated calls, which should make in-dialling more popular. But he is charged for the call in the same way as for a direct call to the PABX operator, which some people consider a disadvantage — especially private callers. For business and service calls the situation should differ, as the cost of the call is slight compared with the advantage of obtaining quick connection. The experience from PABX's where diversion to an operator has been introduced shows that this service is appreciated.

### Economic Aspects

In PABX's with in-dialling facility it is common that all incoming lines are in-dialling lines, among other reasons because it is difficult in advance to decide how great the in-dialled traffic will be. In-dialled traffic may also vary with the time of day, the season of the year etc. Calls placed through an operator also enter on the in-dialling route but are diverted to an operator after number analysis in the in-dialling register.

The setting-up time for an incoming call placed through an operator is around 17—22 sec. The corresponding time for an in-dialled call varies between 3.5 and 9 sec depend on the signalling method. See figs. 1 and 2.

Assuming that the mean conversation time is 150 sec, the total mean occupation time for the circuit is reduced by 4.5—11 % for in-dialling lines compared with exchange lines served by an operator.

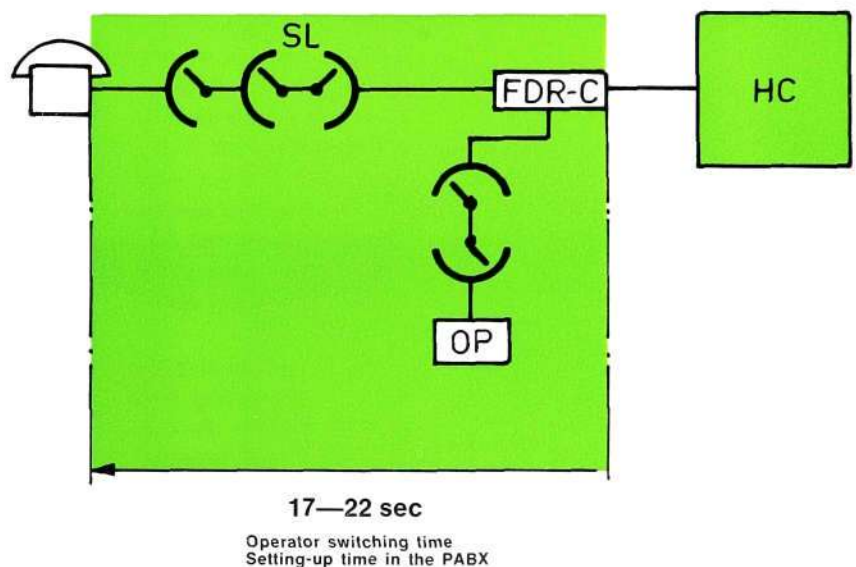


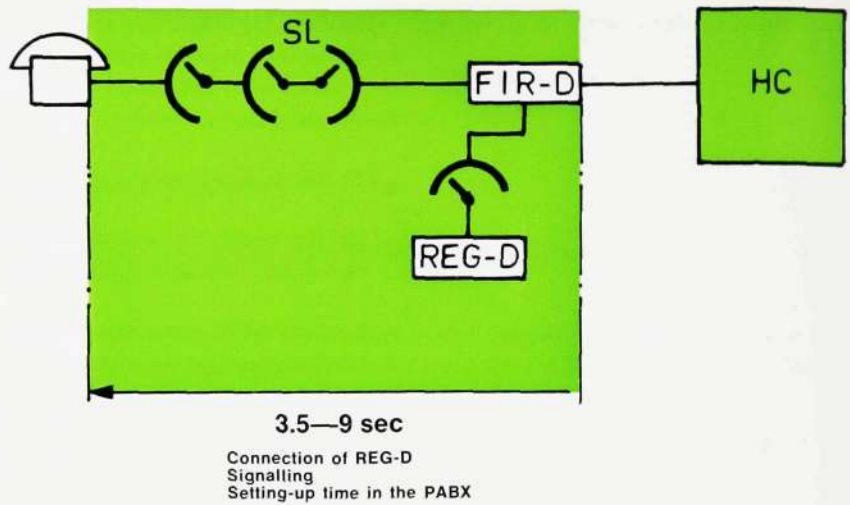
Fig. 1  
Setting-up time in a PABX with manually served incoming traffic

HC Main exchange  
SL Extension stage  
FDR-C Exchange line  
OP Operator's console

Fig. 2

Setting-up time in a PABX with automatically switched incoming traffic

FIR-D Exchange line, in-dialling  
 REG-D In-dialling register



The reduction of traffic implies that the number of incoming lines can in certain cases be reduced. A route with 50 incoming circuits for operator-switched traffic could be replaced by 47 in-dialling circuits if 80 % of the traffic is in-dialled and if the mean occupation time for the circuits with in-dialling falls by 11 %.

The chief gain, however, and the actual object of the in-dialling service, is to reduce the number of operators. Fig. 3 shows the number of operators as function of the number of extensions both for in-dialling and for fully operator-switched incoming traffic. No attention has been paid to operator-switched outgoing traffic or to unsuccessful in-dialled calls diverted to an operator. But it may be presumed that the traffic diverted from the in-dialling equipment to operators is of a more time-demanding nature.

The following assumptions have been made in the calculations:

Total traffic	0.1 erl./ext.
Incoming external traffic ( $A_{FIR}$ )	0.02 erl./ext.
In-dialled traffic	40 % and 80 % of incoming traffic
Operator traffic ( $A_{op}$ )	1/8 of incoming external traffic ( $A_{FIR}$ )
Max. traffic per operator	0.7 erlang

1 % of incoming calls are allowed to wait 30 sec for connection to an operator.

The reduction in number of operators' positions is very slight for small PABX's, but for PABX's with more than 2,500 extension lines the relative reduction is almost constant. The number of operators in large PABX's falls by one-third when 40 % of the incoming external traffic passes via the in-dialling equipment. This is a considerable reduction and leads to a corresponding reduction of equipment and cost. Furthermore a smaller floor area is required for the operators' room. The space requirement in the automatic switchroom is reduced only slightly, since the in-dialling equipment requires space for markers and in-dialling registers which are not required in PABX's without in-dialling facility.

The equipment cost for a PABX with in-dialling facility may be higher than for a corresponding PABX with entirely operator-switched incoming traffic. In large PABX's the costs are roughly equal or even lower for in-dialling exchanges. This is because the cost of operators' equipment falls by an amount roughly equal to the price of the in-dialling equipment. Fig. 4 shows the relative cost for PABX's of types AKD 791/3 and AKD 792 furnished with in-dialling facility. The cost has been indicated in per cent of the cost for a corresponding

PABX of the same size without in-dialling. The cost comparison is based on the following assumptions:

Total traffic	0.1 erl./ext.
Total internal traffic	0.06 erl./ext.
Incoming external traffic	0.02 erl./ext.
Outgoing external traffic	0.02 erl./ext.

5 % of the in-dialled calls are assumed to be diverted to an operator.

Of considerably greater interest than a comparison of the equipment cost is a comparison of the personnel costs for PABX's with and without in-dialling facility. The reduction of personnel is often greater than the reduction in number of operators' positions, since the PABX is usually in service for a longer time than an operator's working day. A general comparison is very difficult to arrive at, as salaries vary greatly between different countries.

In the economic assessment it is also necessary to take into consideration the charges made by the telephone administration for connection of in-dialling lines to the public network. The practice adopted by different administrations in this respect is, however, not dealt with in this article.

## PABX's with In-dialling

The type of business conducted, as also the organization of the enterprise, are decisive factors as regards the reduction of cost attainable through the introduction of in-dialling.

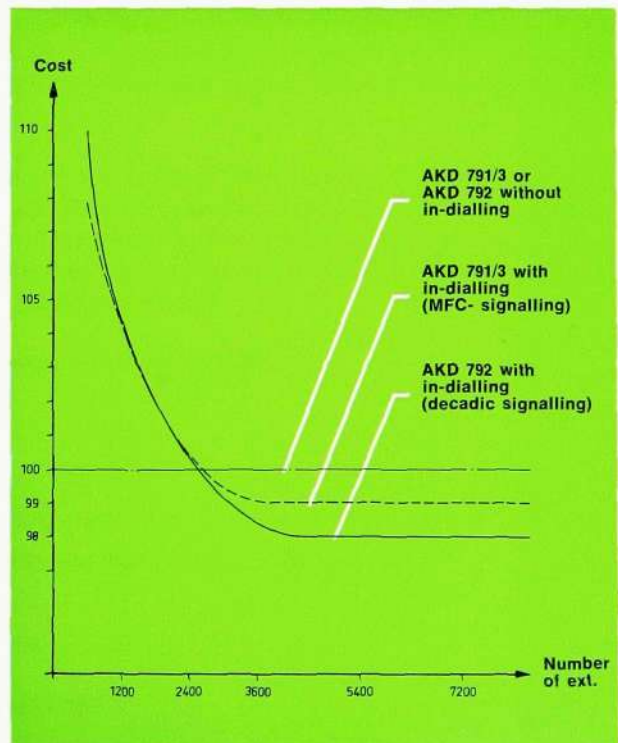
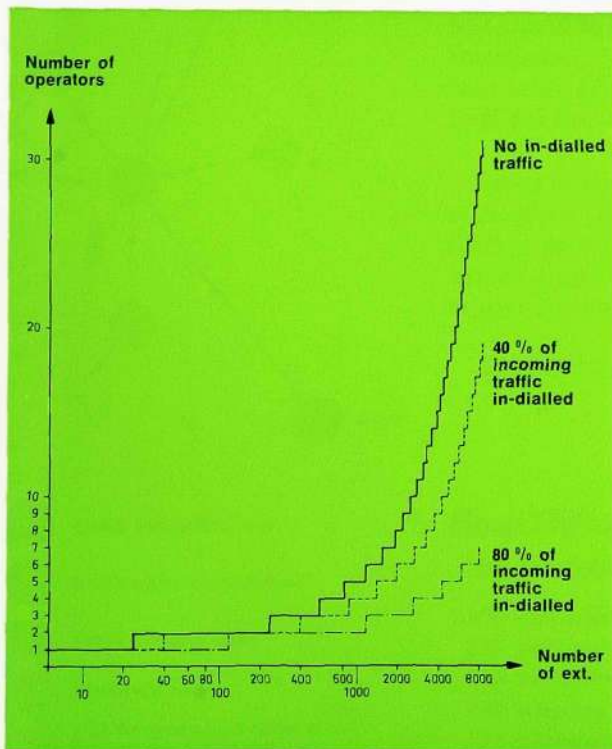
In organizations with units spread over a wide area, but with high telephone traffic between units, in-dialling should bring economical and practical advantages. Extensions of the PABX's probably know the extension numbers of those with whom they normally have contact within the organization. If not,

Fig. 3 (left)

Number of operators for different sizes of PABX with and without in-dialling

Fig. 4 (right)

Equipment costs for PABX's equipped for in-dialling in relation to corresponding PABX's without in-dialling



they can easily look up extension numbers in, for example, a common telephone directory for the entire organization.

Fig. 3 shows that the reduction in number of operators becomes noticeable only for PABX's with more than 2,000 extensions. It should be observed that the diagram does not relate to any particular PABX system but is of general relevance under the stated conditions. It will be seen from the diagram that PABX's with less than 25 extensions need only one operator. For such organizations, therefore, there can hardly be any economic motive for the introduction of in-dialling.

Fig. 4 shows the relative increase of cost due to in-dialling equipment. The increase is greatest for small PABX's but diminishes with increasing size of the PABX. The diagram is constructed for AKD 791/3 and AKD 792 and in principle applies only to these systems. By comparing figures 3 and 4, however, one can draw the conclusion that in-dialling is a traffic facility which is best suited for organizations with a few hundred up to several thousand extensions.

L M Ericsson's experience from organizations where in-dialling has been introduced shows clearly that in-dialling is a very highly appreciated and widely used traffic facility. In-dialled traffic not seldom amounts to as much as 75 % of the total incoming traffic.

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# Rationalization of Telephone Operation at LM Ericsson

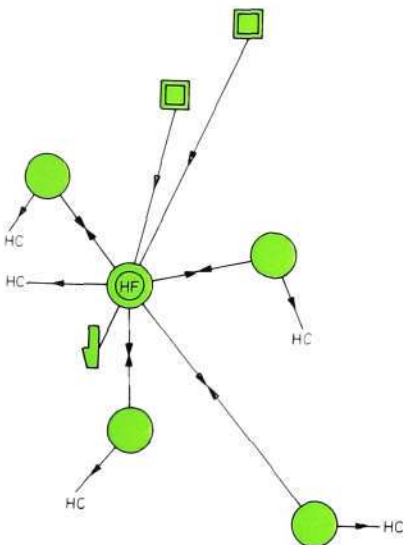
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*In April 1972 a new PABX with in-dialling facility was placed in service at LM Ericsson's head office at Telefonplan, Stockholm. In-dialling has resulted in considerable financial savings for the company, due to a large extent to the fact that 75—80 % of incoming telephone calls now go directly to extensions.*

*This article presents an account of the new PABX and of the in-dialling principle. In conjunction with the installation of the PABX pushbutton dialling and external abbreviated dialling were introduced, which are also touched upon in the article.*

Fig. 1  
LM Ericsson's PABX's in Stockholm linked into a group



-  PABX with transit stage
-  PABX without transit stage
-  Public exchange (HC)
-  Operator's console
- HF LM Ericsson's head office at Telefonplan, Stockholm

LM Ericsson's business is spread over several units within the Stockholm area, each with its own PABX and operators. Considerable telephone traffic takes place between these units. It would therefore be a natural development to link them together into a group (fig. 1), which is successively to be done. The first unit to be incorporated in the group is the head office (HF) PABX. It was commissioned in April 1972. It replaces the two earlier PABX's, one for the head office at Telefonplan and the other for the Tellus building about 500 m from Telefonplan.

Owing to its situation and size the head office PABX will be the central point in the group. Through this PABX will pass all traffic from the public exchange (HC) to the extensions of the group. Traffic between extensions in the various subexchanges will be transited via the head office PABX. This PABX will also be the only one which will have operators.

All PABX's in the group are of type AKD 792.

## Head Office PABX

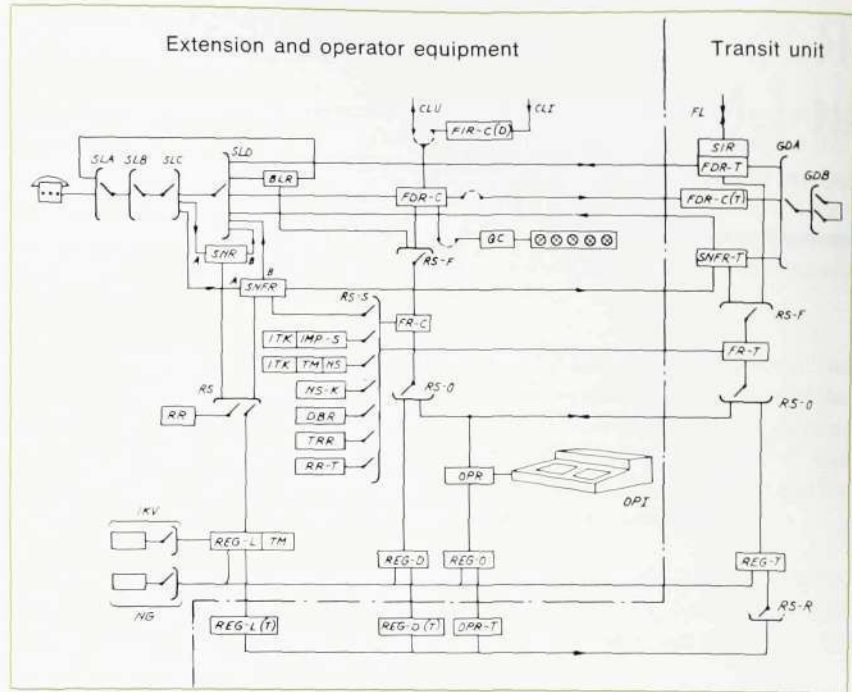
The head office PABX, type AKD 792, has equipment for

- 5,400 extensions
- 270 connecting circuits
- 130 in-dialling lines
- 140 outgoing exchange lines
- 12 operators

Fig. 2

Trunking diagram for AKD 792 with four selector stages and a transit stage

BLR	Record operator's line
CLU	Incoming line from main exchange
CLU	Outgoing line to main exchange
DBR	Metering equipment
FDR-C	Exchange line
FDR-C(T)	Transit matching to exchange line
FDR-T	Tie line. Transit traffic
FIR-C(D)	In-dialling exchange line
FL	Two-way junction line
FR-C	Exchange line auxiliary
FR-T	Tie line auxiliary
GDA, B	Transit stage
IKV	Internal abbreviated dialling
IMP-S	Number sender for rotary dial
ITK	Trunk discriminator
NG	Number group
NS	Number sender for pushbutton dialling
NS-K	Number sender for external abbreviated dialling
OPI	Operator's console
OPR	Operator's equipment
OPR-T	Transit matching to operator's equipment
QC	Queue indicator
REG-D	In-dialling register
REG-D(T)	Transit matching to in-dialling register
REG-L	Extension register
REG-L(T)	Transit matching to extension register
REG-O	Operator's register
REG-T	Transit register
RR	Call-back unit
RR-T	Call-back unit. Transit
RS	Register finder
RS-F	Exchange line auxiliary selector
RS-O	Operator's selector
RS-R	Register finder. Transit
RS-S	Special services selector
SIR	Line signalling equipment
SLA, B	Extension stages
C, D	Connecting circuit
SNR	Enquiry connecting circuit
SNFR	Transit matching to enquiry connecting circuit
SNFR-T	Transit matching to enquiry connecting circuit
TM	Tone receiver
TRR	Speech recording equipment



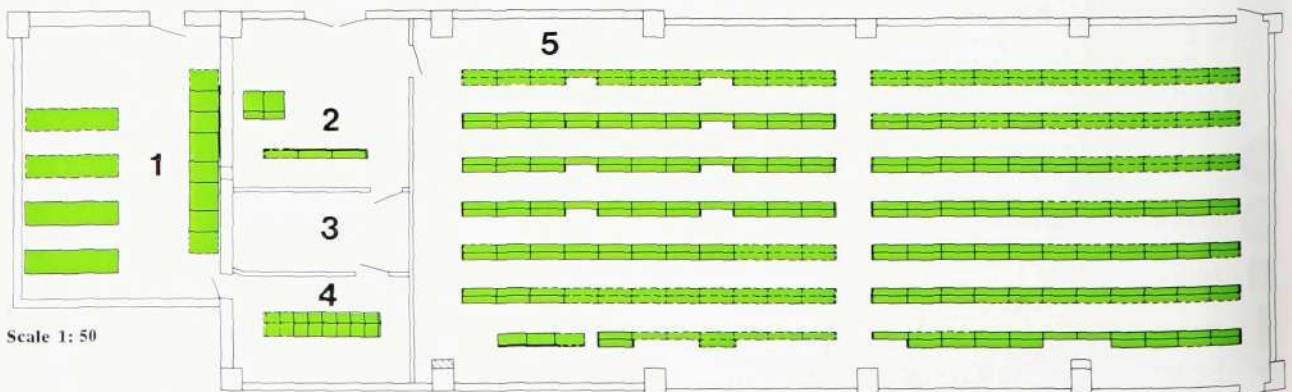
AKD 792 is a code switch PABX, its system structure being very similar to that of AKD 791<sup>1</sup> (see trunking diagram, fig. 2). Capacities and facilities are the same in the two systems. The chief new features are matching arrangements for connection of transit stages. This integration of the transit stages in the basic PABX allows:

- in-dialling to the entire group via the central PABX
- centralized operator switching of calls from the public network
- linked numbering scheme within the group
- PABX facilities within the group

Fig. 3

Layout for PABX AKD 792 at head office, Telefonplan. The accommodation permits expansion of the PABX capacity to 7,200 extensions. Equipment expansion capacity marked by dotted lines.

1. Power equipment and battery room
2. Service observation room
3. Servicing room
4. M. D. F. room
5. Switchroom



## Mechanics and Racking

Owing to its compact construction AKD 792 takes up extremely little space, as is evident from the layout (fig. 3). The racks are of standard type, BDH 223 and BDH 233, which have multijack connectors at the top of the racks (fig. 4).

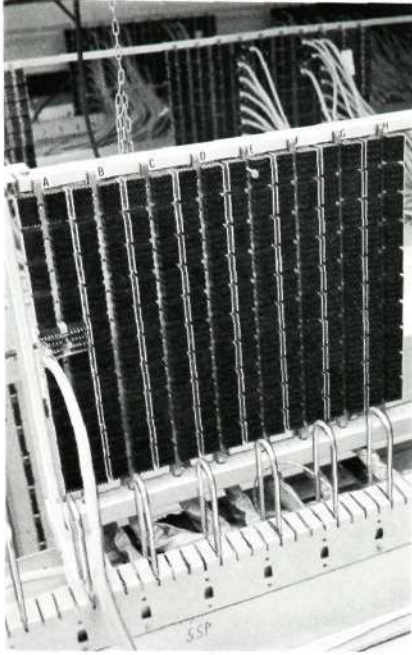


Fig. 4  
Cable termination in multijack connector

## Plug and Jack Principle

For rationalisation of installation work all cables to and from a rack are terminated by plug and jack in the multijack connectors. The method implies that the cables can be rationally manufactured and tested in advance.

The plug and jack method makes the PABX easily extendable. New units can be connected without alteration of the existing rack arrangement. Rewiring can be effected by transfer of cables from one multijack connector to another.

The racks have alternative termination facilities for the cables. Earlier it was necessary to carry out rewiring on special I. D. F.'s.

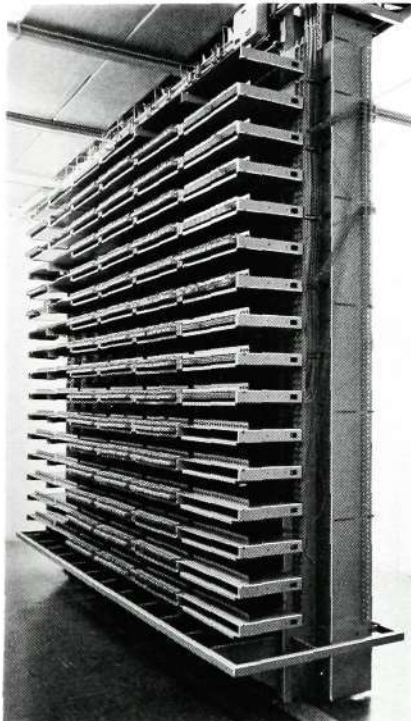
All strapping for a rack is done with special plugs in the multijack connectors and the strapping can be easily altered in the case of extension of the equipment.

All relay sets are connected by plug and jack.

## M.D.F.

The new type of frame BAB 320<sup>2</sup> has been used for the M. D. F. (fig. 5). This type is popularly called a *mini-M. D. F.* owing to its small space requirement. As regards the head office PABX the older type of M. D. F. would have taken up three times as much floor space.

Fig. 5  
M. D. F.



## In-dialling

Incoming calls to the head office PABX come principally from a limited number of enterprises and administrations, and of course from other LME units. With this composition of the telephone traffic in-dialling is a good solution.

The in-dialling characteristic will be seen from fig. 6. Against all expectations no build-up time for in-dialling traffic has been noticeable. The number of in-dialled calls has varied between 75 and 80 % from the time when the PABX was commissioned. This high percentage is presumably due to the effective information drive prior to its commissioning.

## In-dialling and Economy

The introduction of in-dialling has brought both economical and practical advantages, of which only the economical advantages will be considered here.

The need for operators has been greatly reduced since the introduction of in-dialling. Within the Stockholm area there were in January 1972 altogether 41 operators, of whom 20 serving the head office and Tellus exchanges. Today the corresponding numbers are 28 and 10. In the meantime a concentration of the work has taken place to the head office PABX and certain PABX's at local units have been eliminated. The extensions of these units are now connected to the head office PABX. A total of 13 operators has been saved. With an annual cost per operator of 40,000 kronor (incl. social expenses) this represents an annual saving of 520,000 kronor.

The need for operators' accommodation is, of course, reduced in proportion to the number of operators. The room shown in fig. 7 has 12 operators' positions and serves the entire LME Group.

In-dialling in the head office PABX has also led to a saving on equipment and installation corresponding to 2-3 % of the initial capital expenditure.

Installation charges payable to the Telecommunications Administration for the in-dialling number series and for the in-dialling lines have amounted to

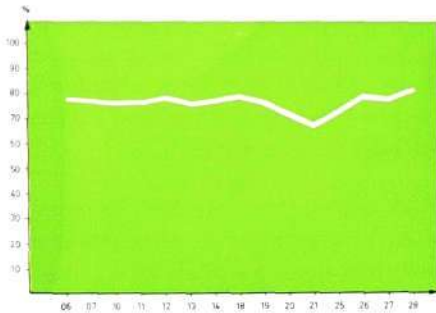


Fig. 6

**In-dialling characteristic from the date of commissioning and one month thereafter**

about 740,000 kronor and the rental for in-dialling is around 150,000 kronor per annum. The extra costs for in-dialling are thus written off in less than two years. Thereafter there is a saving of nearly 400,000 kronor per annum.

### *In-dialling Principle*

An entire series of 10,000 numbers from the Telecommunications Administration series is used for the LME Group. The in-dialling number of an extension is formed by placing 719 before the four last digits of the extension's number. The head office PABX has five-digit extension numbers, digit 9 being loaned from 719 xx xx as first digit. In this way it has been possible to use all 10,000 numbers in the 719 series. Other extension numbers in the group are four-digit.

The main PABX is connected to the 719 outlets at the trunk exchange and at the Högalid tandem exchange. Lines to the trunk exchange thus represent trunk lines, and lines to the Högalid exchange local lines. This has been used in the PABX by associating the category of an incoming call with the line in question.

Both the trunk exchange and the Högalid tandem exchange are of AGF type. Loop signalling is used for setting up, supervision and clearing of the line. Transmission of the last four digits of the in-dialling number is done in 500 selector code to the in-dialling register of the head office PABX. In this register the number is translated into decimal form, after which the call is set up to an extension or operator depending on the number dialled.

An operator can be called either on the group number 719 00 00 or on an individual number associated with the respective operator's position. The latter procedure is used for booking of calls. The operator at the head office PABX

Fig. 7

**Operators' room during the busy hour. Note the small number of operators**



who books a call with the trunk operator requests the latter to set up the call to her number (operator's position).

- A call to an extension is diverted to an operator in the following cases:
- the extension is free but does not answer within 30 sec
  - the extension is engaged
  - the extension has a restricted line
  - the extension is vacant.

In the case of a diverted in-dialled call the operator sees the extension number against a background colour (red) on her number display. She can then answer the subscriber according to the circumstances.

By strapping in the PABX a tone announcement can be given to the subscriber instead of the call being diverted to an operator.

## Pushbutton Dialling

Several principles for pushbutton dialling have been developed. The so-called *diode earth system* has come into wide use. This requires three-wire connection to every extension.

L M Ericsson started at an early stage to work with a two-wire system. A pushbutton dialling system with one frequency per digit (damped oscillation) has been developed and is also in use.

The successful experience from the use of M. F. C. (*Multi Frequency Code*) for register signalling led to a pushbutton dialling system based on eight of the M. F. C. frequencies. Each digit was represented by two simultaneous frequencies selected from two groups of four frequencies each. Frequencies and levels have since been adapted to CCITT's standard.

In conjunction with pushbutton dialling a new telephone set has also been introduced (fig. 8). A questionnaire circulated among head office employees showed that 97 % prefer the new telephone to the previous dial telephone.



**Fig. 8**  
**Telephone set for pushbutton dialling**

**Digit buttons 0—9**  
**Star button**  
**Square button**  
**Service button**

Advantages of pushbutton dialling:

- quicker connection
- easier to "memorize" numbers — one has them in one's fingertips
- possibility of "end-to-end" signalling
- fewer registers in the PABX

## External Abbreviated Dialling and Trunk Discrimination

External abbreviated dialling implies that a head office PABX extension can obtain access to a subscriber by dialling a four-digit local number<sup>1</sup>. This facility is available to all extensions who are unrestricted in respect of some form of outgoing external calls.

External abbreviated numbers are allotted to subscribers who are very frequently called from extensions of the head office PABX. Three hundred numbers have been reserved for abbreviated dialling. Of this number some one hundred (01 xx) are used today for subscribers within Sweden, one hundred (03 xx) for subscribers outside Sweden. The head office PABX has hitherto been equipped for 150 external abbreviated numbers.

As the PABX is equipped for external abbreviated dialling there is little need for other unrestricted traffic routes. Most extensions therefore have unrestricted service solely within the Greater Stockholm area. A few extensions, however, are entirely unrestricted in respect of outgoing calls.

A restrictive form of trunk discrimination in conjunction with abbreviated dialling gives the extensions a good telephone service at lower cost.

*In other respects the PABX can offer the following services:*

- enquiry and transfer
- automatic call-back
- speech recording
- call metering
- centralized call transfer

## References

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# ERICSSON News

from All Quarters of the World

## More than 290 million telephones in the world

According to the latest statistics the total number of telephones in the world is now 291.3 million. This is an increase of nearly 18.6 million (6.8 %) during 1971. Telephone density during the same period increased from 7.4 to 7.8 telephones per 100 inhabitants.

As regards telephone density, in January 1972 the leading position was held by the USA with 60.1 telephones per 100 inhabitants, followed by Sweden (57.6), Switzerland (50.9), Canada (47.4), New Zealand (44.0) and Denmark (35.8).

■ The United States (excluding Hawaii) with 125,142,000 telephones in service on Jan. 1, 1972, had 43 % of the world total, compared with 120,218,000 and 44.1 % for the previous year. Sweden had 4,679,691 telephones, i.e. 1.6 % of the world total, on Jan. 1, 1972. Corresponding figures for Jan. 1, 1971, were 4,505,802 and 1.7 %.

■ Telephone densities (number of telephones per 100 population) by continental areas on Jan. 1, 1972 (Jan. 1, 1971 figures within brackets) were as follows: North America 58.4 (57.1), Central America 3.1 (3.0), South America 3.3 (3.2), Europe 14.8 (13.7), Africa 1.0 (0.9), Asia, incl. Asiatic parts of Turkey and USSR, 1.8 (1.6) and Oceania 29.2 (29.0).

■ Cities with the highest telephone density in the United States were Washington D.C. (123.0), Southfield, Mich. (118.6), Skokie, Ill. (100.0) and Cambridge, Mass. (99.5). Outside the United States Stockholm, Sweden was still in the lead (95.8) followed by Zurich, Switzerland (84.2), and Solna, Sweden (76.5).

## Large order from Kuwait

The Ministry of Communications of Kuwait has placed an order worth over \$3.5 m. for telephone switching equipment with L M Ericsson.

Countries with 1,000,000 or more telephones and 15 per 100 population



(The World's Telephones, American Telephone & Telegraph Co., N.Y.)

The order covers equipment intended for extension of existing exchanges in the country. Since 1966 Kuwait has ordered telecommunications equipment for a total of 117,000 subscriber lines from Ericsson.

## Mexico orders electronically controlled exchanges

The Mexican telecommunications administration Teléfonos de Mexico has placed orders worth about \$3 m. for a new electronically controlled rural exchange system with L M Ericsson.

On an average one exchange of the new type will be installed and put into service every week during 1973 and 1974.

The new automatic exchange has been specifically developed to meet the requirements of automatic telephone service in rural areas in many countries, especially Latin America. The basic development of the system took place in cooperation with A/S Elektrisk Bureau of Norway, a member of the Ericsson Group.

The telephone network of Mexico is currently expanding very rapidly. The average annual growth rate, which has been about 14 per cent during the past few years, is one of the highest in the world and the highest in Latin America.

## New intercom, Ericom, now in full production

The production of the new intercom telephone, Ericom, developed by L M Ericsson Telematerial AB, has now started in earnest. The factory at Oskarshamn produces nearly 1,000 instruments per week.

Ericom systems are already installed in many Swedish enterprises, and foreign sales — particularly in the USA, Switzerland and Norway — are in full swing.

Typical of the Ericom is its duplicate function: loudspeaking when placed on the desk and non-loudspeaking when raised.



The Ericom intercom

## Order for \$ 17 m. from Saudi Arabia

The Ministry of Communications in Saudi Arabia has placed an order worth over \$17 m. with L M Ericsson. The order covers telephone switching equipment, telephone instruments and line material.

The equipment ordered, which will be manufactured in Sweden, will be delivered in the course of the next two years and is intended both for new installations and for extensions of existing installations in 12 cities in Saudi Arabia.

Since 1964 Saudi Arabia has ordered telecommunications equipment valued at over \$40 m. from Ericsson.

## Computer control of Copenhagen local trains

The first stage in the modernization and expansion of the signalling plants on the Copenhagen S Line, which to a large extent carries local traffic, was reached at the end of last year when a new section, the Køgebugt Line, was opened. During the summer of 1973 some ten additional stations will be in service. On attaining its full capacity the S Line will consist of some 80 remote-controlled stations.

The modernization of the S Line implies, among other factors, centralized control of the train traffic and automatization of train despatching, which will free the staff from all routine tasks in conjunction with train movements.

The remote control system consists of two computers (UAC1605) — one for the northern and one for the southern part of the line — and transmission equipment. The computers can function as standby for one another in the event of a fault. A third computer automatizes the train despatching.

The remote-control system and automatic equipment are being supplied by the Signal Department of MI Division, while Dansk Signalindustri A/S, a member of the Ericsson Group, is responsible for the interlocking and line block systems. The order, amounting to about \$9 m., has been placed by the Danish State Railways.

## Sigvard Eklund leaves Ericsson Review after 30 years' editorship



After a unique achievement as editor of Ericsson Review during a period of 30 years Sigvard Eklund has now left the journal and Telefonaktiebolaget L M Ericsson on reaching pensionable age. Sigvard Eklund became editor of Ericsson Review as from No. 1, 1943, and has thus been in charge of its editorial content during exactly three decades.

Ericsson Review wishes to pay tribute to Sigvard Eklund for his long and faithful efforts, which have been an essential factor in creating the respected status which the journal has acquired as imparter of news and ideas within telecommunications.

## Railway signalling equipment ordered by Egypt

After an invitation for tenders with severe international competition L M Ericsson have received an order from Egypt for railway signalling equipment. The order amounts to around \$7 m. The ordered equipment, which will be chiefly manufactured in Sweden, will be delivered over a period of about four years. The project is being financed for the greater part through loans from the World Bank.

Egypt is an entirely new market for L M Ericsson in the field of modern railway signalling equipment of the kind covered by the present order.

The order covers interlocking plants, electronic remote-control systems, train describer system and similar equipment, and will be used for modernization of two suburban lines in the Cairo area.

## Ericofon — one of the best examples of industrial design of the century

The Ericofon — the world's first one-piece telephone — has been selected by the *Museum of Modern Art* in New York to be represented in a collection of some 300 objects considered to be the most interesting examples of industrial design produced internationally in this century. The exhibition will first make a tour of Latin America and finally form part of a collection in a new design centre in Buenos Aires.

The Ericofon, which received this flattering recognition, is an exclusively Swedish product and was introduced by L M Ericsson in 1956. Its advanced design has won it earlier recognition, but its addition to the Museum of Modern Art collection is the first acknowledgment of this unique telephone set as one of the foremost examples of good industrial design of this century.

Since 1956 over two million Ericofons have been manufactured.

The photographs on the next page show the conception of the Ericofon in 1941 and its final form.

## Advanced entry control system for Volvo

L M Ericsson Telemateriel AB have delivered to Volvo, Gothenburg, an entry control system for protection of the new 200 million kronor building, Volvo Technical Center (VTC), and the entire eastern block. Around this block there runs a coaxial cable some kilometres in length, terminating in an alarm centre. The latter is the heart of the alarm and entry control system and consists of a digital check and alarm system known as Telecontal.

Within the area there are transducers which transmit data to some sixty subcentres. From the main alarm centre a continuous "enquiry" is transmitted through the coaxial cable to the subcentres. A printer prints an incoming alarm in the form of a digital combination. The digital combination is then keyed on a keyboard and a sketch of the area concerned, indicating the exact situation and nature of the disturbance, is displayed on a visual display.



Clay models of the Ericofon from 1941.



The Egyptian Minister of Communications, Dr Mahmoud Riad (right), meets Mr Björn Lundvall, president of LME, during an official visit to Stockholm.



The Ericofon as final product in 1956 — now denominated one of the chief examples of good industrial design of this century.

At the Annual International Cable & Wire Symposium held in December in Atlantic City, USA, Mr Sigurd Nordblad of the LME Telephone Cables Division (left in the photograph) received an award for "outstanding oral and visual presentation of an economical and simplified cabling technique for minimizing capacitance and unbalance in telephone cable".

The award relates both to the presentation and to the method of production — cross-stranding — which under Nordblad's supervision was developed within the Telephone Cables Division and has been applied in the new telephone cable factory at Piteå since the beginning of 1972.

The man on the right is Jack Spergel, Chairman of the Committee of the Cable & Wire Symposium, which each year gathers 700—800 participants from cable manufacturers and telecommunications administrations from all over the world.

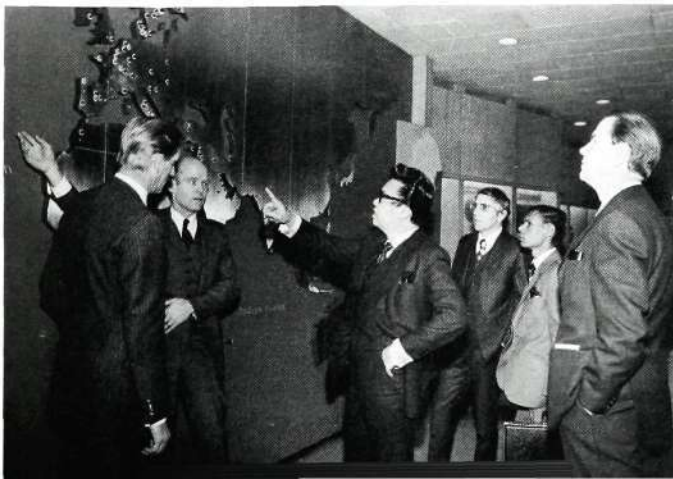


Mr M. Harva (left centre), chairman and Mr L. P. Toivonen (right centre), president of the board of the private telephone administrations, Finland, visited the Ericsson head factory in Stockholm in February. The head of Oy LM Ericsson Ab, Finland, Mr Y. Ollus (far right), is demonstrating a vibration bowl feeder with the assistance of Mr H. Lindström, LME.



In conjunction with the conclusion of an agreement between the Malaysian Ministry of Finance and Svenska Handelsbanken for financing of delivery contracts for telecommunications equipment from L M Ericsson's subsidiary in Malaysia, two representatives of the Ministry visited L M Ericsson in Stockholm. (Centre) Mr Chong Hon Nyan, Secretary General, with (on left) Mr Sven Lönnström and Mr Sven Kappelin, LME, Mr Hans-Dieter Wiese, LME, Mr Hanafiah, Malaysian Ministry of Finance, and (at far right) Mr Leon Odnevall of Svenska Handelsbanken.

The Australian Ambassador to Sweden, Mr J. B. Petherbridge, visited L M Ericsson at the end of January. He is here being welcomed by, from left, Mr Karl-Axel Lunell, Mr Olof Höstbeck, Dr Christian Jacobæus and Mr Lars Edmark, all of LME.





## Documentation on "Human Factors"

A presentation of the 51 papers presented at the "The Sixth International Symposium on Human Factors in Telecommunications", 26-30 June 1972, Stockholm, is now available and can be ordered free of charge from the Secretariat of the Symposium, Televerket, 123 86 Farsta. The documentation has already been sent to delegates and telecommunications administrations. The hosts at this symposium, which was attended by some 90 delegates, were the Swedish Telecommunications Administration and L M Ericsson.

## New export packaging for Ericsson racks

*A new type of export packaging of L M Ericsson relay and crossbar switch racks has been developed within the company. With the new packaging method, which was preceded by comprehensive trials in the laboratory and under transport conditions, the racks are effectively protected against transport damage, damp and corrosion. The smaller weight and volume of the packaging considerably reduces the costs both of packaging and freight.*

The first packing stations for the new export packaging are now in operation at L M Ericsson's factories at Olofström and Ronneby. Instead of the old heavy and cumbersome cases of solid timber, use is now made of assemblable plywood boxes. As the boxes are delivered in parts to the packing stations and require little space, the freight and storage costs are low even for empty boxes.

As a result of the new procedure for suspension and fixation of the rack in the box, new shock-absorbing materials, and plastic cover instead of the earlier cardboard, the new export packaging stands up well to the stresses involved in transoceanic transport.

As a rule the racks are packed watertight. For specially severe conditions in conjunction with export to certain countries with damp tropical climate, steamtight packaging can also be supplied at an extra cost.

## International Teletraffic Congress in Stockholm

During the period June 13-20, 1973, an international teletraffic congress is to be held in Stockholm. It is the seventh in the series of congresses which started in 1955 in Copenhagen and have since been held every third year, at the Hague, Paris, London, New York and Munich. The subject of this year's congress will be "Application of the theory of probability to telecommunication research, engineering and administration".

The hosts at the Stockholm congress will be the Swedish Telecommunications Administration and L M Ericsson, Svenska Philips AB, Svenska Siemens AB and Standard Radio & Telefon AB. The chairman of the organizational committee is Dr Christian Jacobæus, LME. It is expected that the congress will be attended by some 350 persons, among whom representatives of most European countries and also from North America, Brazil, Mexico, South Africa, Indonesia, Israel, Japan, Thailand and Australia.

Some 150 papers will be presented and discussed. The congress will be held in the new Swedish Parliament building. The secretariat will be organized by L M Ericsson and the Swedish Telecommunications Administration.

## Computer control of power networks

A/S Elektrisk Bureau, a member of the Ericsson Group, has received an order for telecommunication transmission equipment for power networks from the Swedish National Power Administration amounting to some \$1 M. The order covers carrier equipment for power lines and terminal equipment for radio links. The equipments will form part of a large computer-based information system for Swedish power production, to be placed in service by the Administration in 1975. The Administration has an option of up to 25 % increase of the order.

The tender concerns L M Ericsson in several ways. ASEA LME Automation AB, in which LME has a 40 % shareholding, will deliver equipment for some \$4 M., including some 50 mini-computers. This delivery will be made through ASEA, the main contractor for the project.

The computer system will control and supervise power production in Sweden, but the other Nordic coun-

tries will also be concerned, since some pooling of power will take place. The computers will be located at some twenty places in Sweden with a central data processing system in Stockholm.

With this computer system the present high reliability of Swedish electric power supply can be maintained even after the introduction of the large nuclear power stations.

## Push-button phones in Holland

A major break-through for push-button telephone instruments in public networks has occurred in the Netherlands where the Telecommunications Administration has placed orders for more than 50,000 telephones of this type with Ericsson Telefoonmaatschappij, a member of the Ericsson Group.

The decision to introduce push-button telephones on a large scale in a European public telephone system may be denoted a new and important development, as previously push-button telephones have been used only in connection with private automatic exchanges or for small scale trials in public networks. The orders now placed by the Dutch administration therefore represent a European break-through for push-button telephones in public networks.

The keysets for the telephones ordered will be made by L M Ericsson in Sweden, while the telephones themselves will be made in Holland. One of the main reasons behind the orders being placed with Ericsson Telefoonmaatschappij is that the designers of this company, in cooperation with L M Ericsson in Sweden, were successful in replacing the usual dial of the Dutch standard telephone instrument T65 by a push-button unit.

For subscribers, push-button telephones mean speedier and more simple dialling and open up possibilities for additional services and for the future use of telephones as data terminals.



Netherlands PTT standard telephone with LME keypad



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

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# ERICSSON

2

1973

# Review





# ERICSSON REVIEW

Vol. 50

No. 2

1973

RESPONSIBLE PUBLISHER: CHRISTIAN JACOBÆUS, DR. TECHN.

EDITOR: GUSTAF O. DOUGLAS

EDITORIAL STAFF: FOLKE BERG,

BO SEIJMER (ERICSSON NEWS)

EDITOR'S OFFICE: S-12625 STOCKHOLM

SUBSCRIPTIONS: ONE YEAR \$1.80; ONE COPY \$0.60

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On cover: Control room for the AKE  
13 exchange in Mexico City.



# Transit Exchange System AKE 132

JOHN MEURLING, LARS-OLOF NORÉN & BJÖRN SVEDBERG,  
TELEFONAKTIEBOLAGET LM ERICSSON, STOCKHOLM

UDC 62-503.55;  
621.395.722  
LME 834  
83022

*LM Ericsson's first stored-program-controlled AKE system was described in Ericsson Review No. 3, 1968<sup>1, 2</sup>. This system has to a large extent been further developed, resulting in the present transit exchange system AKE 132. Several changes have been made in the data processing equipment of the system, one being the introduction of a multiprocessor system APZ 130, which has been further developed into system APZ 150 presented in this article.*

*The article describes how AKE 132 fulfils its function as transit exchange in a complex transit network. On grounds of space the fundamental concepts of stored-program-control are not dealt with.*

## Modern Requirements

The requirements placed on automatic telephone exchange systems have become increasingly stringent during the past years. One of the strictest requirements, which is directly connected with the rapid development of telephony, is that an exchange shall be extendable during its lifetime to many times its initial size. At the same time it must be capable of incorporating a number of functional changes in order to be able to offer new services and for its linking into an increasingly integrated world telephone network. During the automatization stage of trunk traffic the transit exchanges, with their central positioning in the networks, have been particularly affected by these flexibility requirements, as the growth of traffic through them is exceptionally great and they must be able to link together telephone networks of often varying age and design.

Another requirement is that the operational and maintenance methods must be rationalized and the aids designed in such a way that the increasingly extensive and complex telephone networks can be served with reasonable resources.

The AKE 13 system was specially developed to meet these requirements when used as national, international and intercontinental transit exchange. Through the use of stored program control (SPC) the entire system has acquired the flexibility required of transit exchanges today and in the future.

## Basic Structure of the System

The AKE 13 system uses an electromechanical 4-wire switching network, employing code switches. The control is achieved through a data processing system constructed on the modular principle, the capacity of which is dimensioned according to the requirements. High reliability is ensured through synchronous duplication of the control equipment.

The system, the hardware structure of which is shown schematically in fig. 1, consists of:

*The switching equipment APT 131 consisting of switching network with associated switching devices and including their programs and corresponding data. The structure of the switching equipment is described in the following sections and some examples will be given of standard functions. The examples represent only a selection of the functions which the system may comprise. Since its intro-*

duction much design work has been done, which has made it possible to use it in the most varying contexts.

The data processing equipment APZ 150, consisting of the hardware of the control system, processors, stores, transfer control unit to switching equipment, and the necessary operating system and maintenance programs. The subsystem for test and operation, TO, and the input and output subsystems, I/O, with, for example, typewriters and tape stations, also form part of the data processing equipment.

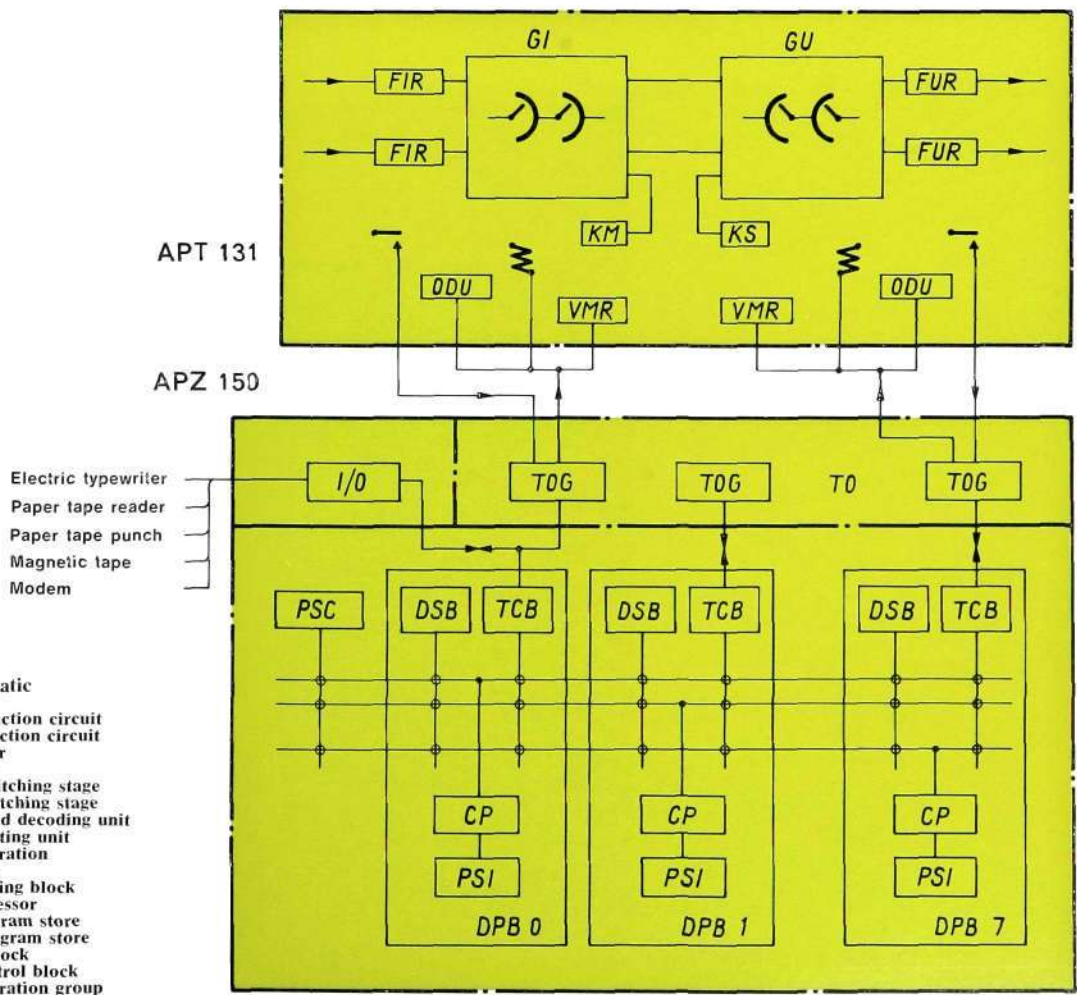
The extension facilities of the data processing equipment have been achieved through a multiprocessor arrangement with up to eight synchronously duplicated processors, each pair with its internal program store. Via a multiplexor network the processors interwork with data stores, transfer control units and a common program store.

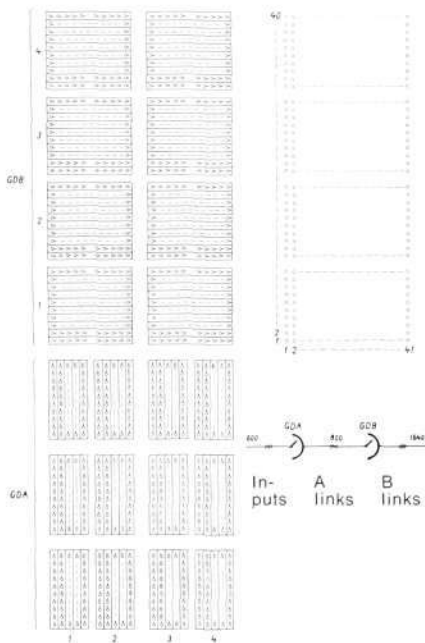
The data processing equipment APZ 150 is the result of further development of earlier control systems made possible, among other things, by the rapid development of components that has taken place and by the operational experience collected from a number of stored-program-controlled exchanges in service.

## Switching Equipment APT 131

### Hardware

The hardware consists of switching stages, junction circuits, signalling devices and operating circuits.





**Fig. 2**  
Grouping plan, 600-group, 4-wire

## Switching Stages

The main requirements placed on the switching stages in the transit system AKE 13 are that they must accommodate large numbers of inputs and outputs with high input load. This has been achieved by building up two-stage code switch groups of 600 inlets, 800 A links and 1640 B links. The grouping plan is shown in fig. 2. There is also an alternative grouping with 800 inlets.

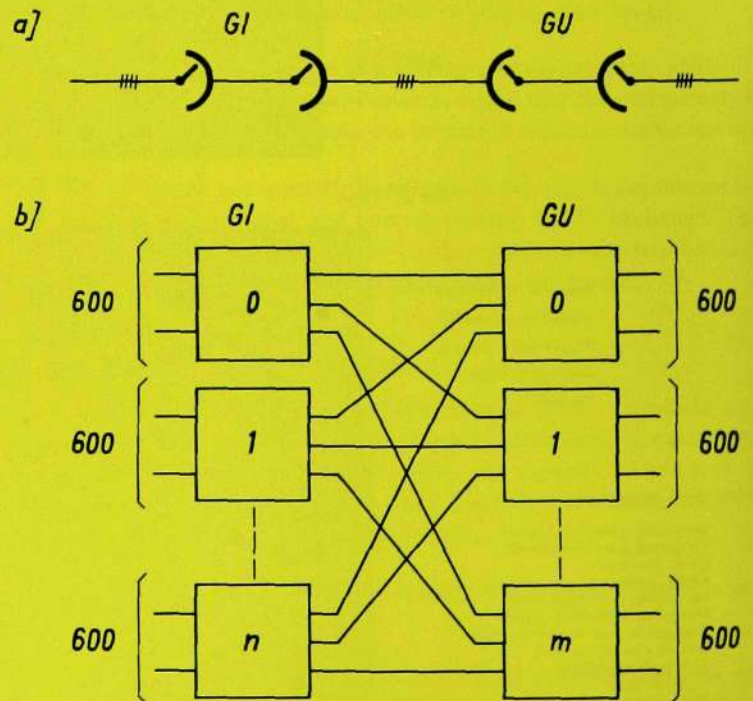
An exchange is made up of a number of incoming and outgoing switching groups interconnected via the B links as illustrated in figures 3a and 3b. The maximum capacity of the grouping arrangement is around 30,000 inlets and 30,000 outlets. The switching stages can also be made two-way.

The requirement of high input load was placed in order to permit free insertion of lines irrespective of the load on individual lines and to allow for heavy overload and to provide insensitivity to unequal traffic loading.

## Junction and Signalling Equipment

The junction and signalling devices consist of printed circuit boards for incoming, outgoing and two-way junctions, code senders and code receivers for different register signalling systems, cord circuits, operator position circuits for different operator functions, and miscellaneous equipments, e.g. tone senders.

Fig. 4 exemplifies the engineering of an AKE exchange. The two-way junctions circuits are connected both the incoming and outgoing stages. As already mentioned these junction circuits may also be connected to two-way switching stages. For register signalling of DC type, e.g. decadic pulsing and 500 selector signalling, the scanning and sending of the signals is done directly in the junction circuits, and code receivers and code senders are normally not used.



**Fig. 3**  
Interconnection of incoming and outgoing switching stages

In this context certain testing equipment, tone generators and instruments for transmission measurements etc. should be mentioned.

## Operating Circuits

Relays with strict timing requirements are directly controlled from transistor-driven reed relays. Other relays are controlled via decoding units, ODU. Through the encoding procedure a large number of relays can be controlled from a small number of inlets. ODU is chiefly built up of electronics.

In the same way the switch operation is encoded and the signals are decoded in the switch operating sets, VMR. The VMR sets consist chiefly of normal telephone relays.

## Traffic Capacity

To illustrate the traffic properties of the AKE grouping arrangement the traffic capacity is defined as the *lowest* of the following three:

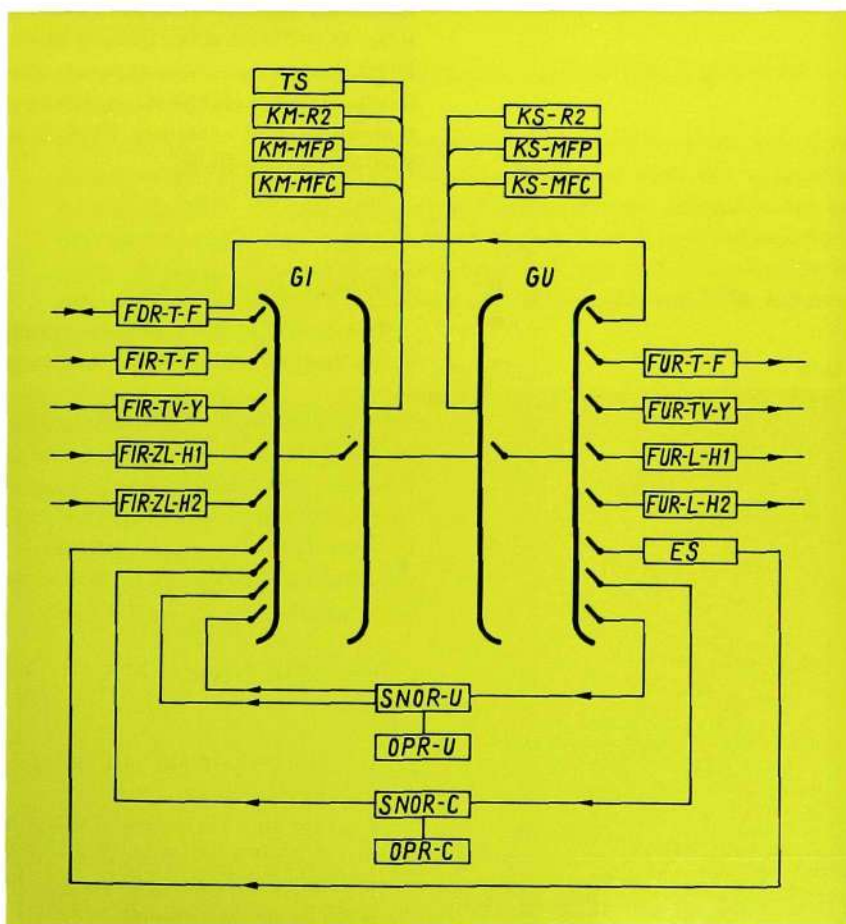
- The traffic per group selector unit which, with uniformly distributed traffic, gives an internal congestion of 0.5 ‰.
- The average load per group selector unit obtained when one unit is loaded with 20 ‰ more traffic than each of the others and which, for the overloaded unit, gives an internal congestion of 2 ‰.
- The traffic per group selector unit which, with uniformly distributed traffic increased by 20 ‰, gives an internal congestion of 5 ‰.

In all cases the internal congestion is calculated towards a route comprising 20 circuits and with route congestion of 1 ‰.

Fig. 4

AKE 132 Trunking diagram. Example of equipment for exchange with national and international traffic

FDR-T-F	Two-way international junction circuit, R2
FIR-T-F	Incoming international junction circuit, R2
FUR-T-F	Outgoing international junction circuit, R2
KM-R2	Code receiver, international signalling, R2
KS-R2	Code sender, international signalling, R2
ES	Echo suppressor
FIR-TV-Y	Incoming national junction circuit
FUR-TV-Y	Outgoing national junction circuit
KM-MFP	Code receiver, pulsed MF code
KS-MFP	Code sender, pulsed MF code
FIR-ZL-H1	Incoming local junction circuit MFC signalling, metering
FUR-L-H1	Outgoing local junction circuit MFC signalling
KM-MFC	Code receiver, compelled MFC
KS-MFC	Code sender, compelled MFC
FIR-ZL-H2	Incoming local junction circuit Decadic signalling, Metering
FUR-L-H2	Outgoing local junction circuit Decadic signalling
SNOR-U	Operator's cord circuit for incoming international traffic + code 12 calls
OPR-U	Operator's position circuit, international positions
SNOR-C	TSP cord circuit for outgoing traffic, national and international
OPR-C	Operator's position circuit TSP (Manual assistance)
TS	Tone sender



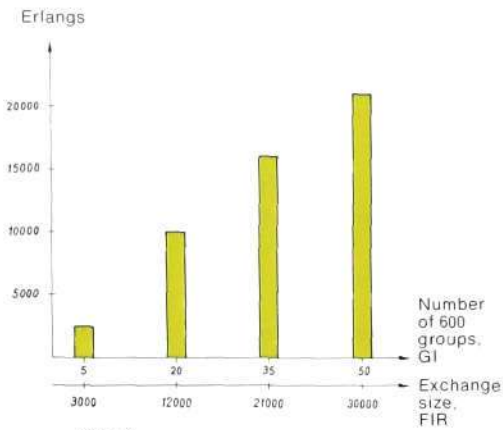


Fig. 5  
Traffic capacity

For most applications the parameters provide adequate margins, which illustrates the service quality of the system. A calculation made for four different sizes of exchange shows the traffic capacity illustrated in fig. 5.

The traffic properties of the grouping are manifestly extremely good. With the selected parameters the overload requirement is the controlling factor, and up to about thirty 600-groups the grouping is practically free from internal congestion. For the largest sizes of exchanges the permissible input load decreases slightly.

The ability to stand up to a high input load paired with full availability, expansion and the reselection function, guarantees a system which is easy to handle and which with wide tolerance will accept variations in traffic conditions without need for extensive rejumping.

The maximum traffic capacity of the switching stages is around 25,000 erlangs. The number of circuits which can be connected depends, of course, also on the mean holding time and the complexity level, and in this case the capacity of the control system is the decisive factor. This capacity is exemplified in fig. 6 which, for two typical exchanges, shows the number of inlets, FIR, per data processing block, DPB, as function of mean holding time at an input load of 0.75 erlang/FIR.

Curve A in the diagram corresponds to a complex exchange from the data processing aspect, which is characterized by a large number of signalling systems, operator functions and complicated traffic cases. Curve B corresponds to a simpler exchange characterized by a moderate number of signalling systems, no operator functions and not too complicated types of traffic. Naturally, for individual exchanges large deviations from these typical cases may occur.

The complex typical exchange (curve A) will, with eight processors, have a maximum capacity of about 22,000 inlets, FIR, at 180 seconds mean holding time. At the same mean holding time the typical exchange represented by curve B will have a maximum capacity of about 30,000 FIR, the capacity being determined in this case by the switching network. In these examples it is understood that the number of outlets, FUR, is equally large, i.e. in the latter case 30,000 FIR plus 30,000 FUR.

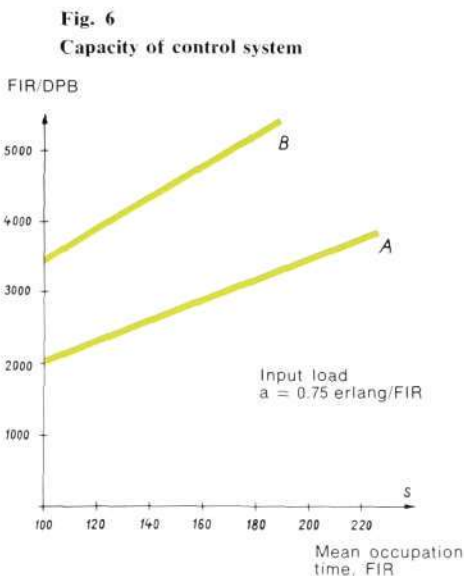


Fig. 6  
Capacity of control system

### Division into Blocks

The control of the hardware is provided by the switching equipment software in the form of programs and data stored in the data processing equipment.

The functions in the switching equipment have been divided into a number of blocks with strictly defined interfaces. Each such block may contain both hardware and software. The general system specification for a transit exchange covers all blocks for the basic form of the system and specifies the interworking between them. The specification may, however, be modified by selecting one of the available alternatives or by designing entirely new blocks. Fig. 7 shows the block diagram for traffic handling.

Between the blocks in APT 131 there are the following forms of communication:

- Interworking via physical wiring.
- Interworking via program. When work has started in a block which requires action from another block, the work must be transferred to the latter. This is done by a program in the first block calling, i.e. making a jump to, a program in the latter block.

- Interworking via data. All writing and reading of data belonging to another block means interworking via data. This is done, for example, when, in order to execute a function, it is necessary to place data in such a way that further action can be taken by another block at a later time.

In the block diagram (fig. 7) the fully drawn lines mark interworking both via hardware, i.e. physical wiring, and via program and/or data. The dotted lines mark interworking solely via program and/or data. By way of example of a block may be mentioned SEL (Selection), the main functions of which are device and path selection. On, for example, an outgoing call from the home exchange SEL selects an outgoing circuit in the relevant route and finds a path through the switching network. SEL also interconnects physically FIR and FUR. The SEL block thus contains:

- Programs for selection of device and selection of path through the switching network
- Hardware of the switching network.
- Data for the switching network in the form both of arrangement and interconnection of the switching stages, and of the momentary states (occupation, setting and blocking) of the switches.

The block diagram with description provides a clear picture of the APT functions. Apart from the hardware belonging to the blocks the diagram shows the program and data stored in APZ 150 which are used for control of the switching equipment.

## Telephony Functions

### Switching Functions

The very satisfactory traffic properties of the AKE system have been achieved through using SPC techniques for the optimum utilization of the switch grouping arrangements.

The most common type of connection, from FIR to FUR, consists in principle of three connection phases.

1. On a call on an incoming line, FIR, a code receiver KM is connected to it through two switching stages.
2. After reception of numerical information a free circuit is selected in the chosen route. This selection is, however, combined with two conditions, namely that there is a free path from the incoming to the selected circuit and that there is a free code sender with a free path from it to the selected outgoing circuit. In this phase the path between FIR and FUR is reserved (in the data store) and connection takes place only between KS and FUR. KS sends digits forward.

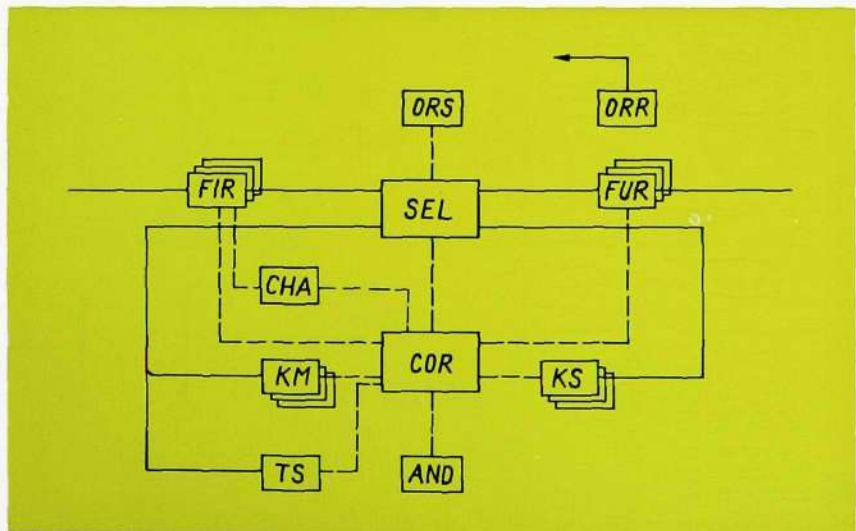


Fig. 7  
Block diagram for traffic handling

SEL	Path selection
ORS	Operation and release of switches
ORR	Operation and release of relays
COR	Coordinator
AND	Digit analysis
FIR	Incoming junction circuit
FUR	Outgoing junction circuit
KM	Code receiver
TS	Tone sender
CHA	Charging

- After transmission of a sufficient number of digits the connection of the reserved route is set up through four stages from FIR to FUR and at the same time KM and KS are released.

The procedure is illustrated in fig. 8.

In register signalling systems with end-to-end signalling, such as MFC, the second condition in phase two is eliminated and through-connection to FUR takes place as soon as sufficient digital information has been received.

With integrated line and register signalling, for example decadic pulsing, on the incoming junction circuit, scanning of the digital pulses takes place directly in FIR and KM is not connected.

The selection of an outgoing circuit takes place in two steps. First a free circuit is selected and then a check is made that there is a free path from the inlet. If there is no free path, reselection takes place by choosing a free circuit in another outgoing group. Through the principle of reselection the very low internal congestion already referred to has been achieved in an economical manner.

The system also offers individual selection, i.e. the connection from an inlet to a specific outlet. This function is used, among other purposes, for test calls and for certain operator connections when it is desired to connect to a given operator's position ("leave word").

### Digit Analysis and Alternative Routing

Strict requirements are placed today on the ability of transit exchanges to analyse the numerical information received. This is well provided for in the AKE 13 system.

The analysis block AND shown in the block diagram (fig. 7) carries out successive analysis of received digits, primarily in order to determine from them the outgoing route desired. A number of other analyses, however, may be required, e. g. calculation of tariff class (often a combination analysis which also uses data concerning the origin of the call), investigation of traffic class, calculation of number length and other information necessary for the setting up and supervision of the call. The route analysis also comprises the determination of one or more alternative routes, and the order in which they are to be used.

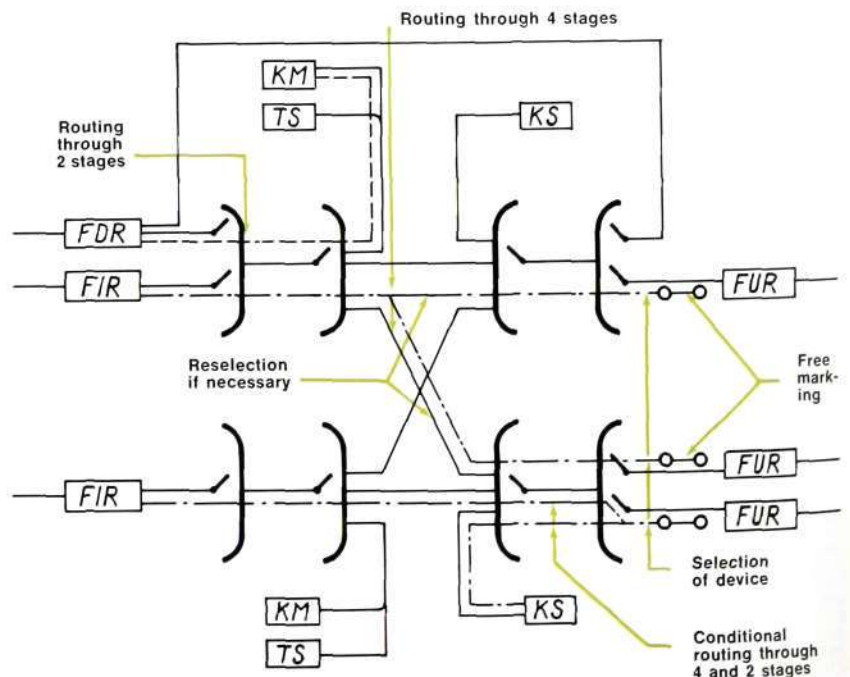


Fig. 8  
Routing through the switching stages

In some networks in which the signalling system allows, redirection of calls is required. This implies that a call which encounters congestion further ahead in the network is cleared and a new attempt is made over another route. This facility, of course, makes use of additional analysis capacity in the system and of the ability to store data concerning the selected path.

Analysis data are stored in electrically changeable memories. This is one of the great advantages of the AKE 13 system. The operational staff can add to or alter the analysis data of the exchange from a typewriter or magnetic tape. See also Operational and Maintenance Functions.

## Signalling

In the design of the AKE 13 system attention has been paid to the large number of signalling systems which exist today and the fact that many may exist simultaneously in the same exchange. This is especially the case in international and intercontinental exchanges.

Register signalling of MF type (e.g. MFC, MFP, CCITT No. 5 etc.) is normally handled through the use of code receivers KM. For link-by-link signalling and all forms of signal translation, code senders KS are used in addition. The interworking between KM and KS, i.e. the interchange of digits and code signals, always takes place on a program basis without any direct physical connection.

For each type of signalling system one group of code receivers and one group of code senders is required, which are connected as link routes in the B stages. The signalling devices contain tone circuits and associated connecting circuits. To a large extent the logical power is provided by the software of the KM and KS blocks. The dimensioning of the KM and KS groups is done with the aid of simple graphs.

Decadic signalling, as already mentioned, is handled directly in the junction circuit. Line signals are also received and transmitted in the junction circuit, but all transfer through the exchange is performed via programs. There is thus no electrical signalling through the switching network. The adaptation of the exchange to different signalling systems and to signalling between them thus takes place through programs in the corresponding blocks as well as through the simple hardware of the junction circuits.

The junction circuits contain receiving and sending relays. Signal reception is done by testing a relay contact and signal sending by operation of a sender relay in the test and operating equipment TO. Fig. 9 shows an example of a simple junction circuit.

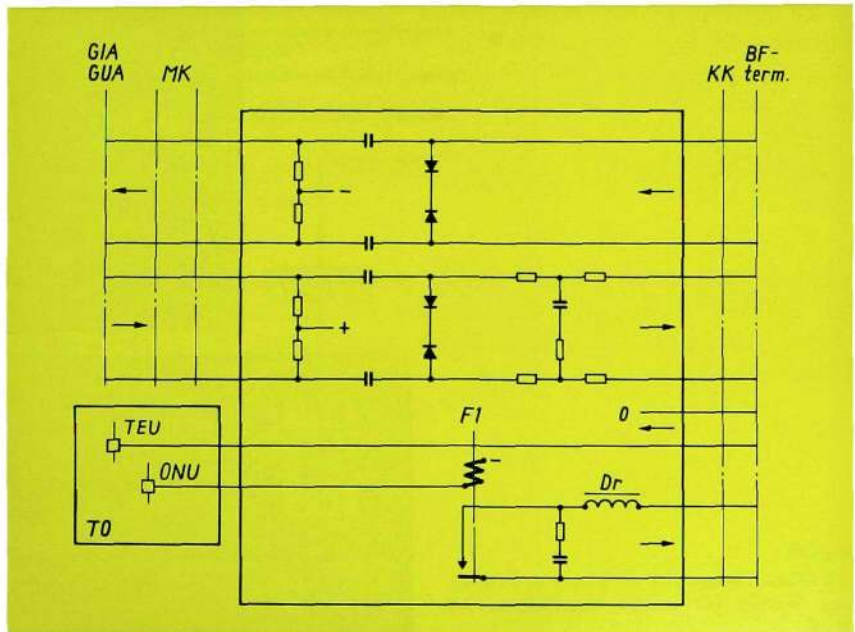


Fig. 9  
Example of circuit diagram, junction circuit  
FIR/FUR-T-4

TEU	Test unit
ONU	Operation unit
GIA	Switching stage, incoming
GUA	Switching stage, outgoing
MK	IDF
KK	MDF
BF term.	Carrier terminal

The 4-wire junction circuit exemplified can be used as an outgoing or an incoming junction circuit. Testing of received signals is done in this case directly in the terminal equipment. The signalling relay F1 is operated directly from an operating point in TO.

In certain transmission systems, especially PCM, it is possible to locate both test and operating circuits directly in the terminal equipment of the transmission system, so that no separate junction circuits are required.

The AKE 13 system is also suited for connection of routes with common channel signalling of type CCITT No. 6. In this case the modems of the signalling channels are connected directly to equipment in the test and operating equipment TO (fig. 10).

A detailed account of signalling with CCITT system No. 6 was presented in Ericsson Review No. 4, 1972<sup>3</sup>. AKE 13 fulfils the requirements of CCITT's specification for signalling system No. 6.

In an AKE 13 exchange the echo suppressors are connected either on a permanent basis in the associated junction circuit or are provided in the form of a pool from which they are connected as required via the switching stages. An example of the latter procedure is indicated in fig. 4.

### Charging

For pulse charging a transit exchange must for certain calls calculate the tariff and send the corresponding metering pulses backward from the incoming junction circuit. This function is carried out by the CHA block. Tariff determination takes place in the analysis block AND which registers the tariff in the data record of the FIR block. CHA then interworks with COR and FIR for determination of the sending frequency for the metering pulses. The transmission function lies in the FIR block. The function is performed entirely in software and is used both for national and international charging. Automatic switching between daytime and nighttime rate is provided when necessary.

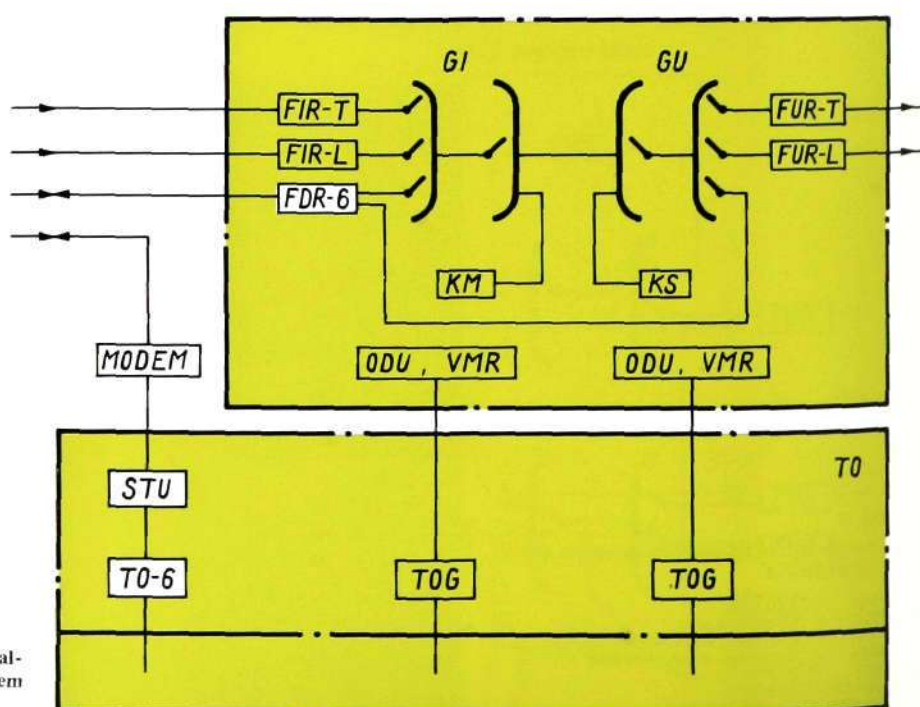


Fig. 10  
AKE 132. Connection of circuits and signalling channel for CCITT signalling system no. 6

Toll-ticketing, i.e. automatic printing of call tickets, can be used as an alternative to pulse charging or in supplementation of the latter procedure, for instance solely for certain international traffic or for traffic from certain subscribers.

In toll-ticketing the information for every call is stored in a data store as long as the call lasts. The basic information consists of the calling subscriber's number, called number and time of receipt of answering signal. At the end of the conversation the time is noted and the duration of the call is calculated. These data are transferred to a magnetic tape recorder. The toll ticketing functions can also be used for settlement of accounts between administrations, as they provide very detailed data. Normally, however, separate and simpler programs are used for settlements both for national and international traffic.

## Manual Services

Many different arrangements can be provided for operator-handled calls. This is done chiefly through software procedures, while the hardware need only be varied marginally.

The following forms of manual operation are the most usual (see trunking diagram, fig. 4).

- *Non-delay working* at cordless positions. The call is connected to a free SNOR and OPR. The digits keyed by the operator are received in KM and the call is then completed in the normal way. The complete connection is thus established through eight stages. If a free SNOR is not encountered, the FIR call can be placed in a queue. Queuing and selection of calls from the queue are done entirely in software. The duplicate inlets from SNOR in GIA marked in the trunking diagram are used for the reestablishment procedure when the operator is to set up a call both to calling and called parties.
  
- *Manual assistance working at traffic service positions, TSP*, implies that the caller dials the called party's number in the same way as for fully automatic calls. The number is, however, preceded by a traffic class digit to indicate a call requiring assistance, for instance a person-to-person call. The connection is established via SNOR and eight switching stages, but the operator is connected to the circuit only for a brief moment after the answer, e.g. to check start of charging or to enter a credit card number. After the operator's work is completed, the switching stages are reset to a prereserved route through only four stages and SNOR is released. Manual assistance is used also for calls to be charged to the called party and for credit card calls. For both forms of manual service the operators' positions may be equipped with visual display units.

Outgoing international calls are also handled by means of one of the aforesaid procedures, the number dialled by the subscriber being used to direct the call to the correct SNOR group. Certain incoming international calls also require the assistance of an operator. In this case as well the connection is set up to SNOR and OPR after reception of an operator signal.

## Data Processing System APZ 150

The data processing system APZ 150 was specially developed for telephony applications and consists of hardware in the form of synchronously duplicated data processing units in a multiprocessor arrangement, test and operation subsystem, input and output subsystem, and software in the form of the operating system programs and data.

APZ 150 is a further development of the APZ 130 system, resulting in larger data processing capacity (Fig. 6). This has been achieved through the use of integrated circuits and semiconductor stores and through the addition of an autonomous scanner which relieves the load on the central processors.

The maximum memory capacity for programs and data has been increased in order to permit more effective use of the large data processing capacity. A program store, common to all central processors, has also been introduced for programs with low usage.

Apart from the synchronous duplication the requirements of high reliability have been met through the integration of advanced hardware and software functions in the system. Programs and data can be easily replaced, for example in conjunction with extension of the plant.

The modular structure of the system permits economic extensions both as regards functions and size.

### *System Organization*

*The data processing equipment* (Fig. 11) consists of 1—8 data processing blocks, DPB, each containing:

- central processors, CP
- internal program store, PSI
- data store block, DSB
- transfer control block, TCB

The functions of the plant can be freely allotted to different DPB, each handling either certain functions for all types of connection (functional division) or all functions for the part of the exchange to be served by each DPB (sectioning). The latter procedure is normally used, as a minimum alteration of already installed equipment is then required even in the case of major extensions.

*The test and operation subsystem, TO*, is divided in the same way as the data processing equipment and connects the transfer control block within the respective data processing block to the switching equipment.

Variable and fixed exchange data relating to a part of the system controlled by a given data processing block are stored in the latter's memory. The central processors work chiefly within their respective data processing blocks. As, in a multiprocessor system, a connection may affect several parts of the system, the various data processing blocks interwork in such a way that all central processors write and read in one another's data stores and transfer control blocks. This interwork takes place via an electronic congestion-free switching network known as a multiplexor.

Within each data processing block the internal program store PSI is permanently connected to the central processor. The common program store, PSC, is accessed via the multiplexor.

To meet the high requirements of reliability placed on a large transit exchange, all central processors, program stores, data stores and transfer control blocks consist of two synchronously working units (Fig. 12). This implies that up to half of the data processing equipment can be taken out of service without affecting the function or traffic capacity of the system. If required, one or more entire data processing blocks in a multiprocessor system can also be taken out of service, in which case, however, the traffic handling capacity of the system is correspondingly reduced.

### Central Processor

A central processor consists of two central processing units, CPU, and a supervisory unit SVU. The latter contains circuits for comparison between synchronously operating parts of the system and logic for initiation and supervision of various measures in conjunction with malfunction signals.

The central processing unit with its machine instruction list is especially designed for telephone exchange applications. This means that fairly simple logic and arithmetic operations can effectively be carried out on large quantities of data in real time by a multiprocessor system. The central processing unit consists of a microprogrammed control unit, an arithmetic unit, a set of process registers and a preservation store for a number of priority levels.

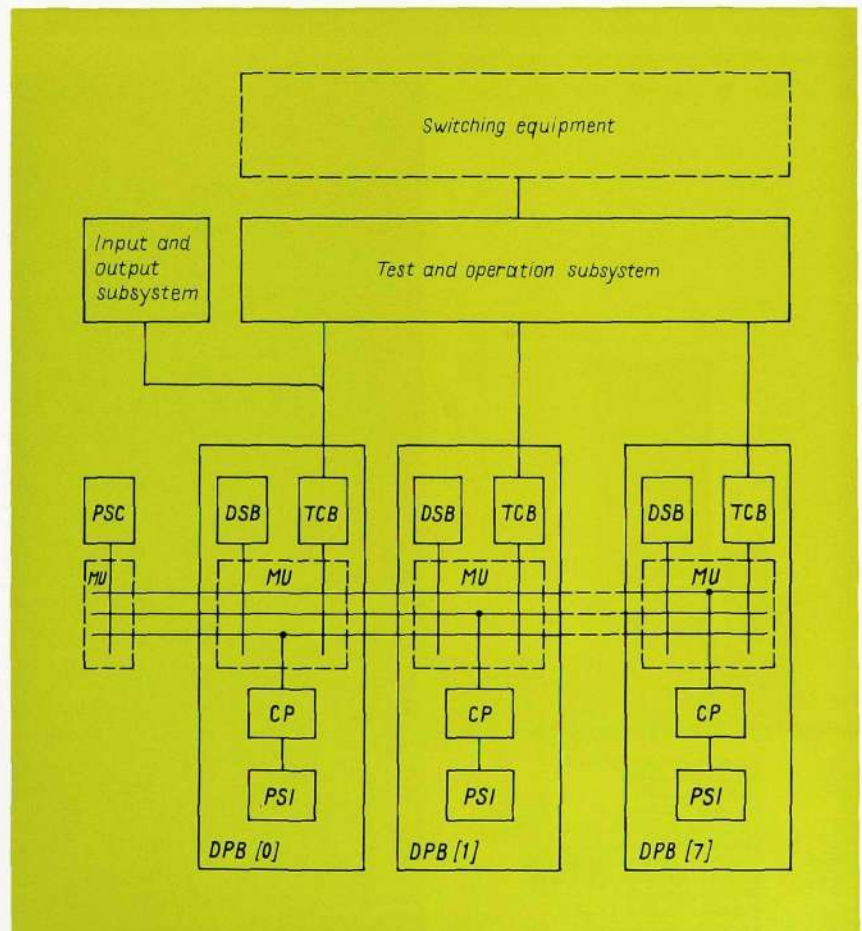


Fig. 11  
Hardware block diagram

- CP Central processor (duplicated)
- DPB Data processing block
- DSB Data store block (duplicated)
- MU Multiplexor (duplicated)
- PSC Common program store (duplicated)
- PSI Internal program store (duplicated)
- TCB Transfer control block (duplicated)

With the aid of the interrupt signals and priority level logic described below, the time of the central processor is so assigned that more urgent tasks are carried out before less urgent (fig. 13).

- *Clock interrupt signals*, periodically generated by an independently working real time clock. These interrupt signals are used by the monitor program of the operating system for administration of ordinary exchange functions.
- *Scanner interrupt signals*, are used for initiation of measures when the scanner in the transfer control block detects changes of state.
- *External interrupt signals*, are used for autonomously operating input and output devices for ordering of service.
- *Malfunction interrupt signals*, are generated by SVU on discovery of malfunction.
- *Level lowering signal*, initiated by the monitor program of the operating system when work on a priority level has been completed and interrupted work at lower levels is to be resumed.

One or more priority levels correspond to each of the above interrupt signals. When an interrupt signal requires working at a higher priority level the information in the process registers is preserved in the preservation store. At the next lowering of level, therefore, an interrupted program continues where it was interrupted.

### Program and Data Stores

As already mentioned all stores are duplicated on grounds of reliability. They are identical and consist of dynamic MOS stores of 20-bit word length. Two of the bits are check bits. Each type of store can be extended up to 256 K words ( $K = 1024$ ). The extension module is 16 K, so that the degree of extension can be adapted to individual requirements. The store cycle time is  $0.8 \mu s$ .

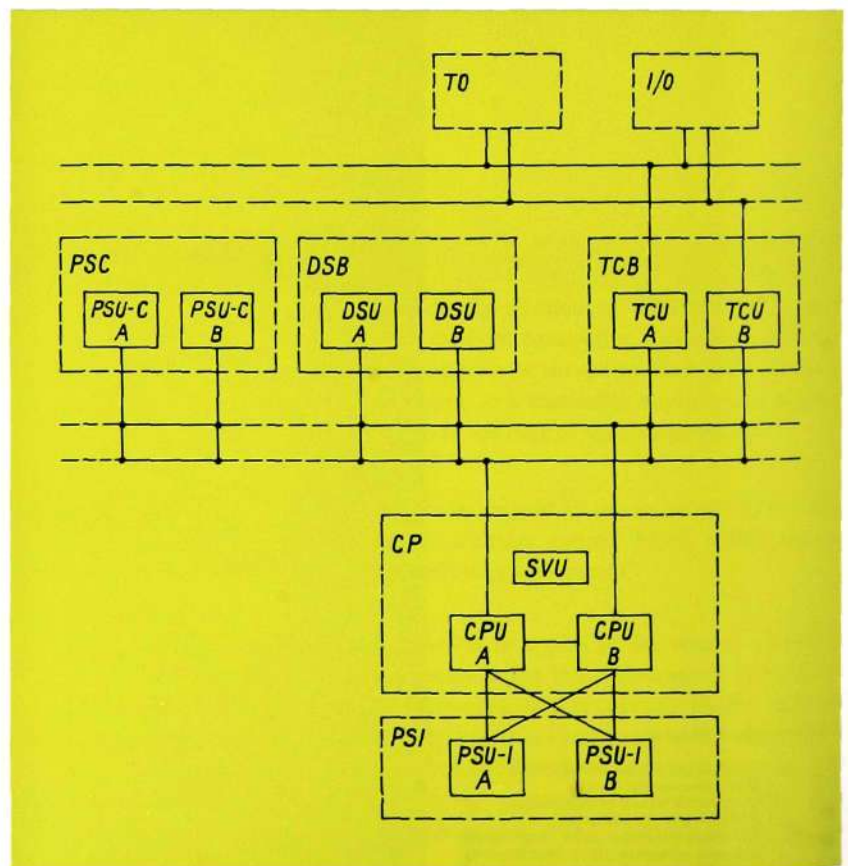


Fig. 12

Duplication in data processing block

CPU	Central processing unit
DSB	Data store block
DSU	Data store unit
CP	Central processor
PSC	Common program store
PSI	Internal program store
PSU-C	Common program store unit
PSU-I	Internal program store unit
SVU	Supervisory unit
TCB	Transfer control block
TCU	Transfer control unit

## Transfer Control Block, TCB

The transfer control block contains connection circuits to the bus system between data processing, test and operation subsystems, and an autonomously working scanner. The task of the latter is to discover changes of state in the switching equipment. For this purpose use is made of an image store in the scanner for test points. The scanning of a series of test points with similar function is initiated by the central processor in the respective data processing block, after which the processor can perform other tasks during the scanning. When a change of state is discovered the scanning is interrupted, after which action advice from the central processor is requested by means of an interrupt signal.

## Multiplexor

With the aid of the multiplexor each central processor can read and write in DSB or TCB. For each DSB and TCB there is a duplicated multiplexor channel consisting of an electronic gate network. Each such channel has up to eight duplicated inlets (one per CP) and a duplicated outlet (to DSB and to TCB respectively).

When the central processor is to access a data store block, it sends corresponding addresses to all multiplexor channels, whereupon the relevant channel opens the gates to the corresponding DSB, after which the exchange of information between CP and DSB can take place. For test or operation in the switching equipment TCB is called instead.

## Test and Operation Subsystem, TO

The circuits in the switching equipment the states of which must be known by the system programs are interconnected with test point matrices in the test and operation subsystem. Information concerning relevant changes of state is obtained by scanning of these matrices.

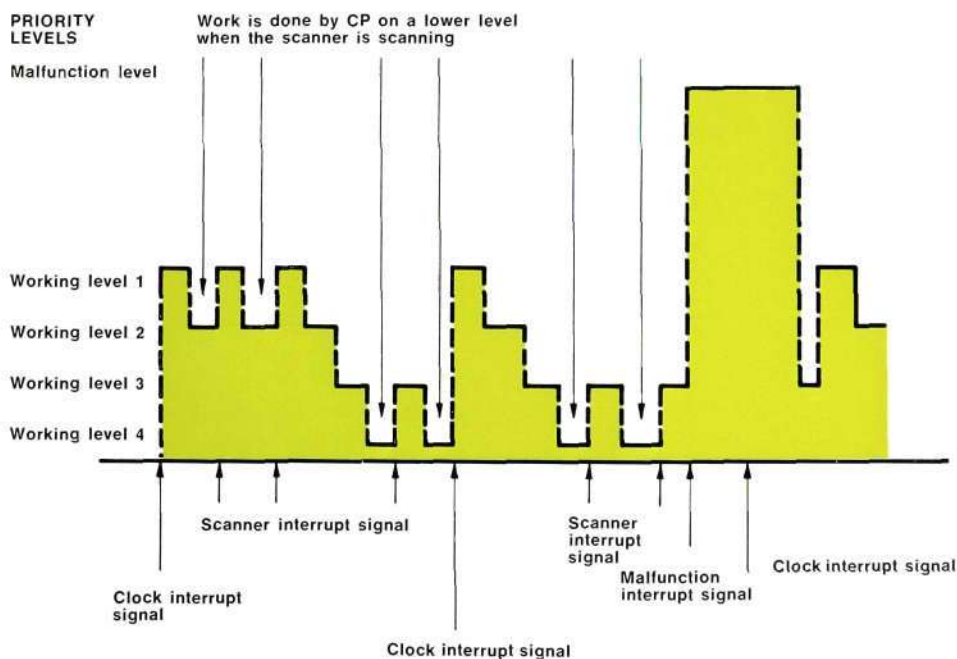


Fig. 13  
Interrupt system

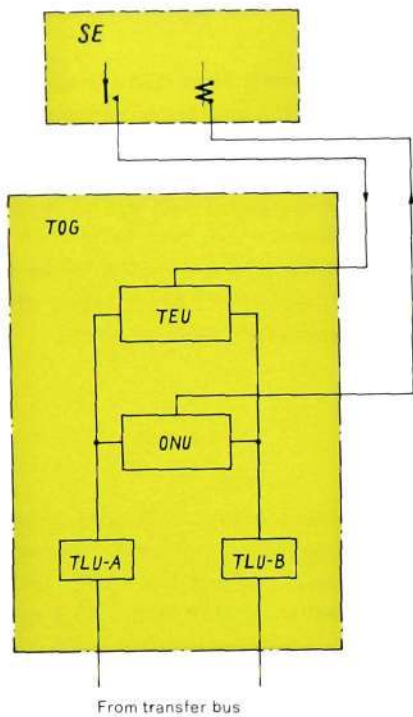


Fig. 14  
Test and operation group TOG

SE	Switching equipment
TEU	Test unit
ONU	Operation unit
TLU	Address decoder

In the same way the circuits in the switching equipment, the states of which are controlled by the system programs, are connected to operation point matrices. These circuits are operated by transmission of control orders by the program to the relevant operation points.

Test point matrices and operation point matrices are placed in special racks directly adjoining the switching equipment. A number of such racks form a test and operation group TOG (fig. 14), which is connected via a bus cable system to a transfer control block TCB. Several test and operation groups can be connected to each transfer control block. The number of test and operation points is adapted to present requirements.

Through conversion tables in the scanner stores, test and operation point words of 16 points can be freely allotted to logic addresses. This reduces waste in the matrices and facilitates rearrangements for extension purposes.

### Input and Output Subsystem

For communication with the system the operational staff uses input and output devices in the form of:

- electric typewriters (TW)
- paper tape readers (TR)
- paper tape punches (TP)
- visual displays (VD)
- magnetic tape handlers (MTH)

connected as shown in fig. 15.

The equipment is designed to be placed in the AKE exchange control room or in different operational centres. Electric typewriters and visual displays can also be connected via modem.

The requirement of data transfer capacity of the input and output subsystem is limited even in the case of a large quantity of input and output devices. On the other hand high requirements are placed on reliability. Alarm and malfunction printouts to typewriters and visual displays must not be lost, the output of charging data on paper or magnetic tape equipments must not contain errors. Commands must be checked in respect of authority and plausibility so that serious errors are not caused by incorrect operations.

### Operating System

The following program functions are included in the operative system for APZ 150:

*Job monitor*, administers the execution of other programs at correct priority level and at correct time.

*Input and output programs*, handle all interworking between the system input and output devices and other programs.

*Maintenance programs*, deal with all maintenance functions for the data processing equipment. The programs comprise functions for systematic service supervision, tracing and blocking of a faulty unit on receipt of a malfunction signal, reorganization of the system in the case of malfunction, diagnosis of faulty units, and reconnection of a unit after repair.

*Loading programs*, used for loading of fixed and movable programs and data.

*Functional change programs*, permit change of programs and data without disturbance of operation in conjunction with change of functions or extension of an exchange.

*Test system programs*, used for testing of programs in conjunction with design, installation or fault tracing.

*Installation testing programs*, used for installation testing of data processing hardware.

The program volume of the operating system in a normal AKE 132 exchange is altogether about 120 K words, about half of which are stored in an external memory. Of the total program volume the maintenance programs account for about 80 K words (K = 1024).

### Reliability Aspects

Very high reliability requirements are placed on transit exchanges owing to their central position in the network. For APZ 150 this implies that, even in the case of malfunction of hardware or software, it must perform its control of functions with only negligible or no disturbance of the service.

Thanks to the earlier described synchronous duplication principle and through systematic supervision with the aid both of hardware and software functions, a hardware malfunction caused, for example, by a faulty component can be quickly detected and the faulty unit can be isolated. Occasional hardware malfunctions do not affect the ordinary service. Normally, furthermore, several simultaneous hardware malfunctions can occur without disturbance of the service.

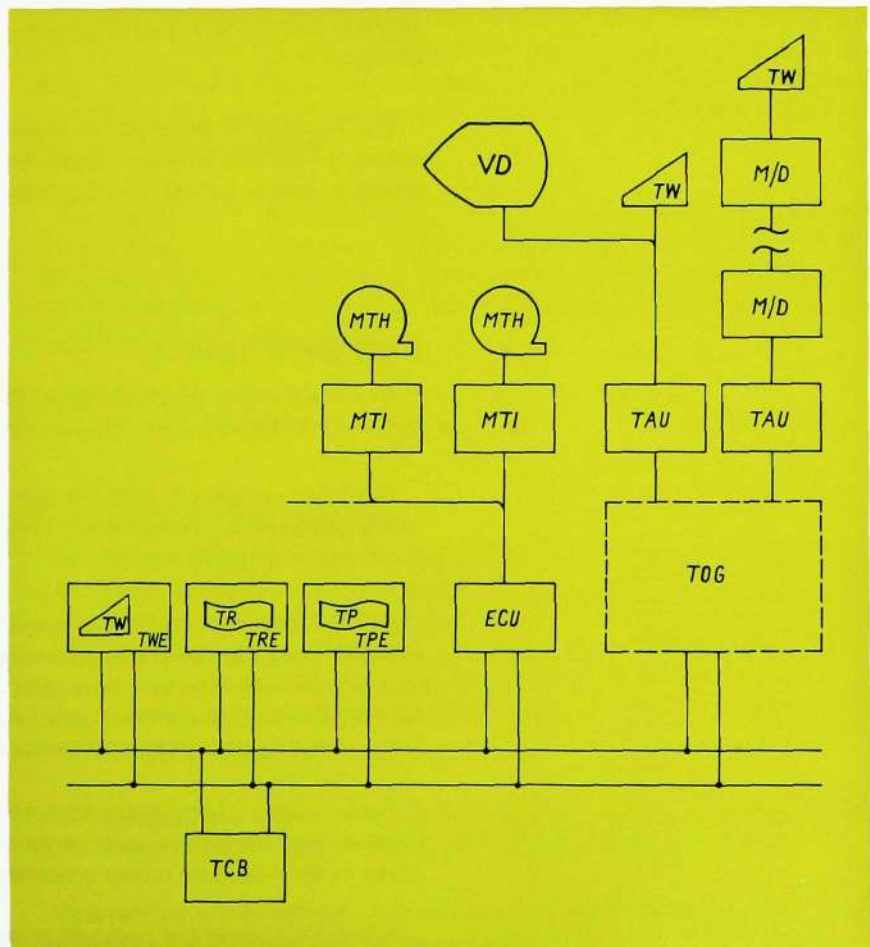


Fig. 15  
Input and output group

- VD Visual display
- ECU Control unit for connection to external memories
- M/D Modem
- MTH Magnetic tape handler
- MTI Magnetic tape interface unit
- TAU Terminal adapter unit
- TCB Transfer control block
- TOG Test and operation group
- TP(E) Tape punch (equipment)
- TR(E) Tape reader (equipment)
- TW(E) Typewriter (equipment)

Even after careful tests of the exchange programs before they are put into service, minor design faults may remain. These faults can be quickly discovered and remedied through extensive supervision in the form of software and hardware functions. Normally such measures disturb only an occasional call or a small group of calls. In some cases, however, more radical action must be taken and the system must be restarted. This is done by restoring the variable data of the data stores to normal, after which the program execution is started again from a restart point. The latter measures have a negligible effect on the functioning of the exchange, as they take little time and established connections are not disturbed.

To keep the system in operation even if a complex fault situation should arise, there is an automatic restart function for the whole system. In this case destroyed program and data store contents are reloaded with the contents from other stores or from the external store so that all stores are set to normal state. The service is then resumed from a restart point.

For high reliability it is, of course, also necessary to minimize the duration of faulty states. When a fault arises, therefore, the operational staff are given detailed and easily interpreted malfunction printouts to assist in the continued fault tracing. The system also incorporates advanced aids for diagnosis of faults in hardware or software.

## Program System

Apart from the operating system referred to above, the total program volume required per data processing block consists also of about 35 K words for traffic-handling and about 60 K words for telephony operation and maintenance. The program volume, however, varies according to the required functions in an exchange.

The structure of the program system is designed for the minimum possible processor load and memory requirement and to permit rational management in planning, design, installation and service.

## *Program Structure*

As already noted, the programs are inserted at different priority levels. Within each level the following hierarchical division of the programs is adopted:

*Supervisory programs*, with the task of administering the running of the correct program at the correct time. These programs consist of job monitor programs in the operating system.

*Index programs*, are executed periodically with the object of scanning, for example, groups of devices in the switching equipment in respect of changes of state which require further action. The earlier described autonomous scanner is used for discovery of such changes of state. Change of state in data store records is one of the signalling methods between different programs.

*Task programs*, carry out tasks ordered by the index programs. Correct task programs are selected by index programs depending on the state information stored in the data store record concerned.

*Subroutines*, consist of common program sequences.

## *Data Structure*

Both fixed and variable data are organized in files consisting of a variable number of similar records. One record, for example, is associated with each of the devices within a given group of devices. All records for the group of devices form a file for that group.

The format for different types of records has been extensively standardized. This permits flexible interworking between different program functions.

Different tree and list structures are used for permanent or temporary linking together of records within the same or different files. An example of this is the analysis tree for traffic routing and idle lists for selection of device.

## *Block Structure*

Programs and files are combined into blocks of functions with well defined interfaces. Where necessary, hardware units, such as groups of devices, are also associated with these blocks of functions.

The form of the relations between different blocks has been earlier exemplified in the description of the block diagram for traffic handling in APT 131. The same principles are used in the operating system.

For interworking between programs and/or data records associated with different blocks a series of standardized macroinstructions has been produced. These are of functional type, such as "call signal", "send next digit". In this way a new signalling system, for example, can be easily incorporated in the system by addition of a new signalling block without affecting the system in other respects. The interworking between incoming and outgoing signalling systems is then handled in a standard manner by the coordination block COR referred to under Switching Equipment.

This arrangement provides flexible units with well defined characteristics which, through their design, are independent of the size and function of the particular exchange. Another gain is that all AKE 13 exchanges can for the most part have standardized software and only to a small extent need have programs adapted to the individual exchange.

## *Standardized Subroutines*

Frequently recurring measures in the programs are given the form of standardized subroutines. They consist of sequences of instructions which are placed in a similar manner in each of the programs in which they are used or in one position in the program store. In the latter case they are called in by means of jump instructions. The subroutines have a functional character, e.g. "initiate printout on typewriter according to specification", "start time supervision at specified time", etc.

The subroutines are defined by means of macroinstructions. Through a choice of parameters they are given different characteristics in the programs.

Through use of the subroutines the necessary program volume as well as the design work for new functions can be limited.

## Programming

A large number of aids has been developed for design and planning of the program system for AKE 13.

### *Programming Language*

An *assembler language* based on symbolic codes is used for programming. Programs written in this language are fed into the programming system APS, which translates them into computer code adapted to APZ 150. The programming language also contains advanced facilities for definition and use of *macro-instructions*. A few applications of this have been described earlier. A far advanced use of the standardized macroinstructions has resulted in the gradual development of a function-oriented program language of higher order.

For testing of programs the program language contains an extensive set of test directives with which the programming language can simulate the data processing equipment in an exchange. In this way new programs are quickly and effectively tested before being installed in an AKE 132 system-testing or customer plant.

The programming system also includes an extensive set of *instructions for planning and assignment* of programs and data for AKE 132 exchanges, among which directives for program and data outputs and for control of library files in which the standardized software is stored.

### *Programming System*

The programming system APS offers the means of effective handling of the design, testing and planning of the software. APS is adapted to the IBM 370 series but is to a large extent computer-independent since the greater part of it is written in Fortran. The system can therefore be easily converted for use in other types of computers. In total the system comprises about 150,000 Fortran statements.

The system can be run either in a local computer installation or via a terminal. The latter procedure is used by some of LM Ericsson's European subsidiaries which, via a terminal, use an IBM 370 system at LM Ericsson in Stockholm.

## Operation and Maintenance Functions

Functionally it is particularly within the administrative field, i.e. operation and maintenance, that the AKE 132 system offers a series of new and important facilities concerning both the exchanges and the associated networks. These functions are essentially realized in the software by exploiting fully the flexibility and considerable logic capacity offered by SPC technique.

### *Communication between Operational Staff and Exchange*

Most of the communication between operational staff and exchange takes place via typewriters and paper and magnetic tape equipment. These are placed in a control room or in different maintenance centres, e.g. international maintenance centres, IMC. The form of these equipments has been touched upon earlier. In addition control panels with controls and indicators are included in the test desks.

A special command language comprising several hundred commands has been developed for commands to be given to the system via typewriters and paper and magnetic tape equipment. Printouts and output of information to paper and magnetic tape equipment are made in special language consisting of a large number of different types of messages.

### *Alteration of Exchange Data*

The daily operation in a transit exchange involves constant alterations of traffic routing data, transfer of circuits between different routes etc. Special programs which assign or alter exchange parameters stored in the memory, therefore, form part of the system. The programs are so designed that desired alterations are expressed in terms easily understood by the operational staff and with built-in plausibility checks, so that the permissible range of variation for the exchange is not exceeded. The programs are naturally designed so that, when alterations are put into effect, they do not disturb normal service.

### *Service Supervision*

The service supervision has a double task. In the first place one obtains a check of quality, since indications are presented of when and to what extent disturbances occur, and in the second place data are received for fault tracing by indicating the cause of the disturbance.

Examples of service supervision functions are:

- *Fault ratio counting*, which implies that if the number of disturbances for, for example, a given route or exchange function per period or per number of calls exceeds a predetermined limit, an alarm is issued and a printout of the situation is presented.
- *Fuse supervision* for the entire APT 131. Fuses exist for groups of racks, individual racks and devices, and the state of the fuses is tested periodically. The blowing of a fuse is signalled, if required, also by printout.
- *Congestion supervision*, which is normally arranged per route. The number of calls to the route and the number of times calls fail owing to congestion are recorded on counters. If during a given period the number of lost calls exceeds a predetermined value, a printout is presented.

Among interesting and important properties of the AKE system the traffic load supervision and control should be noted. These functions provide a guarantee that the exchange retains the highest possible traffic handling capacity in an overload situation, while at the same time preventing the spread of a local overload to other parts of the network.

The maintenance staff can at any time request typewriter printout of the state of a route with data of all engaged devices and the reasons for their occupation, i.e. traffic, local or remote blocking.

### *Supplementary Tests*

In supplementation of the ordinary tests which are automatically carried out in the system there are the following test facilities among others:

*Traffic route testing*, which is important for continuous evaluation of the service quality of the exchange. It gives a picture of the situation actually encoun-

tered by traffic in a network. The necessary test program is stored in the control equipment.

*Circuit and switch testers* are used, when required, for cyclical testing of code receivers, code senders and switching network.

*Traffic observation* permits supervision of individual connections, e.g. in conjunction with setting up of a new traffic route. Apart from printouts of call data, connection for monitoring of the call may take place via the B links.

### *Fault Tracing in Switching Equipment*

Several means exist for testing of devices and tracing of faults in switching equipment after a fault indication. The most important is the test desk, on which the operator can set up test connections or a connection to an optional device connected to the switching network. Relays and switches are operated on special commands from the operator. Speaking and listening equipment or measuring instruments can be connected to the test desk.

In conjunction with the setting up of test connections there is a valuable fault tracing aid through which a printout of all devices and switches used on a connection is obtained.

For study and checking of the signalling functions, both of junction circuits and code receivers and code senders, use is made of a signal and state recorder function integrated in the system. When setting up a test connection, the recorder will, for example, print out the signal sending and signal receiving functions for the devices used in the connection.

### *Fault Tracing in the Data Processing Equipment*

It is, of course, very important that a state of malfunction in the data processing equipment should be as brief as possible. The operational staff therefore receives detailed and easily interpreted printouts as basis for fault tracing. The system also includes advanced means for diagnosis of malfunction in hardware and software.

### *Statistics*

The data received during service observation of the exchange can be recorded statistically at the same time as fault prevention measures are immediately taken. This creates a basis for the long-term planning of maintenance.

These statistics are supplemented by traffic measurements, for which AKE 13 offers very extensive facilities. The complete traffic measurement programs, which also include measurement of community of interest and of load distribution, provide the best means for accurate traffic measurement in and supervision of a complex network with alternative routing.

### **Construction Practice and Power Supply**

The characteristic components of the system are code switches, electronic components and miniature relays mounted on printed circuit boards, and a small number of telephone relay sets.

The switch racks are of BDB type. The code switches are made up in sets for plugging into a rack. The relay sets for switch operation, VMR, are placed on the same rack. The racks are connected to the exchange cabling through multi-jack connectors.

Most of the switching devices, FIR, FUR, KM and KS, are mounted on printed circuit boards. The boards are placed on shelves which plug into the BDH rack in the same way as relay sets. In certain cases, on grounds of standardization or production technique, the switching devices are given the form of normal BCH relay sets.

For the test and operation equipment TO a special type of rack has been developed in view of the large quantity of wiring required. On these racks, denoted BDE, are inserted units for 1-4 shelves. The exchange cabling is connected directly to these units. The racks are single-sided.

For the data processing equipment a special BDH type of shelves with double board depth is used. Part of the wiring in APZ 150 has the form of front cabling, i.e. connection is effected with plugs directly to the front edges of the printed circuit boards.

The rack height is 2900 mm.

The central power equipment is of normal type with rectifiers and batteries for 48 V. The distribution uses a new principle, with individual conductors for each rack.

The racks contain DC/DC converters for generation of the voltages for the electronics. In these -48 V DC is chopped and then transformed and rectified. Pulse width regulation is employed.

In the switching equipment 5 V is used in ODU and 12 V for operation of relays. In the data processing equipment + 5 V is used, for instance, for the circuits, while the semiconductor stores use 16 and 19 V.

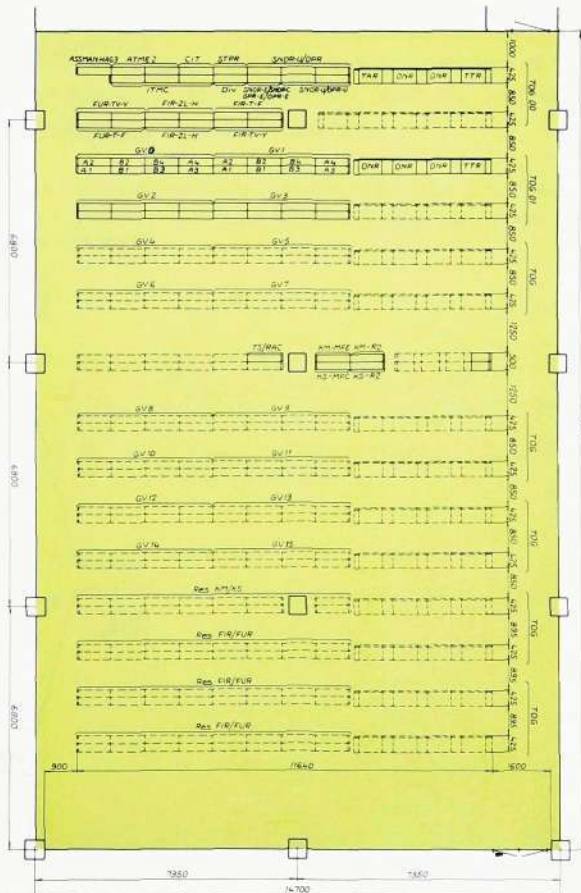
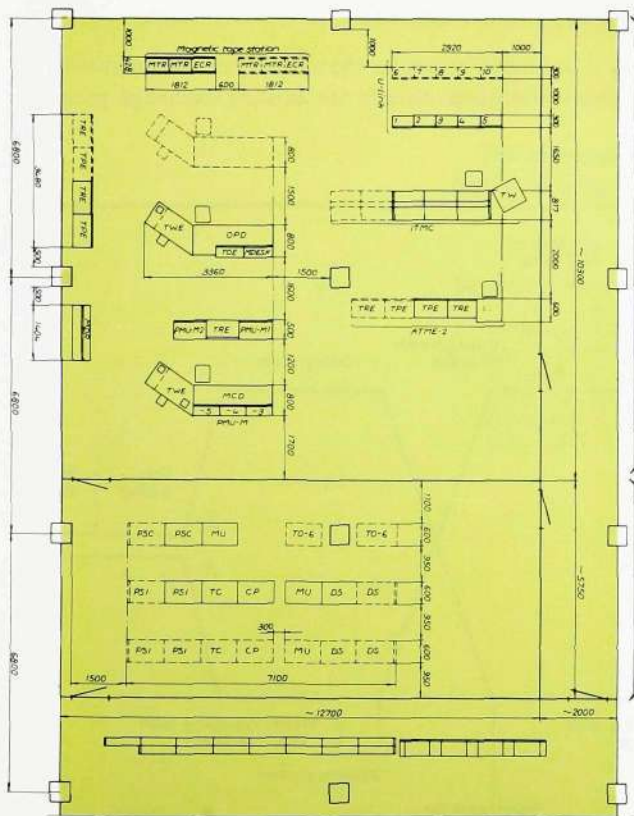
An example of a layout for an AKE 132 exchange is shown in figs. 16-17. The space requirement is considerably less than for a corresponding crossbar switch exchange of conventional type.

Fig. 16 (left)

International transit exchange AKE 132 for 4800 incoming and 4800 outgoing lines. Control and processor room

Fig. 17 (right)

International transit exchange AKE 132 for 4800 incoming and 4800 outgoing lines. Switching equipment



## Installation, Testing and Functional Changes

The installation of an AKE 13 exchange is simpler than that of a conventional crossbar switch exchange, since the AKE exchange has fewer racks and the wiring work is easier. Installation staff with a knowledge of conventional installation work need not be retrained for installation of AKE 132. Thanks to the plug and jack principle the exchange cables can be laid, formed and connected to their plugs before the racks are delivered, with the exception of the racks for the test and operation equipment.

*Installation testing* of the hardware is done first, and then of the software.

From the hardware aspect the switching and data processing equipments are tested separately. This is done in all cases chiefly by means of special installation testing programs executed by the data processing equipment of the exchange.

The operating system of the data processing equipment is standardized and the correctness of this software is further verified in conjunction with other tests. The data processing maintenance system and the switching programs are checked by means of simulation of faults and by test connections. The operational and maintenance functions of the switching equipment are then checked by testing all functions.

In order that the exchange may be finally tested under conditions which correspond as closely as possible to actual operation, a peak traffic test, a combined test of different parts of the system and a simulated operational test are finally made.

*Functional changes* must be continuously introduced in a telephone exchange, as noted earlier.

The daily alterations of, for example, traffic routing are carried out by means of special commands and programs as earlier described. As a result of the synchronous duplication, the system restart function and special programs, the entire exchange program and/or all exchange data can be replaced at one time without disturbance of ordinary operation (fig. 18).

On such an occasion a command separates the system into two mutually independent sides. One side continues to handle the existing exchange program,

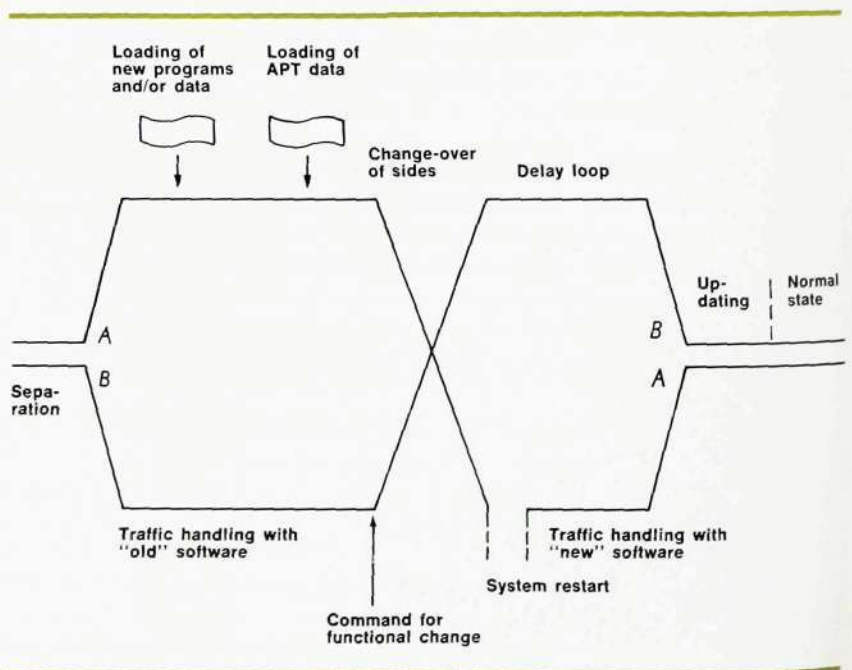


Fig. 18  
Simplified sketch of the process for a functional change

while the other side is loaded with a new program, at the same time as the old program is held in readiness for return to it if necessary. A command is then given which results in changeover of the sides, whereupon the necessary exchange and temporary data for connections in progress are transferred to the side with the new program. In the event of a fault caused by a programming error the system returns automatically to the old program. When the new exchange program has been found to function satisfactorily, it is transferred to the side with the old program, after which both sides are restored to parallel operation. A similar procedure is used when new hardware units are to be added to the system.

## Summary

System AKE 132 is designed for national, international and intercontinental transit exchanges with complicated signalling systems, complex operator functions and a large final capacity.

*The system is insensitive to temporary traffic fluctuations, which in combination with very advanced operational and maintenance facilities greatly simplifies and rationalizes operations.*

From the network point of view the AKE 132 is an important operational aid as it can carry out, for example, traffic measurements of community of interest, supervision of all connected circuits and maintain continuous overload checks in the central points of the national and international networks.

The data processing system is build up on a modular principle with up to eight synchronously duplicated processors, which allows flexible adaptation to the required application and size of exchange.

High reliability is guaranteed by duplication of central processing units in the data processing equipment combined with effective supervisory, fault tracing and fault rectifying routines.

Far reaching standardization has been achieved through division of the programs into functional blocks with strict interfaces, and the individual programs for a given application are limited to a minimum.

The programming system APS constitutes a rational aid which permits the design of programs through the use of well established commercial computers.

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# AKE 131 Rotterdam Exchange and Experience from First Year of Operation

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*On October 29, 1971, a new LM Ericsson AKE 131 transit exchange was placed in regular traffic in Rotterdam and the exchange was officially opened on December 22 of the same year.*

*The exchange, called Rotterdam DC II, functions as district centre. It is the first stored-program-controlled (SPC) transit centre in commercial operation in the world and also the first SPC exchange controlled by several interworking processors in a so-called multiprocessor system.*

*The operation of this exchange has naturally been followed with great interest in the world of telephony and the results and experience hitherto are presented in this article.*

## System Survey

The AKE 131 system delivered to Rotterdam consists of a switching equipment APT 130 and a data processing equipment APZ 130 (fig. 1). A block schematic of the entire system is shown in fig. 2.

The switching equipment contains

- link-connected selector stages dimensioned for high input load, whereby the lines can be connected to optional inlets. As the system has very low internal congestion and offers reselection, it is insensitive for instance to temporary traffic fluctuations.
- repeaters and signalling devices such as junction line equipments, code senders and receivers for different register signalling systems, tone senders etc.
- operating circuits, for selector stages and relay racks, which, through a coding procedure, allow a large number of operational functions to be performed with a small number of signals.

The switching equipment is made up of code switches, telephone relays assembled into relay sets, printed-board-mounted reed relays and electronic components.

The data processing equipment contains

- processors, the number of which can be varied between one and eight according to the load. They work in a multiprocessor arrangement, which implies that, via a multiplexor, they interwork with one another, with data stores and with transfer units. The latter control the switching equipment. High

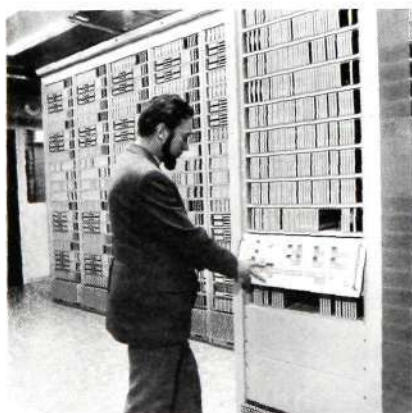


Fig. 1  
The data processing unit of AKE 131, Rotterdam

reliability is ensured through synchronous duplication of control equipment. Owing to this duplication computer errors can be quickly discovered and eliminated and program and exchange data can be changed without disturbance of the service.

- input and output devices in the form of typewriters, tape readers, tape punches, tape recorders with associated operative and maintenance programs.

The hardware of the data processing equipment is made up of semiconductors, mounted on printed circuit boards, and of ferrite core stores.

The programmes, which by definition belong to the switching and data processing equipments, are organized in functional blocks with well organized interworking. The blocks are also independent of the particular system configuration, i. e. the number of processors connected, the size of the switching equipment etc.

## Facts about Rotterdam DC II

As a background to the following account a few data will be presented concerning *Rotterdam DC II* and the network in which it operates.

### The Telephone Network

From the traffic engineering point of view the Netherlands telephone network is divided into 22 districts (fig. 3). Each district is divided into 10 sectors, each consisting of at most 10 local exchange areas. All district exchanges are interconnected via a mesh-shaped network.

### Functions of the Exchange in the Network

The Rotterdam AKE 131 exchange functions together with an existing ARM exchange as district centre and as a transit point for automatic international traffic (fig. 4).

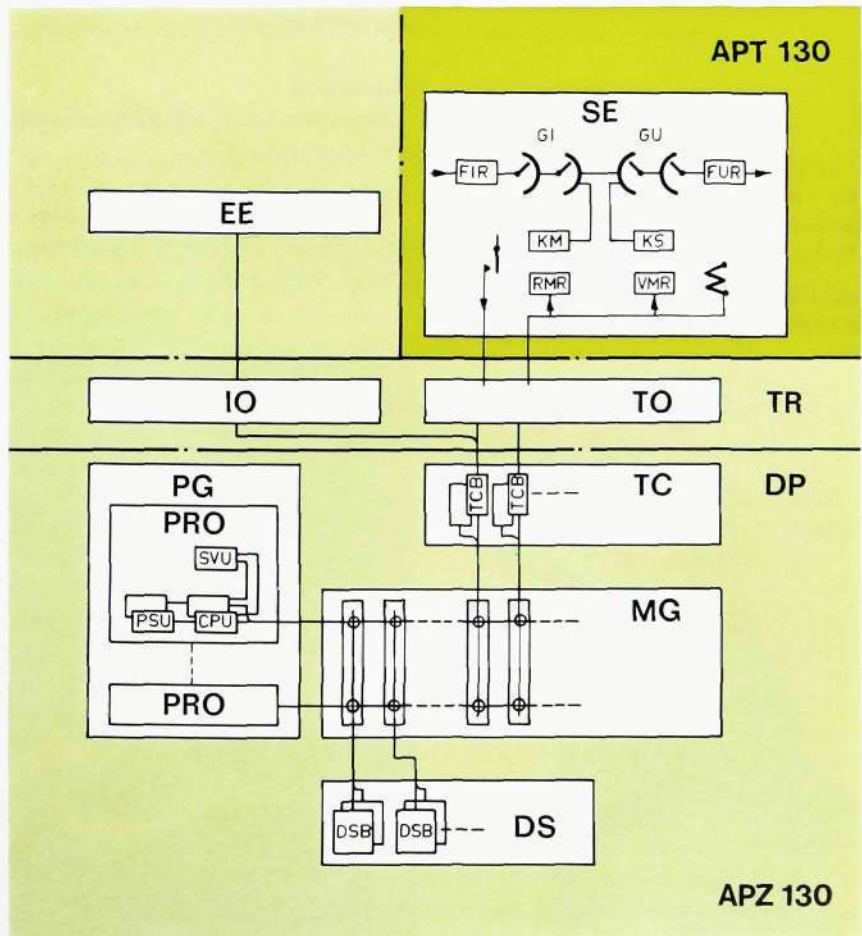


Fig. 2  
Block schematic of AKE 131

SE	Switching equipment
EE	External units
IO	Input and output units
TO	Test and operating units
TR	Transfer unit
PG	Processor group
TC	Transfer control block
DP	Data processing equipment
PRO	Processor
MG	Multiplexor group
DS	Data store
CPU	Central processing unit
DSB	Data store block
FIR	Incoming junction circuit
FUR	Outgoing junction circuit
GI	Incoming selector stage
GU	Outgoing selector stage
KM	Code receiver
KS	Code sender
PSU	Programme store unit
RMR	Relay operating unit
SVU	Supervisory unit
TCB	Transfer control block
VMR	Switch operating unit

## Capacity

At the time of its cut-over Rotterdam DC II was equipped for 2,400 incoming and 2,400 outgoing lines. The data processing equipment comprises two processors and the necessary data stores. The exchange building also houses an international maintenance centre and a control room with, among other equipment, input and output devices for communication with the data processing equipment.

## Traffic Routing and Signalling

The trunking diagram will be seen from fig. 5. The following types of signalling occur on the connected lines:

- decadic pulsing
- MFC signalling
- AGF signalling (a signalling system for interworking with L M Ericsson exchanges of type AGF)
- 2VF signalling (CCITT system No. 4)

The selector stages of the speech network consist of one-way groups of 600 inlets with expansion facility through two substages to altogether 1640 outlets which are used for links to other groups and for common signalling devices.

A connection from an incoming to an outgoing line is set up through four substages. Calls to devices with high call intensity and short occupation time, such as code senders and receivers, are set up through two substages.

## Accommodation

One floor of a new building (fig. 6) is reserved for Rotterdam DC II. Switching equipment, data processing equipment and control room equipment are set up in separate rooms.

## Expansion

Rotterdam DC II will be successively expanded from 2,400 to 12,000 incoming and outgoing lines.

The first extension of 1,200 lines was completed at the beginning of 1973 and the next extension of 3,600 lines and an additional processor will follow by the end of the year.

Fig. 3 (left)  
Districts of the Netherlands telephone network

Fig. 4 (right)  
Principal traffic routes for AKE 131

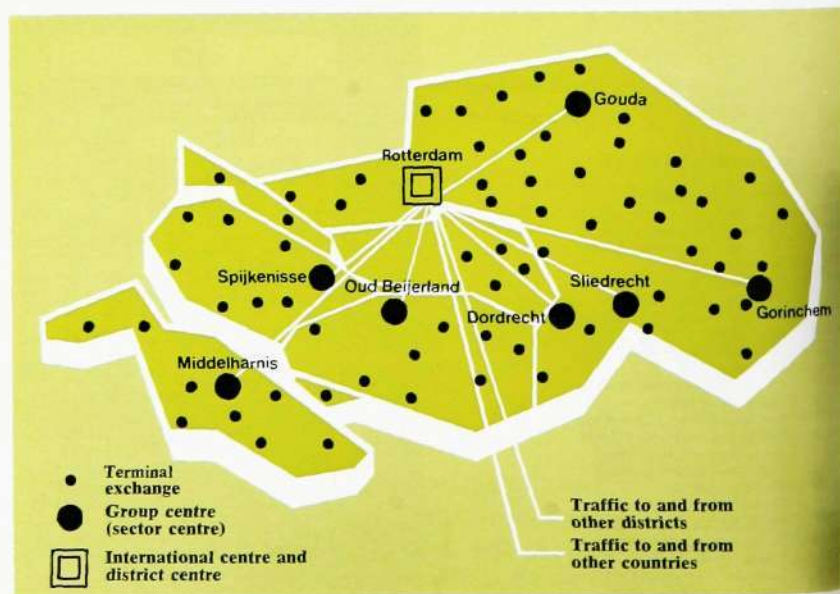
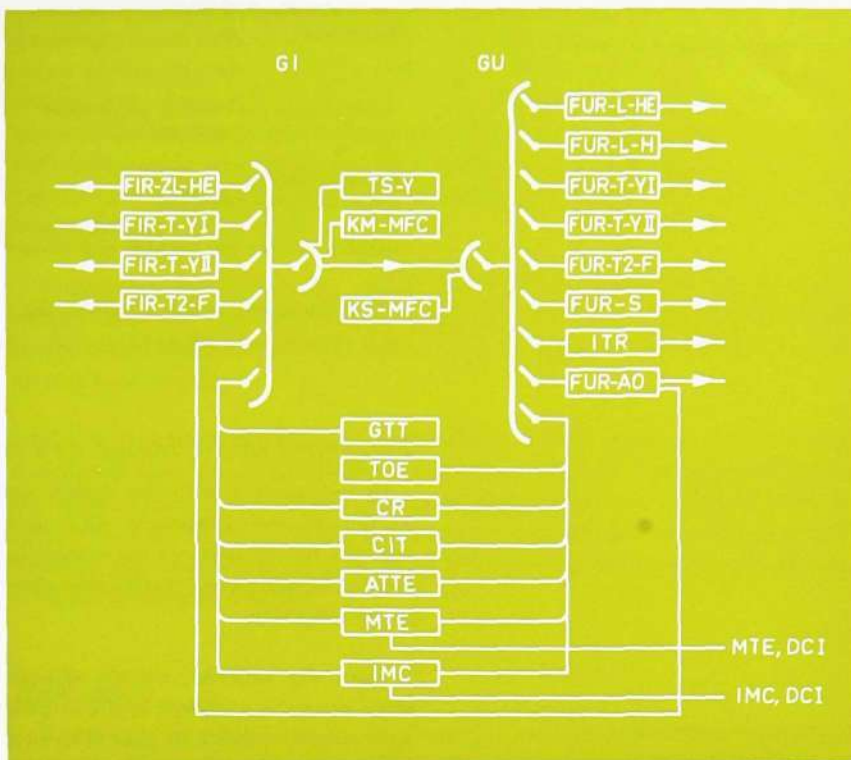


Fig. 5

Trunking diagram for AKE 131

- FIR-ZL-HE 2-wire MFC lines
- FIR-T-YI 4-wire MFC and DP lines
- FIR-T-YII 4-wire international MFC and DP lines
- FIR-T2-F 4-wire international 2VF lines
- FUR-L-HE 2-wire MFC and DP lines
- FUR-L-H 2-wire AGF lines
- FUR-T-YI 4-wire MFC and DP lines
- FUR-T-YII 4-wire international MFC and DP lines
- FUR-T2-F 4-wire international 2VF lines
- FUR-S 2-wire special service lines
- FUR-AO Lines for assistance operator
- ITR Lines to announcing machine
- KS-MFC Code sender for MFC traffic
- KM-MFC Code receiver for MFC traffic
- TS-Y Tone sender for 2nd ring tone and busy tone
- ATTE Automatic transmission equipment (Master and Slave)
- CIT Circuit tester
- CR Test desk in control room
- GTT Equipment for generation of test traffic
- IMC International maintenance centre
- MTE Manual transmission measurement equipment
- IMC, DCI Line to DCI for remote control of IMC
- MTE, DCI Line to DCI for remote control of MTE
- TDE Traffic observation equipment



## Operational Experience

The cut-over of Rotterdam DC II was preceded by extensive design work and laboratory tests. The first year of operation in Rotterdam has yielded much valuable experience which will benefit the entire AKE family and has confirmed that the system possesses excellent traffic and maintenance properties.

## Service Quality

From the subscribers' point of view the chief property of a telephone exchange is its service quality in various respects.

The traffic in the entire Rotterdam district is continuously supervised by a large number of traffic route testers (TRT), Rotterdam DC II being included in the test program. The tests show that the number of unsuccessful calls during the whole of 1972 owing to technical faults in DC II is around 1 per mille.

The transmission characteristics of the exchange have been measured during the period and proved to be within the limits recommended by CCITT.

As the AKE 131 system is very exact as regards signalling time measurement, it has been possible, by observation of the traffic via DC II, to discover faults in interworking exchanges which had earlier been difficult to trace (fig. 7).

The traffic handling capacity has also been measured and the correctness of earlier traffic calculations and simulations, both for the switching and data processing equipments, has been verified.

## Component Properties

The frequency of component failures for each part of the system is shown per rack and year in table 1. This is an essential parameter for deciding on the necessary maintenance effort. It must also be noted that the number of racks in an AKE 13 exchange is only half of that required in a conventional exchange of the same size.

Fig. 6  
The exchange building in Rotterdam



**Table 1**  
Frequency of component failures

Equipment	Number of racks	Failures/rack and year
Central data processing equipment	30	0.4
Test and operating equipment	17	1.82
IO	2	2.0
Code selectors	64	0.047*
Other switching devices	90	0.28

\* 0.00027 failures per vertical and annum

The tabulated values confirm the very good component properties of the AKE system, not least as regards the code switch.

### *Programs and Change of Programs*

In conjunction with the design and testing of programs for AKE 131 in Rotterdam and subsequent AKE exchanges, the necessary tools and working routines for all parts of the system have been successively extended. Changes during the design and installation phase could therefore be quickly incorporated in the programs.

Since the cut-over, certain changes of program have been made, due to some extent to a change in the original functional requirements. These changes have mainly related to improvements of function. Owing to the synchronous duplication of the processors all changes could be easily introduced during service.

In order to be able to introduce new functions and to prepare for extension of the exchange, and in conjunction therewith to finally rectify earlier weak points, a new edition of the exchange program was introduced with excellent result during January 1973.

### *Operational and Maintenance Measures*

Operational and maintenance measures in AKE 131 with associated network are initiated from eight typewriter terminals with the aid of some 150 commands (fig. 8). Examples of some such functions are traffic measurements, transmission measurements, changes of routing etc.

As more experience has been gained, the exchange has in due course been further touched up and the manuals for the operational staff have been successively improved.

Fig. 7

AKE 131 produces exact print-outs of weaknesses in its own and in interworking exchanges



### *System Restart and System Stop*

At the cut-over of a new complex system certain disturbances in conjunction with the introduction of regular traffic and increase of the traffic load are unavoidable. The disturbances which have arisen, however, have been quickly eliminated thanks to effective cooperation between the Netherlands PTT and LM Ericsson.

During the spring of 1972, for example, certain disturbances started in the form of increased system restarts and stops. The disturbances were most frequent in conjunction with alteration work, as is usual after cut-over of a new telephone system.

The object of system restart is briefly illustrated below. In order to avoid locking of the system the marker in a crossbar system is time-released if a fault occurs in, for example, a special switching operation.



**Fig. 8**  
Control room showing, among other equipment, typewriter terminal for commands

In a SPC system certain types of errors in programs and data might correspondingly cause locking of the system. To prevent this from happening a system restart occurs automatically. The system is thereby placed in a restart condition and can thereafter handle traffic again. Connections in progress are not disturbed thereby. The exchange staff can also set up system restart, e. g. in conjunction with fault tracing. The restart facility gives the system a satisfactory self-healing capacity and at the same time the traffic disturbances in this context are reduced to a minimum.

During the first months the number of system restarts increased on the introduction of new types of traffic and new lines. The causes of restart have been successively eliminated and their number has continuously diminished to a satisfactory level (fig. 9).

The system stops that have occurred with manually initiated restart have in most cases been due to a combination of several factors, e. g. imperfections in the maintenance system of the data processing equipment combined with incorrect manual operation owing to incomplete manuals for the operating staff. The necessary action was taken at all points so that the cause of the system stops could be eliminated (fig. 10).

## Summary

Rotterdam DC II has extremely advanced functions and in two respects is a pioneer in the world, namely as SPC transit centre and as multiprocessor-controlled exchange.

The new exchange has a very good service quality and the number of unsuccessful calls due to technical failures during 1972 was around 1 per mille. The excellent component properties are illustrated particularly by the fact that the code switch had only 0.00027 failures per vertical and year. Since the system works so exactly, furthermore, failures difficult to detect in interworking exchanges have been traced.

Since the processors work in parallel it has been easy to introduce changes of program and an entirely new program was introduced without disturbance in January 1973.

**Fig. 9 (left)**

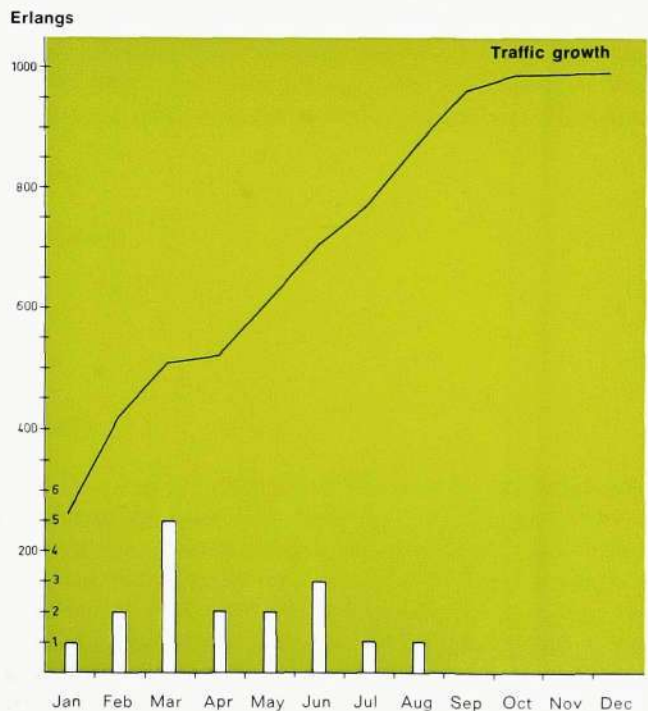
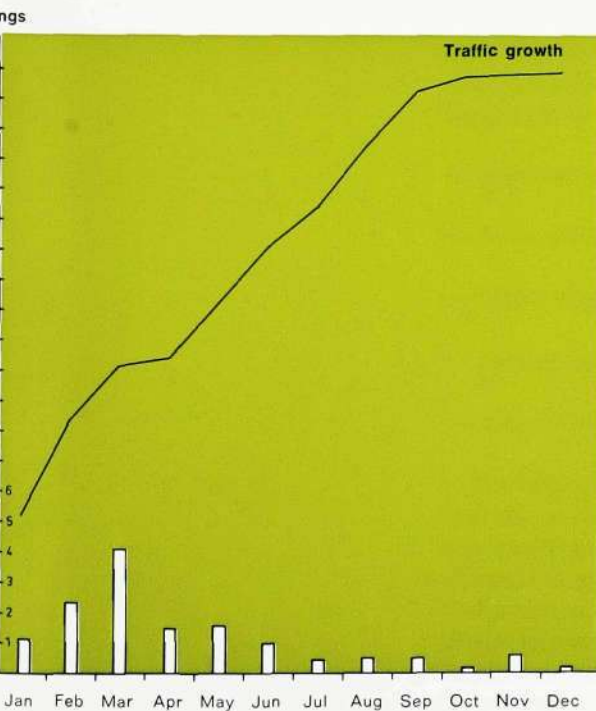
### Traffic growth and number of system restarts during 1972

The piles indicate the daily (8 a. m.—8 p. m.) average of automatic system restarts and of system restarts commanded by the staff during fault tracing. (Major alteration work was in progress during March.)

**Fig. 10 (right)**

### Traffic growth and number of system stops during 1972

The piles indicate the number of service stops per month (8 a. m.—8 p. m.). (Major alterations were in progress during March.)



The traffic handling capacity has corresponded to earlier calculations and simulations and temporary fluctuations of the traffic intensity have been entirely absorbed by the system.

In intimate cooperation between the Netherlands PTT and LM Ericsson failures have been analysed and remedied during a run-in period. This, in conjunction with other experience from the operation of the Rotterdam exchange hitherto, will be of benefit to all AKE exchanges.

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# New Equipments for FDM Carrier Terminals in the M4 Construction Practice

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*LM Ericsson today offers a complete range of f.d.m. (frequency division multiplex) equipments for assembling terminals for carrier systems providing 120, 300, 960, 2 700 and 10 800 telephone circuits. All equipments have been engineered in the M4 construction practice. Most of these equipments and the M4 design principles have been presented in earlier issues of Ericsson Review<sup>1-7</sup>. Several multiplexing equipments have now been modernized and, in various respects, substantially improved. In the following article the author gives further details on these modernizations.*

The main objective in developing the new equipment has been to take advantage of the latest achievements in modern electronics with respect to components and circuit design techniques while retaining the proven mechanical and electrical principles of the M4 construction practice. This has resulted in new equipment which is fully compatible with earlier M4 equipment and which has:

- improved performance
- lower power consumption
- higher reliability
- simpler maintenance
- reduced size and weight.

The redesigned equipment consists primarily of higher-order multiplex subsystems, such as a mastergroup translating equipment for assembling basic supermastergroups, supermastergroup modulating equipment providing a 900-channel line group, and supermastergroup translating equipment for assembling line groups of 2 700 and 10 800 channels. A new common frequency supply for carrier terminals providing up to 2 700 circuits has also been developed. In the diagram shown in the following section the redesigned equipments are indicated by non-coloured rectangles.

# Multiplexing Equipments

Fig. 1 shows the multiplex subsystems of which large-capacity terminals are made up. The modulation plans, which are shown in figs. 2 and 3, are in accordance with CCITT recommendations, both Plan 1 and Plan 2 being represented. This means that multiplex terminals can be made up either with or without the basic mastergroup occupying the 812-2 044 kHz frequency band as a basic block for interconnection.

Since the supermastergroup translating equipment for 60 MHz, i.e. for the formation of 10 800-channel line groups, has been described in detail in a recent article<sup>8</sup>, the present article deals with the multiplexing equipments for translating basic mastergroups into basic supermastergroups, for converting basic supermastergroups into 900-channel line groups and for translating basic supermastergroups and 15-supergroup assemblies into 2 700-channel line groups. These equipments have certain common characteristics, most of which are new, such as:

### The Modulators

The modulator design uses double-balanced transistor circuits, which provide good suppression of both direct leak and carrier leak. Thus very low values are obtained for the levels of these leaks as well as those of other interfering frequencies within the pass band. This is necessary, for example, in wideband data transmission, as stressed by the recent CCITT revision of its Recommendation G. 233 § k.

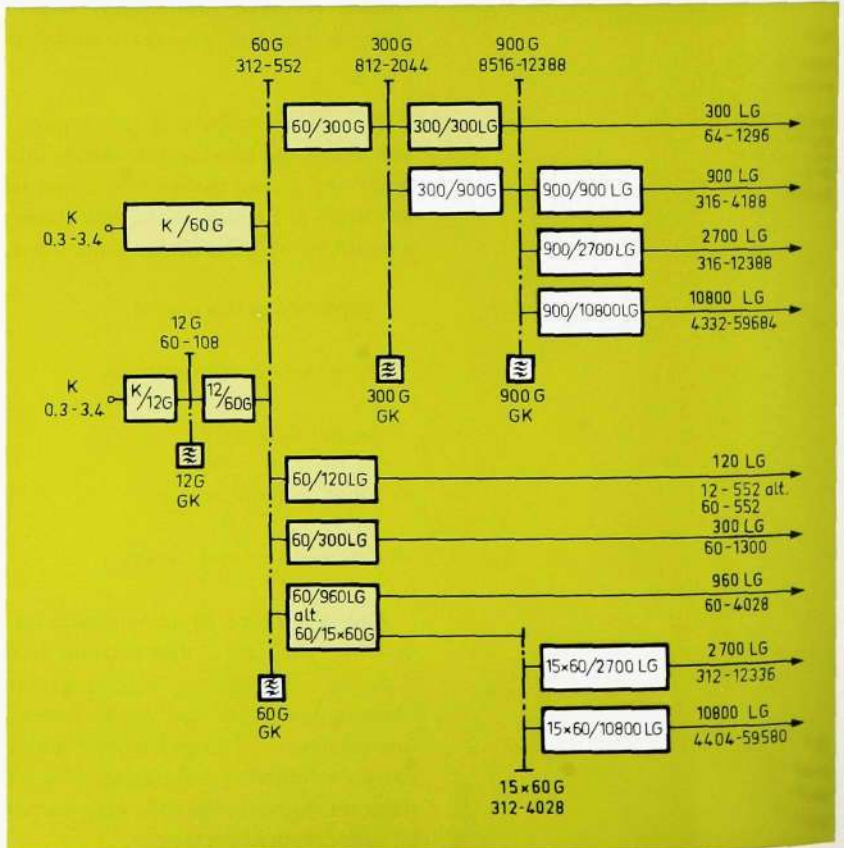
### The Combiners and Separators

These units combine the different batches of channels into the desired higher-order assemblies of channels, and vice versa. They use active circuits, i.e. the units include amplifiers to reduce transmission losses. The low impedance in conjunction with series resistors at the input of the combiner amplifier and at the output of the separator amplifier provide good decoupling between the associated mastergroup, supermastergroup or 15-supergroup assembly filters, permitting the multiplex subsystems to be partly equipped as desired, without the attenuation distortion in the pass bands being appreciably affected.

**Fig. 1**  
Multiplex subsystems of which medium- and large-capacity f.d.m. terminals for the formation of 120- to 10 800-channel line groups are made up

The upper part of the diagram shows multiplex subsystems including a 300-channel mastergroup stage, the lower part showing subsystems without mastergroup stage. (Non-coloured blocks denote redesigned equipment.)

- K channel
  - 12 G basic group
  - 60 G basic supergroup
  - 300 G basic mastergroup
  - 900 G basic supermastergroup
  - 15x60 G basic 15-SG assembly
  - LG line group
  - 120 LG 120-channel LG, etc.
  - GK through-connecting filter
- Frequencies in kHz



### The Station Cable Equalizers

These units, too, use active circuits. The equalizers serve to compensate for slope introduced by the station cabling. Equalization of up to 50 m cable is provided.

### The Amplifiers

The amplifiers have been incorporated in the same apparatus units that contain the combiners or separators and the station cable equalizers. A wideband design and certain switching facilities permit the same units to be used at several places in the new equipments. Thus fewer types of apparatus units are needed to make up a complete terminal, which is an advantage from the point of view of spares holding.

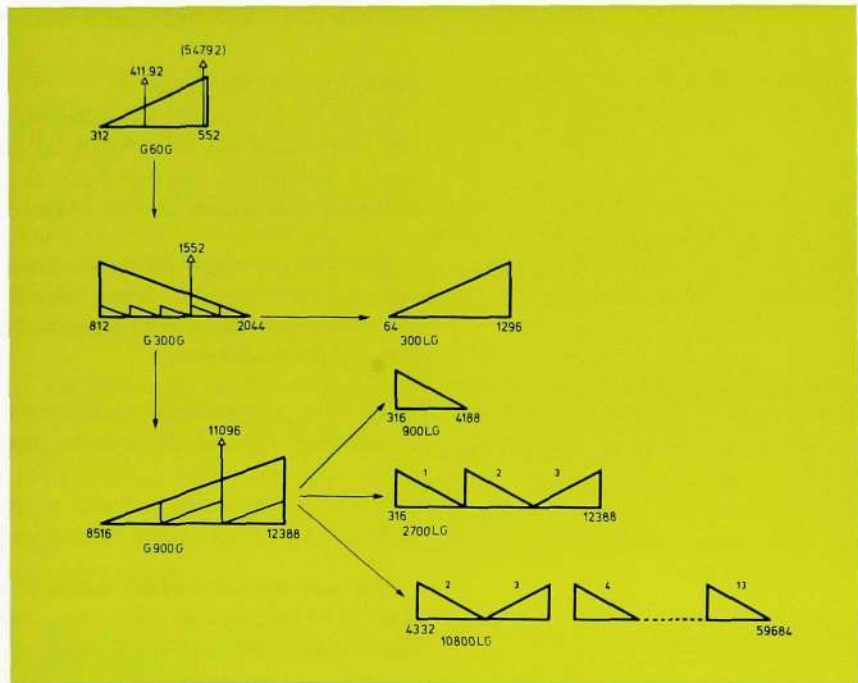
### Noise

The fact that all units have been designed using active circuits prevents transmission levels falling to too low a value; the lowest level is -37 dBr, giving favourable noise characteristics.

**Fig. 2**  
Frequency arrangements for terminals using mastergroup allocations

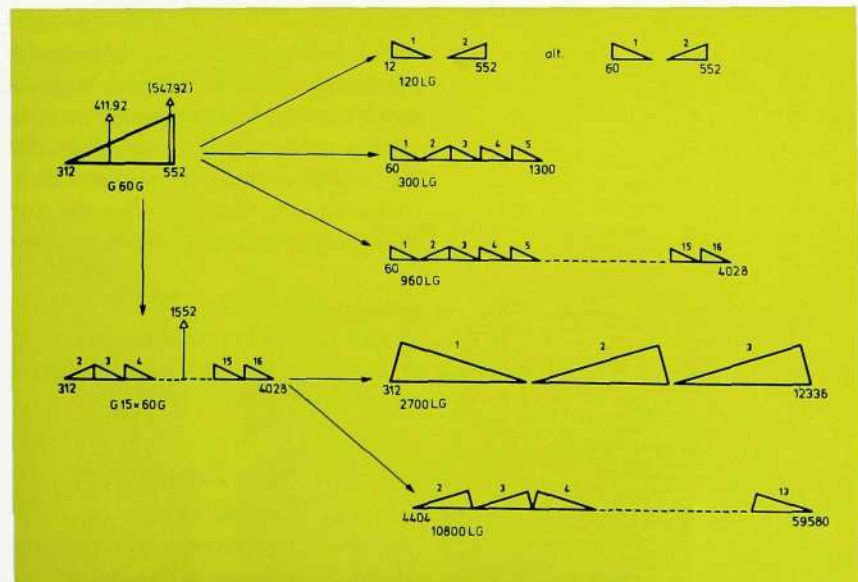
The triangles on the left symbolize basic supergroups (G 60 G) etc., those on the right line frequency bands, e.g. 300-channel line group (300 LG), etc.

Frequencies in kHz



**Fig. 3**  
Frequency arrangements for terminals using supergroup allocations

Frequencies in kHz



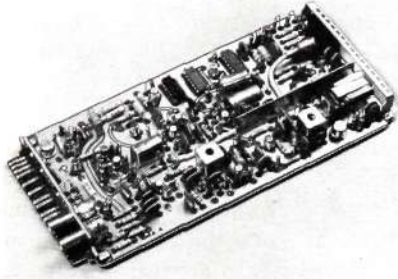


Fig. 4  
Phase-locked oscillator 13 200 kHz

### Duplicated Outlets

All units for batches of 300 or more channels have duplicated outlets following the cable equalizer. These outlets are mutually decoupled, so that one of them can be used, for example, as extra outlet for

- extension to a test point at a central position in the station, e.g. a distribution frame
- connection of a recorder
- automatic switching to standby routes.

### Test Points

Besides the previously mentioned test points there are easily accessible test points for maintenance and fault location purposes. Short-circuit-proof maintenance test points are provided at all outputs, so that a short circuit will not noticeably affect the transmission level in the system and possible poor matching at the output will not affect the test level. At all inputs, as well as at certain other suitable locations, fault location test points facilitate fault tracing. These points, too, are protected against short circuits.

### Phase-locked Oscillators

Up to the present the technique usually employed for the generation of carrier frequencies has been based on the use of harmonic generators and frequency multipliers supplied from a centralized master oscillator equipment, with basic frequencies such as 124 and 440 kHz.

The disadvantage of this technique is that impurities in the basic frequencies, such as *superimposed hum and noise, increase in level in the carrier frequencies* in proportion to the multiplication factor, and are then fed into the transmission path via the modulators.

By using *phase-locked oscillators* the effect of such disturbances can be considerably reduced. In addition, these oscillators are much less sensitive to level variations, which facilitates the distribution of basic frequencies. Both from the economic and technical points of view, the use of phase-locked oscillators provides attractive solutions to system problems.

The basic operation of the oscillator involves a simple crystal oscillator which is tuned to the required carrier frequency and which feeds an appropriate modulator and demodulator via two mutually decoupled outlets.

To achieve the requisite frequency stability, the oscillator is driven by means of a basic frequency as follows:

The oscillator frequency is divided in a frequency divider such that it obtains the nominal value of the basic frequency; the signal thus obtained is then compared with the basic frequency in a phase detector. The detector provides a d.c. voltage proportional to the phase difference between these two signals. This d.c. voltage controls the oscillator continuously, thereby maintaining the correct frequency, and thus providing the required frequency stability. A phase-locked 13 200 kHz oscillator is shown by way of example in fig. 4.

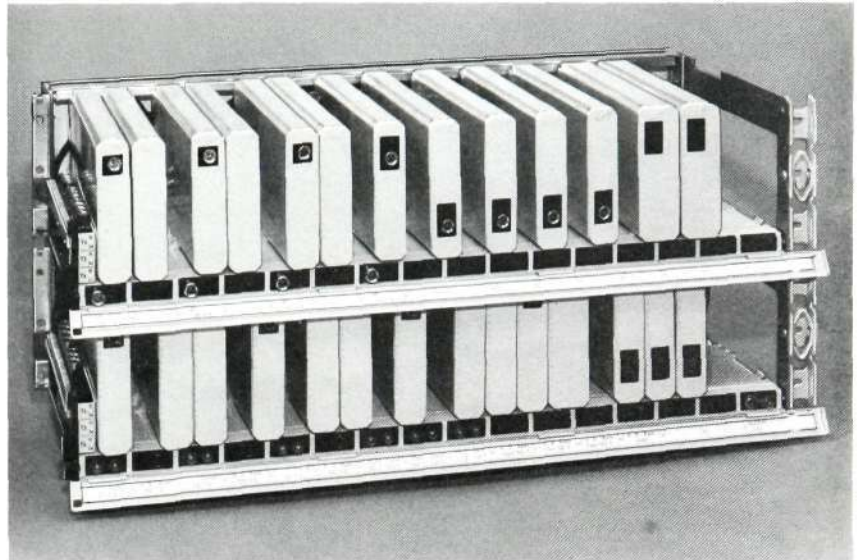
### Individual Pilot Receiver

Individual pilot receivers are used for supervision and regulation of the mastergroup and supermastergroup levels. A more detailed description of them will be found below.

## Multiplexing Equipment Design

The multiplexing equipments for translating three basic mastergroups into one basic supermastergroup and three supermastergroups or 15-supergroup assemblies into one 2 700-channel line group each occupy one stack of two

**Fig. 5**  
**Mastergroup translating shelf stack for the formation of a basic supermastergroup**



shelves, the supermastergroup modulating equipment for converting one basic supermastergroup into a 900-channel line group occupying a single shelf. The various shelf assemblies are shown in figs. 5, 6, 7 and 8.

Since the various multiplexing equipments are similar in design and differ mainly in those sections which are selective, e.g. filters, only one of them is presented in some detail. For this purpose the supermastergroup translating shelf stack has been chosen; the relevant modulation plan and block diagram are shown in figs. 9 and 10 respectively.

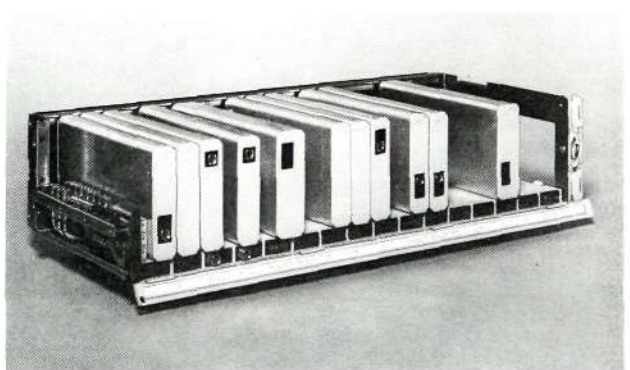
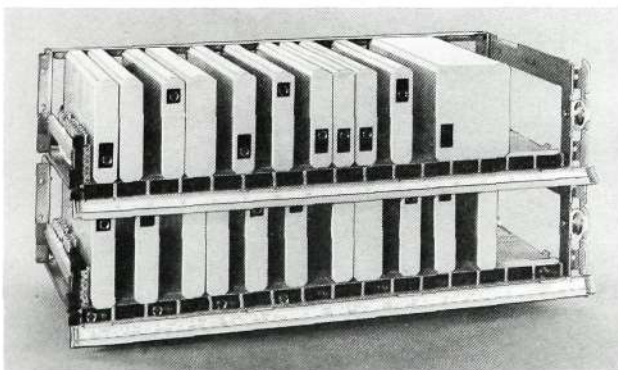
The 2 700-channel line frequency band is normally assembled by translating three basic supermastergroups 8 516-12 388 kHz in accordance with CCITT Recommendation G. 332, Plan 1A. In certain applications it may be convenient to replace supermastergroup 1 with the basic 15-supergroup assembly 312-4 028 kHz in accordance with CCITT Recommendation G. 332, Plan 1B. The same shelf stack can be used for both alternatives after replacement of the apparatus units concerned.

The generation of the carrier frequencies 12 704 and 16 720 kHz uses phase-locked oscillators.

In the receive path a pilot receiver for 11 096 kHz is provided at the output of each demodulator. Where supermastergroup 1 has been replaced with a basic 15-supergroup assembly, which includes the 1 552 kHz pilot, this frequency is converted into 11 096 kHz by means of a carrier of 12 648 kHz, which is obtained from a separate phase-locked oscillator shown at the bottom of the block diagram, fig. 10.

**Fig. 6 (left)**  
**Supermastergroup translating shelf stack for the formation of a 2 700-channel line group**

**Fig. 7 (right)**  
**Supermastergroup modulating shelf for the formation of a 900-channel line group**



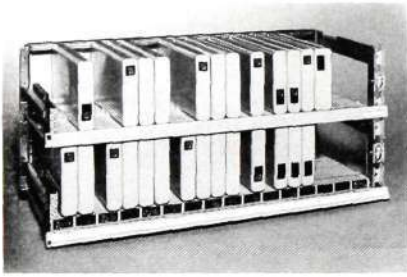


Fig. 8  
Shelf stack for translating three basic 15-supergroup assemblies into a 2700-channel line group

## Level Supervision and Regulation

To compensate for the level variations which will inevitably occur in carrier systems and to simplify maintenance and fault location, equipment for automatic level regulation with alarm facilities is provided in the receive paths of all basic groups, supergroups, etc.

In the multiplexing equipments yielding basic groups and supergroups, use is made of centralized pilot receivers providing level regulation in steps. This equipment has been described in detail in an earlier issue.<sup>9</sup>

In the redesigned equipments for the higher modulation stages, however, an individual pilot receiver is provided for each basic mastergroup and supermastergroup or 15-supergroup assembly, which permits the levels of the received pilots to be supervised continuously and individually. The need for such facilities has arisen since recent discussions have shown that the introduction of supermastergroup switching equipment into the network is to be expected in the near future. Automatic supermastergroup switching here implies switching to a standby route in the event of a fault occurring in the transmission path. In addition, the continuous supervision equipment provides for direct connection of recorders for level recording.

The pilot receiver for a supermastergroup is designed for operation from the 11 096 kHz pilot frequency (fig. 11). With the aid of a built-in modulator the same receiver can be used for basic mastergroups using the 1 552 kHz pilot frequency. The modulator is supplied with the 12 648 kHz carrier frequency. The equipment for the generation of this frequency is included in the mastergroup translating shelf concerned.

After filtering, amplification and rectification, a d.c. voltage proportional to the pilot level is produced in the pilot receiver. This voltage then serves to control a number of logic circuits which provide the desired output functions. Besides outlets for a signal to control supermastergroup switching and a d.c. signal for level recording, there is a d.c. voltage outlet controlling a thermistor-type a.g.c. network included in the transmission path. In addition, there are outlets providing various types of level information serving to initiate alarms.

The signal which controls supermastergroup switching is initiated by a sudden fall in level of more than 9 dB, and can be sent out either immediately following a pilot failure or after the pilot signal has been absent for more than 300 milliseconds. It is also initiated by a level error of more than 4 dB which cannot be corrected by regulation.

Separate alarm circuits indicate when output level errors exceed 4 and 1.5 dB respectively. However, in order that sudden variations within the regulation range shall not give an alarm, this is delayed for 40 seconds to allow the regulator time to act. Hence only excessive level errors remaining after regulation are indicated.

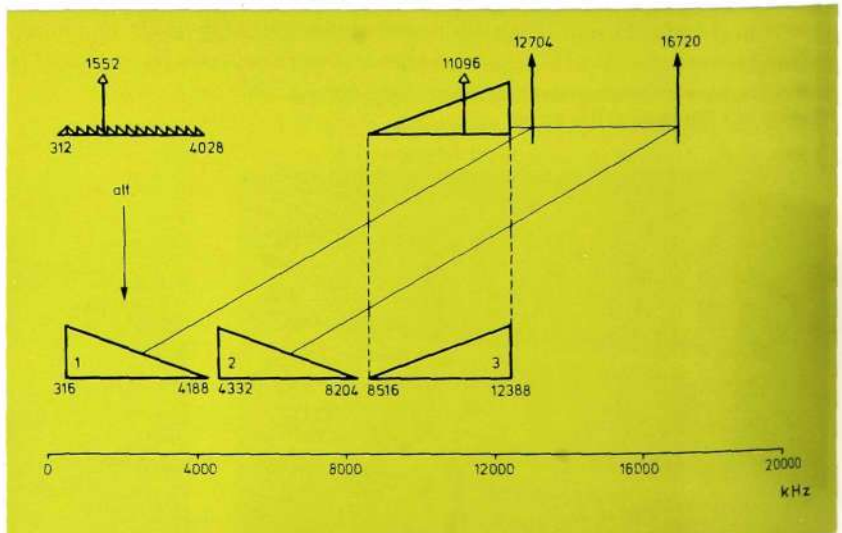


Fig. 9  
Modulation plan for assembling three basic supermastergroups into a 2700-channel line group

Alternatively, a basic 15-supergroup assembly can be substituted for supermastergroup No. 1 (in accordance with CCITT Plan 1B)

Fig. 10

Block diagram for supermastergroup translating equipment providing 2 700-channel line groups in accordance with CCITT Plan 1 (A and B)

Top: send path; centre: receive path; bottom: carrier generating equipment. Frequencies in kHz. Units marked with \*) can be exchanged for alternative units handling 15-supergroup assemblies (in accordance with CCITT Plan 1B)

F Fault location test points  
M Maintenance test points

- Amplifier
- Cable equalizing network
- Band-pass filter
- Low-pass filter
- Modulator or demodulator
- Rectifier
- Phase discriminator
- Frequency converter
- Oscillator

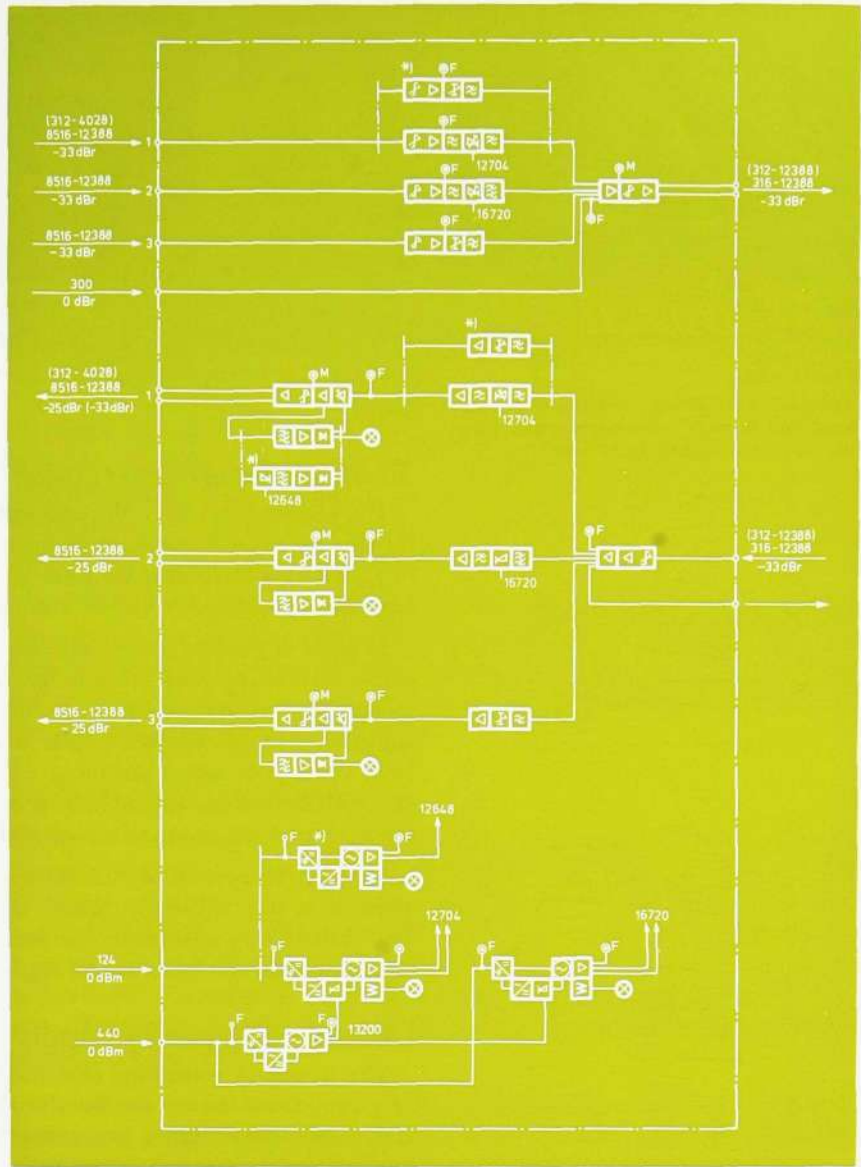
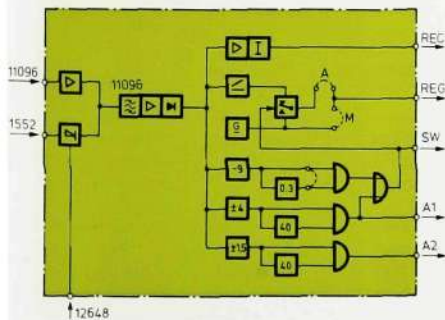


Fig. 11

Individual pilot receiver for 1 552 and 11 096 kHz

- A, M Manual switching between automatic level regulation and fixed gain
  - REC To recorder
  - REG Regulating current for level regulation
  - SW Control signal for supermastergroup switching
  - A1, A2 Alarms for level deviations of more than 4 dB and 1.5 dB respectively
- Frequencies in kHz

- Fixed d.c. generator
- Control current generator
- Level discriminator (level deviation from nominal value > 4 dB)
- Delay circuit (40 seconds)
- AND gate
- OR gate



## Through Connection Filter

To prevent crosstalk between adjacent batches of channels in through connection, use must be made of through-connection filters providing well-defined limits for the batches of channels concerned.

Filters are available for the through connection at basic frequencies of all four different batches of channels, i.e. basic groups, supergroups, mastergroups and supermastergroups. Fig. 1 illustrates these filters at the interconnection points between the different modulation stages of the multiplex. Two of these filters have been redesigned, viz. those for the basic supergroup and supermastergroup. The filter sets have been designed as three mutually well-screened assemblies, the two filter sections being separated by an amplifier.

A standard shelf for through supergroup or supermastergroup connection can accommodate four such filter sets, corresponding to two through connections in both directions of transmission (fig. 12). The attenuation/frequency distortion in the pass band of the through supermastergroup filter is shown by the characteristic curve in fig. 13.

## Through Supergroup Filter

The filter has attenuation peaks for 308 kHz and 556 kHz as standard, though no crystals are employed. In addition, the same filter can be used with either

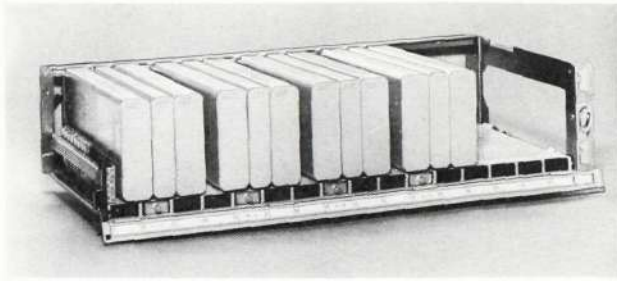


Fig. 12 (left)

Shelf for through supermastergroup filters

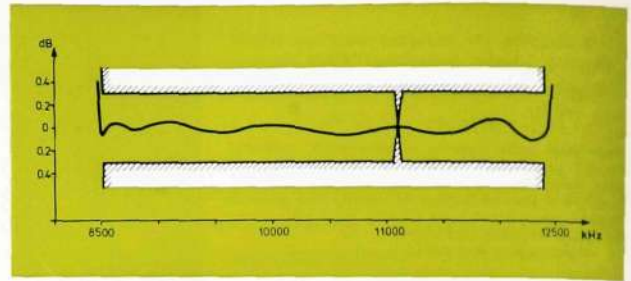


Fig. 13 (right)

Attenuation/frequency distortion in pass band for through supermastergroup filter, the curve representing an average

of the supergroup pilots 411.92 kHz or 547.92 kHz as reference frequency, with unchanged performance regarding attenuation/frequency distortion in the pass band.

### Through Supermastergroup Filter

The requirements for a through supermastergroup filter proposed so far by the CCITT, i.e. with complete protection for all the supermastergroup positions in 12 MHz systems, cause the filter to be too large and expensive. The problem has been noticed by the CCITT and is being studied.

In order to provide an economically justified through-connection filter alternative even today, L M Ericsson has developed a filter which utilizes the stop attenuation already present in the filters of the supermastergroup translating equipment. In this manner a filter is obtained having a performance, dimensions and a price which remain at a level both realistic and optimal in respect of 12 MHz systems. In addition, it meets fully the requirements for through supermastergroup connection in 60 MHz systems, Plan 1.

Through connection in 60 MHz systems in accordance with Plan 2 can be effected in two frequency bands, viz. 312-4 028 kHz and 8 620-12 336 kHz. The multiplexing equipment has been designed in such a way that external through-connection filters can be dispensed with in either case.

### Common Frequency Supply

The frequency generating equipment for carrier terminals consists basically of a centralized master oscillator with basic frequency generating equipment and decentralized carrier generating equipments incorporated in the various multiplexing equipments, where the basic frequencies are used for generating the carrier frequencies required for the modulators. The pilot frequencies, however, are generated in the centralized frequency supply for simplicity of maintenance.

A choice can be made from three different common frequency supplies according to the capacity of the carrier terminal concerned, viz.:

- ZAF 04 for large-capacity stations with multiplex systems up to 60 MHz
- ZAF 05 for medium-capacity stations with 4 MHz and 12 MHz multiplex systems
- ZAF 03 for smaller-capacity stations with multiplex systems up to 1.3 MHz.

Table 1 shows the master oscillator frequencies with data on stability for the respective common frequency supplies.

Common frequency supply	Master oscillator frequency (kHz)	Maintenance intervals			
		1 month		3 months	
		Frequency stability	Multiplex system capacity (ccts)	Frequency stability	Multiplex system capacity (ccts)
ZAF 04	2 500	$\pm 10^{-8}$	$\leq 10\ 800$	$\pm 10^{-8}$	$\leq 10\ 800$
ZAF 05	4 960	$\pm 5 \cdot 10^{-8}$	$\leq 2\ 700$	$\pm 10^{-7}$	$\leq 960$
ZAF 03	12	$\pm 5 \cdot 10^{-7}$	$\leq 300$	$\pm 10^{-6}$	$\leq 120$



Table 1

Common frequency supply

The table shows the relationship between multiplex system capacity and maintenance intervals

**Fig. 14**  
Common frequency supplies for large- and medium-capacity f.d.m. carrier terminals

Both systems can be supplemented to generate the following pilot frequencies: additional group reference pilot 84.14 kHz and supergroup reference pilot 411.86 kHz, and alternative frequency comparison pilot 308 kHz. The blocks on the right indicate equipments for frequency checking in the respective common frequency supplies. Frequencies in kHz

-  Crystal oscillator with temperature regulation
-  Instrument for visual frequency comparison

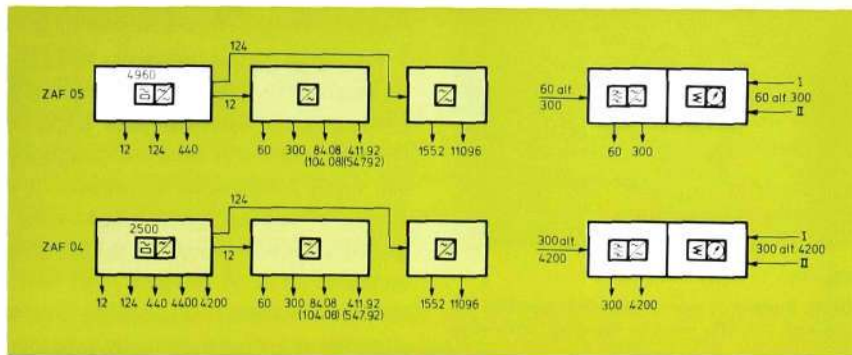


Fig. 14 shows the basic configuration of the two common frequency supplies for large- and medium-capacity stations, systems ZAF 04 and ZAF 05. The diagram shows the carrier basic frequencies and pilot frequencies that can be obtained from these systems. All frequency supplies are duplicated and provided with automatic changeover facilities, except those for the frequency comparison pilots, where changeover is effected manually.

A detailed description of the centralized frequency generating equipment has been given in an earlier issue<sup>10</sup>, so that this article is confined to novel features that have been introduced, such as a new equipment for the generation of carrier basic frequencies, the generation of some new pilot frequencies as well as two new frequency checking equipments.

### Basic Frequency Generation

The new equipment for generation of carrier basic frequencies 12, 124 and 440 kHz employs a master oscillator generating a frequency as high as 4 960 kHz from which the necessary basic frequencies are obtained by means of frequency dividers. As a result, superimposed hum and noise are correspondingly reduced and this, together with the use of phase-locked oscillators in the associated carrier generating equipments, makes it easier to meet the more stringent requirements for low hum and noise levels in multiplex systems recently proposed by the CCITT.

The master oscillator has a frequency stability of  $\pm 5 \cdot 10^{-8}$  per month and, as may be seen from table 1, can be used in carrier systems providing up to 2 700 circuits.

All the duplicated equipment for generating the carrier basic frequencies 12, 124 and 440 kHz, including changeover units, is accommodated on a single shelf. The electrical design is illustrated in fig. 15, the mechanical design being shown in fig. 16. The master oscillator contains a quartz crystal unit enclosed in a temperature-controlled oven to ensure the necessary frequency stability. The frequency conversion from 4 960 kHz to the required carrier basic frequencies is achieved by means of a single unit per frequency.

Each chain of generating equipment is completed with a changeover unit; if the level of the regular equipment falls by more than 2-3 dB, this unit will automatically switch the load to the standby equipment. The unit includes alarm facilities.

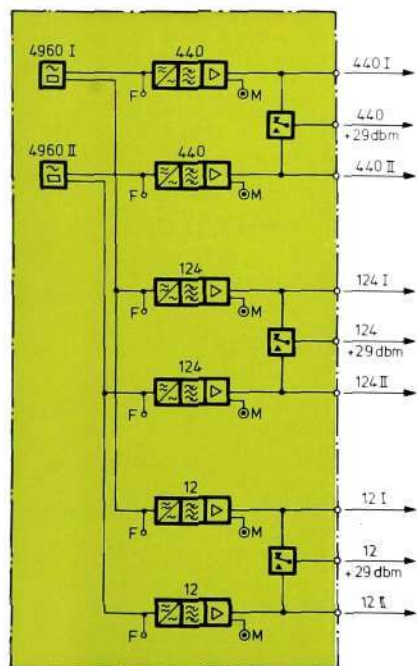
### Pilot Generation

In addition to the common group and supergroup pilots 84.08 and 411.92 kHz (as well as 84.14 and 411.86 kHz), the edge pilots 104.08 and 547.92 kHz can now be provided. These pilots permit groups and supergroups to be used for the transmission of wideband signals, e.g. data, and have so far been systematically used mainly in satellite systems.

As an alternative to the frequency comparison pilots 60 and 300 kHz the 308 kHz pilot frequency can now be generated by means of a separate equipment.

**Fig. 15**  
Generation of carrier basic frequencies 12, 124 and 440 kHz in the ZAF 05 system

Outlets with +29 dBm level are used for distribution to local carrier generating equipments. Other outlets feed other frequency generating equipment, etc.  
Frequencies in kHz



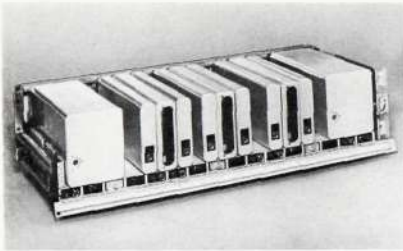


Fig. 16

Basic frequency generating shelf yielding 12, 124 and 440 kHz used in the ZAF 05 system

## Frequency Checking

To enable the two master oscillators to be synchronized with each other or with an external reference frequency, all pilot generating shelf stacks that generate a frequency comparison pilot are provided with frequency checking equipment. The beat method is used for frequency comparison, i.e. the equipment combines two input frequencies to produce a difference frequency. The difference frequency is indicated on an indicating instrument and can also be applied to a recorder. Synchronism of the frequencies is obtained by adjusting the master oscillator so as to produce zero beat on the instrument. A beat duration convenient for instrument reading is obtained by multiplication of the input frequencies to a higher frequency before frequency comparison.

### Frequency Checking Equipment for 60 and 300 kHz as well as for 300 and 4 200 kHz

In a transmission network it is common practice to appoint the master oscillator in a certain station to act as a national frequency standard.

The frequency comparison pilot sent out by this station must therefore be distributed to all other stations in the network where synchronization is to be carried out. For this purpose, intermediate stations must be provided with equipment for through connection of this pilot.

The frequency of the frequency comparison pilot depends on the size of the system. Since several systems may occur in a network, facilities should also be provided to permit one pilot frequency to be converted into another in through connection.

Two equipments are now available, one for through connection of 60 or 300 kHz in combination with pilot conversion from 60 to 300 kHz or vice versa, and a corresponding equipment for 300 and 4 200 kHz. The former is designed for networks with 4 MHz and 12 MHz systems, the latter for 12 MHz and 60 MHz systems.

The two equipments, shown in fig. 14 (far right), are similar in design and contain facilities for frequency checking as well as for through connection

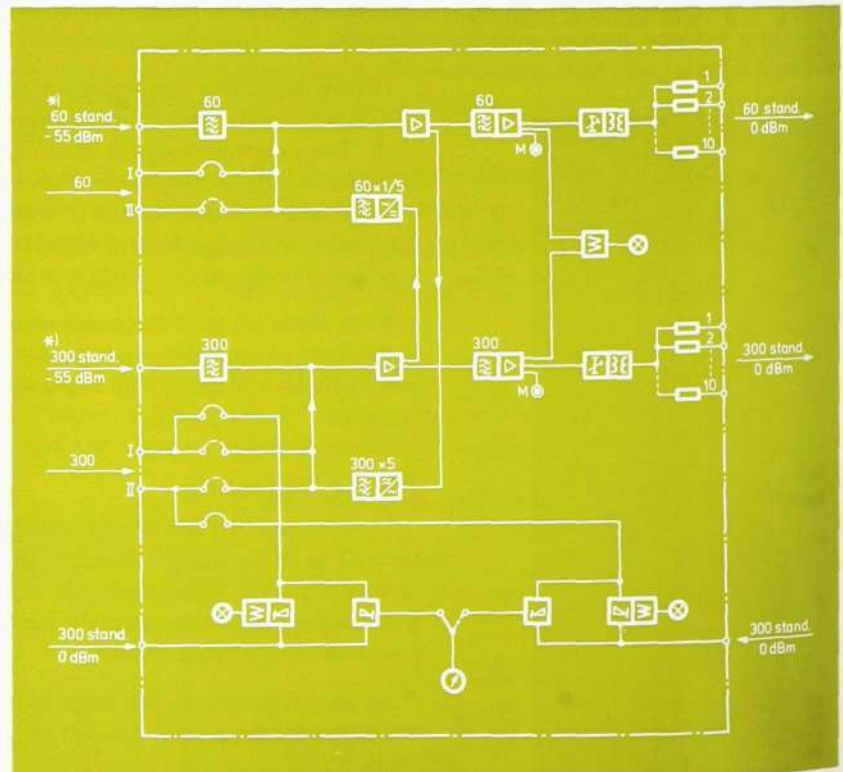


Fig. 17

Frequency checking shelf for frequency comparison pilots 60 and 300 kHz

The upper half of the figure shows equipment for through connection of 60 or 300 kHz as well as distribution and conversion of these frequencies. The lower half shows equipment for manual frequency checking and automatic frequency supervision

60 I, 60 II, 300 I and 300 II: Locally generated pilots

60 stand. and 300 stand.: National standard frequencies

\* Along with the line frequency bands 60—4 028 kHz and 312—12 388 kHz (316—12 336 kHz) respectively

Frequencies in kHz

and frequency conversion. One of them, the frequency checking shelf for 60 and 300 kHz, is shown in more detail in fig. 17. The upper half of the figure shows the through-connection and frequency conversion equipment, the lower half showing the frequency checking equipment. A frequency comparison pilot, 60 or 300 kHz, received from a line system is applied to the through-connection equipment together with the line frequency band concerned. This equipment selects and amplifies the pilot for distribution to outgoing line systems. The purity of the pilot is then so high that no crosstalk between different line systems will occur.

After filtering, the pilot frequencies can be converted by multiplication or division to produce the alternative frequency, which is then further distributed.

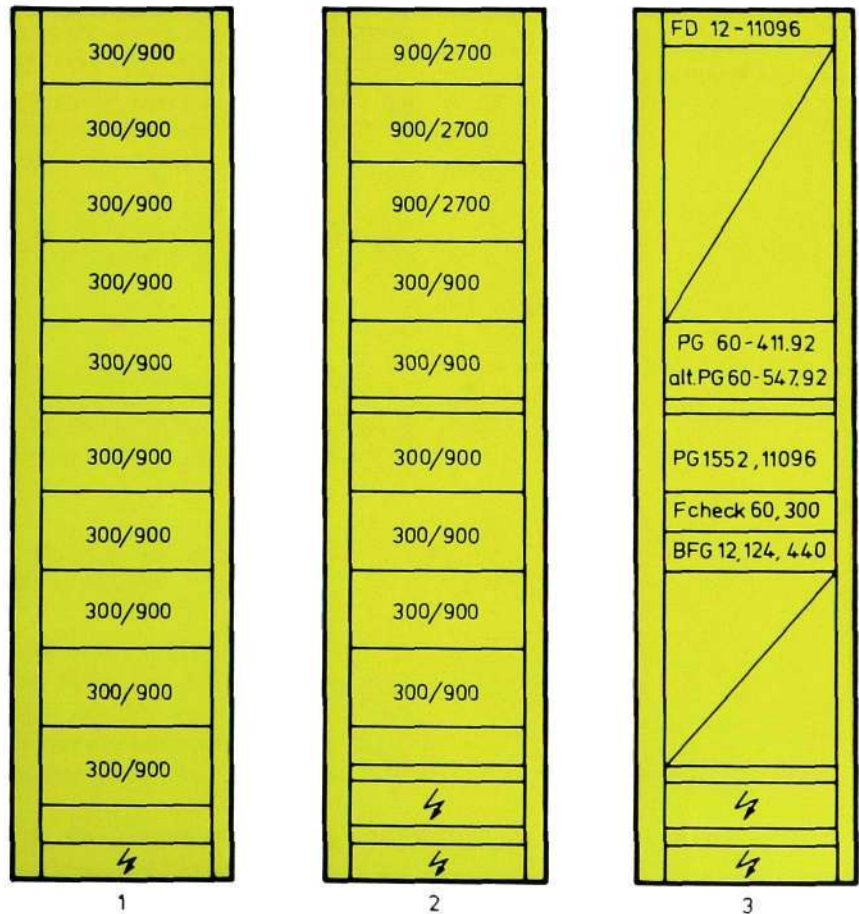
To make routine frequency checking unnecessary, both frequency checking equipments can be supplemented with facilities for automatic frequency supervision which send out an alarm when a frequency deviation exceeds a certain limit. This limit can be preset to different values by strapping.

The frequency checking shelf contains two identical sets of equipment for automatic frequency supervision. Each set can be fed with the frequency comparison pilot from one of the two local master oscillators (regular or standby) and the pilot derived from the national frequency standard. Thus both master oscillators can be continuously supervised, if desired in conjunction with a level recorder.

### Bay Arrangements

The various shelves and shelf stacks can be combined into a range of systems and subsystems.

They can be mounted in bays to suit the requirements of virtually any individual application. A few examples of bays housing the redesigned equipments are given in fig. 18. The first bay shown contains only one type of trans-



**Fig. 18**  
**Examples of bay layouts**

- 1 Bay frame containing only one type of translation equipment (300/900 = mastergroup translating equipment yielding basic supermastergroups)
- 2 Bay frame combining two translation stages (900/2700 = supermastergroup translating equipment yielding 2700-channel line groups)
- 3 Bay frame containing ZAF 05 common frequency supply

FD Frequency distributing shelf  
 PG Pilot generating shelf stack  
 F check Frequency checking shelf  
 BFG Basic frequency generating shelf

lation equipment, whereas the second bay combines equipment representing two modulation stages and contains duplicated power packs. The third example shows a common frequency supply for multiplex systems providing up to 2 700 circuits. The unused space can be utilized to accommodate translation equipment.

## Summary

This article has described certain modernized and redesigned multiplexing equipments engineered in the M4 construction practice; together with other equipment they now constitute a complete and modern range of multiplex sub-systems for assembling f.d.m. carrier terminals providing up to 10 800 circuits.

The modular design principles provide a high degree of flexibility in station planning. Transmission performance has been made to conform to the more stringent requirements applying today. With the facilities offered by the M4 design, equipments are obtained which require minimum maintenance.

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# ERICSSON *News*

from All Quarters of the World

## Highlights from Ericsson Group 1972 Annual Report

The 1972 Annual Report of the Ericsson Group, the distribution of which started during May, contains among other matter an account of the technical development during the year. The main points in the development and the chief figures from the financial statement are presented below.

■ Within ELLEMTEL, owned on a 50/50 % basis by the Swedish Telecommunications Administration and L M Ericsson, development is continuing on a computer-controlled local exchange system.

■ Work is proceeding on the introduction of computer control in crossbar switching systems, and field tests have started.

■ Field tests which are in progress on a new international signalling system in a computer-controlled transit exchange in Australia have shown satisfactory results.

■ The first computer-controlled PABX developed by the French subsidiary Société Française des Téléphones Ericsson has been installed. The PABX has a very large capacity.

■ At A/S Elektrisk Bureau in Norway a combined PABX and transit exchange has been developed for communication networks in conjunction with power distribution.

■ Development of a new PMBX based on electronic components has been completed at the parent company.

■ The work on the picture telephone has now advanced so far that an introduction on a limited scale is possible.

■ Developments within the pulse code modulation (PCM) field have been intensified at the parent company.

■ Work on an all-electronic controller for street traffic signalling has been completed at the parent company.

■ At AB Rifa a new technique has been developed for the production of monolithic microcircuits which can work with the battery voltages used in telephone systems.

■ The Group invested in 1972 about \$75 million on technical development.

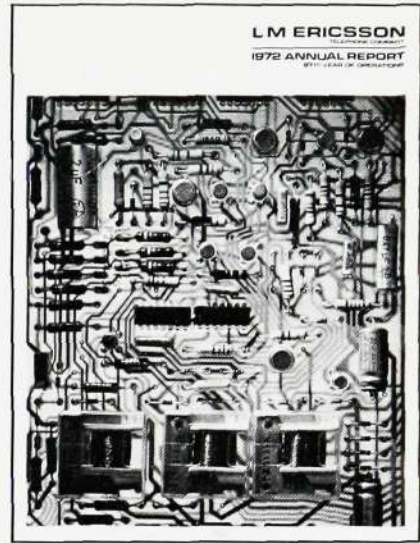
### *From the Financial Summary*

■ Group order bookings increased during 1972 by 18.1 % to \$1054 million.

■ Sales increased by 14.2 % to \$892.8 million.

■ Income before special adjustments and taxes was \$112.4 million. The chief markets were Sweden (19 %), Europe excluding Sweden (49 %), Latin America (19 %).

■ The number of employees within the Group was 70,650, of whom 27,400 in Sweden.

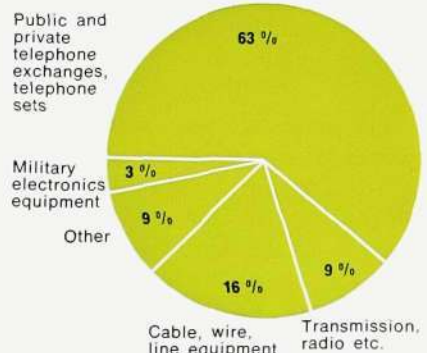


### *\$ 89m order to Ericsson do Brasil*

Ericsson do Brasil, a subsidiary of the Ericsson Group, has received an order worth about \$89m for equipment and installation of new telephone exchanges in the city of São Paulo. This is the last order under the general agreement signed a year ago between the telephone operating company in São Paulo and Ericsson do Brasil for delivery of equipment for 500,000 subscriber lines over a five-year period.

Deliveries and installation of most of the equipment ordered will be concluded by the middle of 1976 and the final delivery will be made towards the end of 1977.

The major part of the contracted equipment will be manufactured at Ericsson do Brasil's plant in São José dos Campos near São Paulo. This company, which holds a leading position on the market for equipment of the Brazilian public telephone network, is quickly expanding.



**Breakdown of Group sales by different product groups**

## New computer system for telephone exchanges developed by Ericsson

L M Ericsson Telephone Company has developed a new computer system for telephone exchanges. The new system, which has been developed primarily for crossbar exchanges, will make it possible to introduce a number of new facilities aimed at improving the service for subscribers as well as telephone administrations.

The system can either be used as an integrated part of a new crossbar exchange or for modernization of existing exchanges of this type. This modernization means that old exchanges can be up-dated to a technical level closely corresponding to that of today's computer-controlled exchanges. As, since 1950, L M Ericsson has delivered crossbar exchange equipment to serve more than 10 million subscriber lines throughout the world, the market potential for the new system is considerable.

The computer system offers particular advantages to telephone administrations for new as well as existing exchanges. In the case of old installations, these can be up-dated to the technical level that corresponds to the demands for facilities and performance which are expected to arise during the foreseeable future. Operation and maintenance can be further rationalized and centralized, partly due to the electrically variable memories that are incorporated in the system. This means that telephone exchanges can be easily adapted to serve new traffic demands by feeding them with new instructions from an electric typewriter. Adaptations of this kind in old exchanges previously called for extensive and costly manual operations.

For telephone subscribers the new system offers considerable advantages by enabling new service facilities to be programmed into the system and offered to the individual subscriber.

Substantial orders for the new system have already been received from telephone administrations in the Scandinavian countries.

## LM Ericsson's first automatic telephone exchange completes 50 years of service

On May 10, 1973, it was exactly 50 years since the first automatic telephone exchange for local service was put into operation in Rotterdam. The exchange, which is still giving faultless service to its subscribers, was the first of the Ericsson 500-line selector type to be installed anywhere in the world.

The 50-year jubilee was celebrated by the Dutch Telephone Administration at a ceremony at which particular emphasis was placed on the reliability of the 500-line selector.

Since 1923 Ericsson have delivered 500-line selector equipment to serve more than 5 million subscribers throughout the world. The Swedish telephone network was to a large extent automatized with this type of exchange. Today Ericsson's 500-line selector still serves subscribers in the Stockholm 08 area.

The 500-line selector remains in series production despite the arrival of more modern equipment such as Ericsson crossbar and computer-controlled exchanges — a good proof of the reliability and technical viability of the 500-line selector.

## Première in Norway for electronically controlled exchanges

The first exchanges of the Ericsson semi-electronic rural system, based on code switches, type AKK 50, were connected to the public telephone network in Aremark, Norway, at the end of February 1973. The system contains the most modern electronic components, including integrated circuits, and was developed by L M Ericsson in Stockholm and its subsidiary A/S Elektrisk Bureau in Oslo. The present network comprises a group centre and four terminal exchanges for altogether some 400 subscribers.

AKK 50 is specially adapted for rural areas with a relatively sparse population and many small communities. The exchanges are therefore designed for unattended operation, which implies that great emphasis has been placed on reliability and the possibility of effective supervision from a central point.

The code switch is used also in the stored-program-controlled AKE exchanges. The control system is electronic with permanently programmed control logic.

The cut-over went off smoothly and the period of operation hitherto has shown satisfactory results.

The AKK 50 system is at present being installed in Mexico, which has ordered some one hundred exchanges.



At the ceremony in Rotterdam Fred Sundkvist, L M Ericsson, delivers a memorial gift in the form of a bronze sculpture to H. van Willigenburg, Director of Telecommunications, Rotterdam District (right)

## Talk-back and acknowledgement system for Ericall and Diricall radio paging units



The pocket receivers in the Ericall (radio) and Diricall (inductive loop paging) systems manufactured by Svenska Radio AB (SRA) can now be supplemented by a mini-transmitter which permits the paged person to confirm to the operator that the paging signal has been noticed. The answer is transmitted as an acknowledgement signal in the form of a tone or voice announcement. With the Diricall inductive paging system — which from the start was designed for reception of voice announcements from an operator — two-way communication can thereby be established.

## Large private network in operation in England

A private telephone network of unusual extent has been taken into service in England by the large textile manufacturers, Courtaulds Ltd. The network system is based on L M Ericsson AKM 303 code switch equipment and, according to Courtaulds, is expected to reduce telephone charges for all of its various units by altogether £250,000 per annum.

At present about 200 PABX throughout the whole of England are connected to the system, which however is dimensioned for up to 500 PABX. At the Courtaulds works at Coventry a new PABX of L M Ericsson type AKD 791 has been installed. Otherwise the connected PABX's represent a cross-section of the systems used in the United Kingdom today.

The new telephone network, presumably the first private network with 4-wire connection, is intended for

The talk-back and acknowledgement systems were developed by SRA and consist essentially of the following elements:

*Mini-transmitter* in the form of a clip for attachment to the pocket receiver and with an output of about 15—20 mW. The mini-transmitter is very slightly smaller than the ordinary clip. The range is about 300—1000 metres outdoors and about 30—100 metres indoors. The system works within the 160 MHz band and is frequency-modulated. The transmitter is also available in the form of talk-back with tone signal equipment for selective switch-on of the stationary receivers.

*Stationary receiver* with high sensitivity and automatic squelch circuit against background noise. To cover a larger area several receivers can be connected in parallel. Any receiver with sufficient signal strength is automatically connected to the central equipment and operator. For tone-selective switch-on of the receivers they are equipped with plug-in tone receivers.

The new system is marketed outside Sweden by Svenska Radio AB.

transmission both of telephone calls, telex, data and facsimile. It comprises five fully automatic zone centres: London, Coventry, Spondon, Manchester and Aintree. Each zone centre has a three-digit zone number. PABX's connected to the zone centres have individual two-digit numbers. Usually each zone centre is connected to its respective PABX on at least two routes, so that incoming and outgoing calls can take place simultaneously.

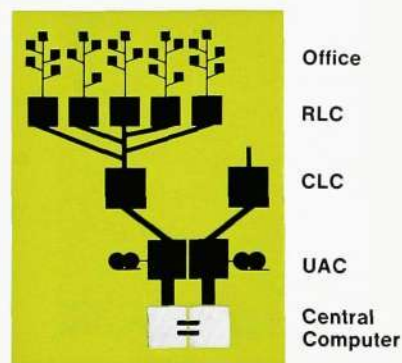
The project leader in England has been *Frank Hutton*, responsible for Courtaulds telecommunications. The BPO representative for this project was *W. Pettit. Arthur Parr*, head of Swedish Ericsson PABX Division, has in the past two years been in continuous contact with *Per Granqvist*, coordinator of the project in Sweden at LME's Subscriber Equipments Division.

## Data communication system for 400 Swedish bank offices

Skandinaviska Enskilda Banken, the largest commercial bank in Scandinavia, had in April 295 cash terminals at 85 offices connected on-line to a central computer plant via a data communication system delivered by L M Ericsson.

The communication system, which was delivered at the end of 1970, was commissioned in the summer of 1971 on trial and, in February 1972, operation of the on-line system started. At present it is planned that 25 new offices with some 70 terminals shall be put into service per month.

When installed to full capacity L M Ericsson's system will comprise 14 regional line concentrators (RLC) from Malmö in the south to Sundsvall in the north, to which altogether some 800 cash terminals and 300 other terminals at some 400 offices will be connected. These RLC are connected via central line concentrators (CLC) to a communication system consisting of two computers UAC 1610, one of which will normally be active and the other standby. The communication computers are connected to the central computer plant via a channel-to-channel adapter. Both communication computers and line concentrators are of L M Ericsson make.



## New President of Ericsson Colombia

Mr Daniel Carlsson has succeeded Mr Fredrik Croneborg as President of the Ericsson Group cable factory in Colombia, Fábricas Colombianas de Materiales Eléctricos Facomec S.A.

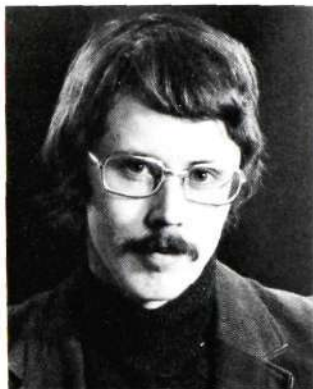
## New chairman of the boards of Italian subsidiaries of the Ericsson Group



At the annual general meeting of FAT-ME, SIELTE and SETEMER, subsidiaries of L M Ericsson, Dott. Carlo Bombieri, until recently President of Banca Commerciale Italiana, SpA, Milan, was elected chairman of the boards and management committees of these companies. He succeeds in these posts Dott. ing. Luigi Baggiani, who remains a member of their boards and management committees.

At the same time Mr Arvid Westling retired from the post of vice chairman of the board and management committee of SETEMER. He is succeeded in these posts by Mr Ivar Hilfing, who continues to be a member of the boards and management committees of FAT-ME and SIELTE.

## Professorship for member of LM staff



Thomas Ericson, D.Eng., of L M Ericsson's Long Distance Division in Stockholm, has been appointed Professor of Data Transmission at the Linköping Institute of Technology.

Thomas Ericson was born in 1942 and since 1970 has been employed at L M Ericsson, where he is in charge of theoretical investigations within digital transmission via the telephone network.

He took a M.Sc. degree in 1966, D.Sc. in 1969 and D.Eng. in 1972 at the Royal Institute of Technology in Stockholm. During the period 1966—69 he was employed at the Research Institute of National Defence (FOA).

Thomas Ericson has contributed a number of articles and papers to Ericsson Review and Ericsson Technics.

## Amateur radio club formed at LM Ericsson, Stockholm

The Ericsson Group Radio Amateurs, formed at the parent company in Stockholm in April this year, wishes through Ericsson Review to invite radio amateurs within the Ericsson Group throughout the world to notify their station signal, name and address and L M Ericsson Company — among other purposes for transmission of messages from visiting radio amateurs at the main offices in Stockholm. Address:

**L M Ericssons Amatörradioklubb,  
126 25 Stockholm, Sweden.**

The Ericsson Group Radio Amateurs have, with the cooperation of the company management, established a club station with call signal SKØFI on the 17th floor of the well-known LM tower at Telefonplan, from which a fantastic 360-degree Stockholm panorama is visible.

## Technical Week in São Paulo



Dr Christian Jacobæus

A Brazil-Sweden week for technical development was held in São Paulo from May 21—25. Some 25 Swedish exporting enterprises, among which L M Ericsson, participated in demonstration of know-how, technique and

systems within different fields. The main sponsor was the Swedish Export Council.

L M Ericsson contributed four lecturers:

Dr Christian Jacobæus, Technical Director of the Group, spoke on "Trends in Telecommunication Technique", John Hammargren, Signalling Department of MI Division, on "Automatic Dispatching, a Step Towards Tomorrow's Railway Transport System" and "Road Traffic Signalling, Specially Concerning Public Transports", P.-B. Janson, L M Ericsson Telemateriel AB, on "Modern Loudspeaking Communication Systems" and Claes Hagland, L M Ericsson Telemateriel AB, on "Security Transmission Systems".

Dr Jacobæus concluded his address with the following words: "To sum up, it may be said that telecommunications technique will become a more electronic technique, but still with very essential elements of mechanics. One must reject the possibility of the use of new nonelectrical techniques such as fluidistors and chemical relays. The advantages and the lead of electronics and electromechanics are so great that they cannot be superseded within the foreseeable future. Likewise the fundamental sciences of physics and chemistry show no new discoveries which appear to lead to new principles of design.

It is therefore a very well founded judgement that telecommunications technique will continue to develop on its previous lines, still carrying, of course, the stamp of the often ingenious and devoted technicians in industry and administrations."

## New Textbook of Telecommunications

A new textbook of telecommunications now exists, TELECOMMUNICATION SYSTEMS, by Arne Cavalli-Björkman, of the Teaching Section of the Telephone Exchange Division.

The textbook forms part of a course package within the subject of telecommunications at technical colleges, but will also be used at LME's introductory courses in telephony. English and Spanish editions are under preparation.

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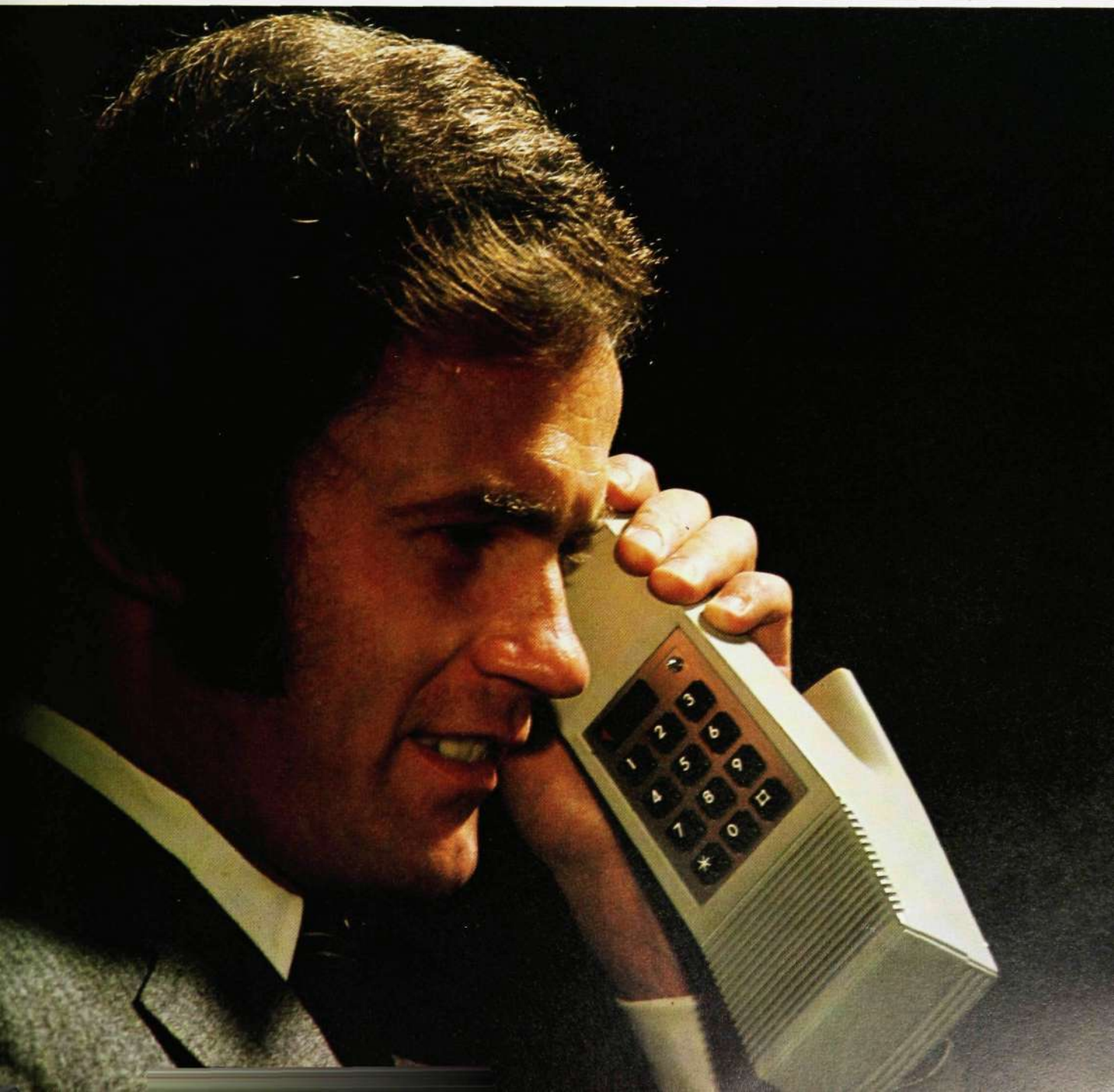
TELEFONAKTIEBOLAGET LM ERICSSON

ERICSSON

3

1973

*Review*





# ERICSSON REVIEW

Vol. 50

No. 3

1973

RESPONSIBLE PUBLISHER: CHRISTIAN JACOBÆUS, DR. TECHN.

EDITOR: GUSTAF O. DOUGLAS

EDITORIAL STAFF: FOLKE BERG,

BO SEIJMER (ERICSSON NEWS)

EDITOR'S OFFICE: S-12625 STOCKHOLM

SUBSCRIPTIONS: ONE YEAR \$1.80; ONE COPY \$0.60

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# ERICOM 30001 — a New Philosophy within Intercommunication

ANDERS JÖRGENSEN & HORST ZIEGLER, LM ERICSSON TELEMATERIEL AB STOCKHOLM

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UDC 621.395.24  
LME 822  
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*The article describes a newly developed one-piece intercom instrument both for loudspeaking and non-loudspeaking conversation and considerably simpler to use than earlier types. The authors describe its mechanical design and also touch upon the intercom system in which it is used.*

The rapid advance of intercom systems has come about primarily for the following reasons:

- a) simple, quick push-button dialling
- b) direct connection to the called party, normally without any manual operation on his part
- c) privacy button to prevent direct access
- d) simple paging
- e) low operating cost and high reliability

ERICOM 30001 (fig. 1) is a new and important member of the intercom system AVF 404\*. It offers the following advantages over and above those mentioned under a—e:

- loudspeaking and non-loudspeaking facilities in a single station (*one-piece station*)
- only 13 buttons
- easy to use
- automatic switching between microphone and loudspeaker on change-over between loudspeaking and non-loudspeaking conversation
- clear call indication
- usable both as desk and wall set
- instructions for use and list of numbers for 15 extensions attached to the bottom of the instrument
- small dimensions and low weight

\* AVF 404 — a four-wire duplex system — includes a series of exchanges for systems from 10 to 5400 extensions and of intercom stations for varying purposes.

## Design Philosophy

The instruments used in intercom systems are generally of loudspeaking type. There is always, however, a need for non-loudspeaking intercoms on account of privacy requirements or ambient noise. In such case the intercom can be furnished either with a receiver, to which the incoming speech signal is connected by means of a hook switch, or with a handset to which the incoming and outgoing speech paths are switched. In order to be able to provide combined loudspeaking and non-loudspeaking function these intercoms require three or four acoustic converters and a cord for the receiver or handset.

There are also intercoms on the market with combined function and with only two acoustic converters. The switching from loudspeaking to non-loudspeaking state is effected by connection of pads in series with the microphone and receiver. These intercoms have certain limitations, however, when used as loudspeaking instruments. The loudspeaker aperture must be so small as to be effectively covered by the ear during non-loudspeaking conversation. The device used as loudspeaker or receiver must be of light weight for the intercom to rest stably in the hand when used as handset. This means that the frequency range of the loudspeaker is limited downwards by the size of the loudspeaker aperture and that the loudspeaker has a low power owing to the small magnet. Another disadvantage is that, when the intercom is used as handset, there is access to the non-loudspeaking — loudspeaking position switch so that, during normal conversation, ear injury may occur owing to the powerful sound to which it is subjected. Such intercoms, therefore, should have a low radiated power also in loudspeaking position and should be furnished with a secondary loudspeaker when a greater volume is required.

A goal of the ERICOM project was to eliminate these disadvantages.

## Design of ERICOM 30001

Before the design work on the intercom telephone was started several different solutions were studied, one of which was based on a handset placed on a stand containing an acoustic component, e.g. a loudspeaker. The intention was to use the handset microphone also during loudspeaking conversation in the following manner.



Fig. 1  
ERICOM 30001  
(Design: Carl-Arne Breger)

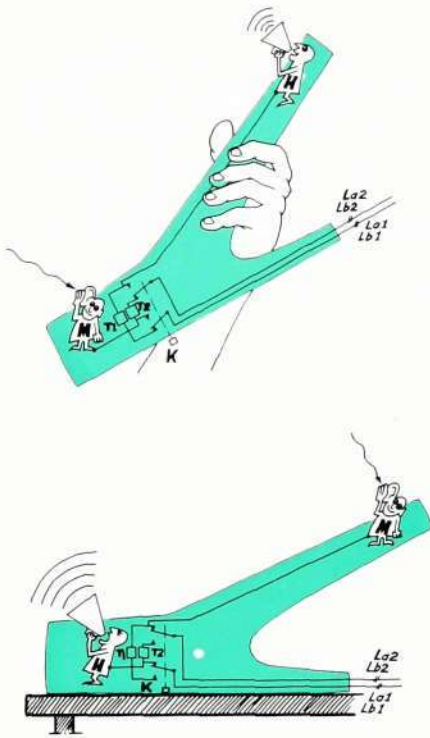


Fig. 2

The ERICOM is loudspeaking when it rests on the desk and non-loudspeaking when raised. Switching is effected automatically by means of switch K. Microphone and loudspeaker change functions, and attenuation and frequency correction circuits T1 and T2 are connected to the microphone and loudspeaker circuit.

Fig. 3

The illustration shows how easy it is to make an internal enquiry on the intercom while a customer is waiting. It also shows how well the ERICOM lies in the hand when used as non-loudspeaking instrument.



On raising of the handset the loudspeaker in the base would be disconnected (via the hook switch) and the receiver in the handset connected into circuit. A pad would also be connected to the microphone circuit to adjust the sensitivity to the sound level for non-loudspeaking conversation. This solution would require at least three acoustic components.

With a loudspeaking and non-loudspeaking instrument contained in a common casing it was also thought to be necessary to have three acoustic components, which, apart from the cost of the components, would require also a larger volume.

The idea of using only two acoustic components and switching their functions when transferring from loudspeaking to non-loudspeaking conversation, however, provided a practical solution to the problem. The development work thereafter proceeded on the basis of this solution (fig. 2).

The ERICOM is so shaped that it can be held in a natural grip when used as non-loudspeaking instrument (fig. 3). The angle between keyset and the horizontal plane, however, is not greater than that the instrument remains in position even if digits are dialled with greater than normal force.

When the ERICOM is used as non-loudspeaking instrument, the risk of an unpleasantly high receiving level if the hook switch is unintentionally touched is entirely eliminated.

The microphone aperture is small, so that satisfactory screening is attained when the microphone is used as receiver for non-loudspeaking conversation.

Since the loudspeaker is placed at the bottom, the instrument has good stability when used both as handset and for loudspeaking conversation.

The instrument is in its normal position when it stands on the desk. The hook switch is depressed, which means that the incoming line pair (La1, Lb1, fig. 2) is connected to the loudspeaker H and the outgoing line pair (La2, Lb2) to the microphone M. In this position the instrument functions as an ordinary four-wire loudspeaking instrument.

When the instrument is raised, the line pair for incoming speech is switched over to the microphone via the frequency-dependent pad T1. The microphone now functions as receiver. At the same time the pair of wires for outgoing speech is switched to the loudspeaker via the frequency-dependent pad T2. The loudspeaker now functions as microphone and the instrument is non-loudspeaking.

In the pads the necessary level and frequency corrections are made, which are necessitated by the fact that the same acoustic component in one case functions as receiver, in the other as microphone.

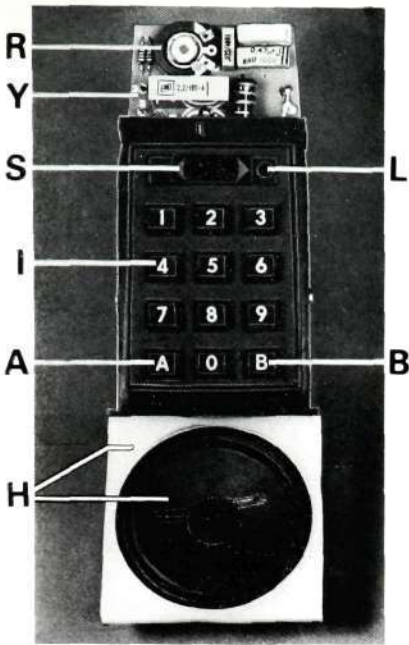


Fig. 4 (right)  
ERICOM casing

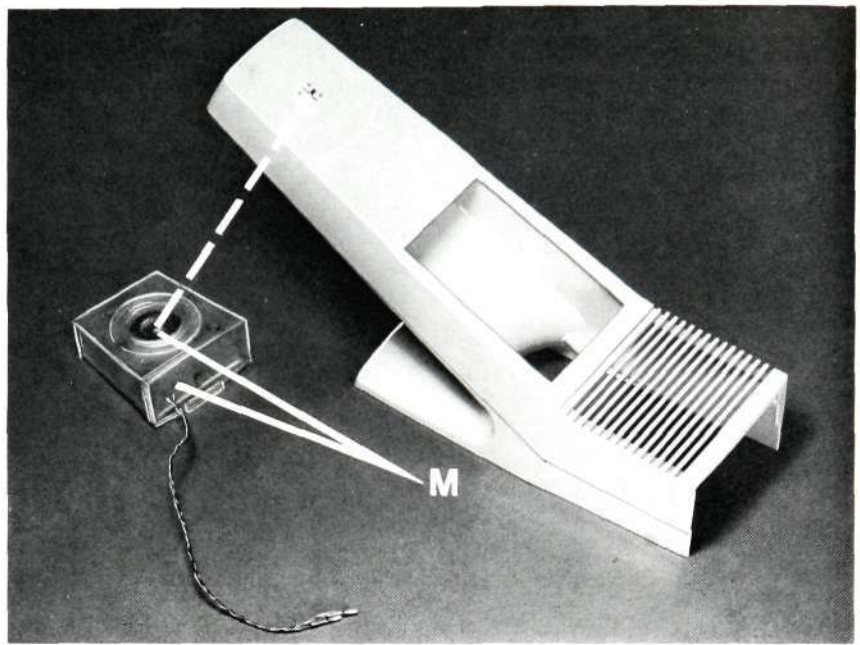
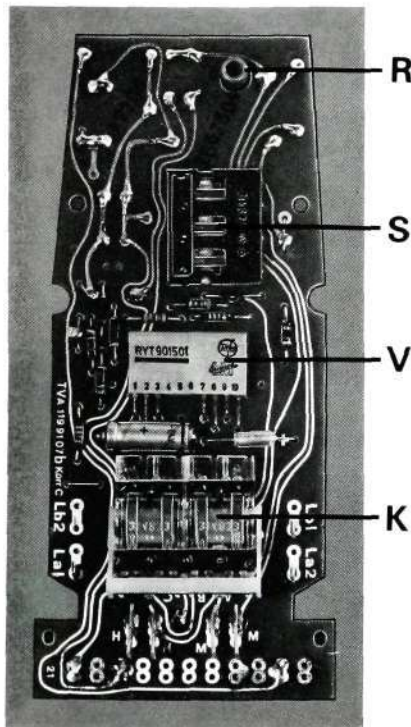
M Microphone with holder

Fig. 5 (left)  
Keypad unit

R Potentiometer  
Y Component unit  
S Privacy switch  
I Keypad  
A Privacy override and talk button  
H Loudspeaker with gasket  
L Call lamp  
B Clearing button

Fig. 6  
Component unit

R Potentiometer  
S Privacy switch  
V Preamplifier in cermet technique  
K Hook switch for transfer from loudspeaking to non-loudspeaking



## Mechanical Design

The ERICOM is made up of four units, viz

- casing (fig. 4) containing microphone and microphone holder
- keypad unit (fig. 5) carrying the keypad (I), loudspeaker with gasket (H), privacy switch (S) and component unit (Y)
- base carrying the hook switch lever and, on the underside, a list of numbers and directions for use
- cord and plug.

A special holder for wall mounting is also available.

The requirement of good quality and small dimensions has been met through the use of new components. The contact system for privacy and hook switches (fig. 6) is based on L M Ericsson's well tested miniature relay technique. To ensure reliable keying L M Ericsson's new keyset<sup>1</sup> has been used. The microphone amplifier is made on the cermet principle developed by AB RIFA, which ensures greater reliability than discrete components. It also limits the pick-up of radio signals. The cord is partially spiralized, made of tinsel strands, and the plug is of an attractive design.

The call lamp has a light conductor which provides a very distinct indication of calls. Alternatively the call lamp can be replaced by a light emitting diode.

The ERICOM is simple to install and service since it is held together by only two screws.

## Circuit Diagram

### Incoming Calls

On incoming calls to the ERICOM a test is made via diode D2 to see whether the station is switched for privacy or direct access. If in privacy condition contact

Fig. 7

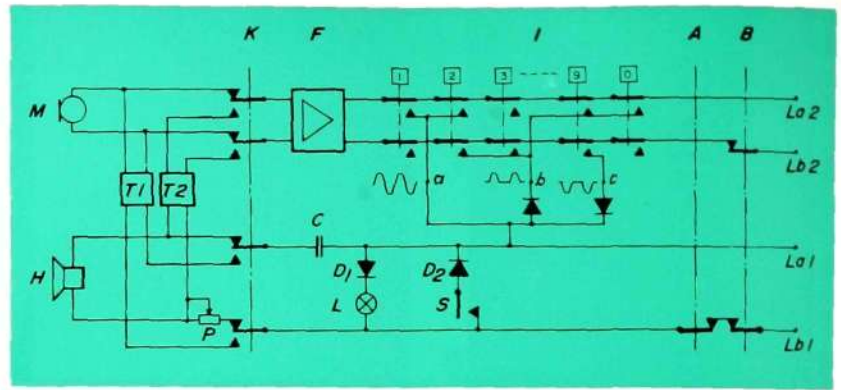
Simplified circuit diagram of ERICOM 30001

- A Privacy override and talk button
- B Clearing key
- C Capacitor
- D1, 2 Diodes
- T1, 2 Pads
- F Preamplifier
- I Keyset
- K Hook switch for transfer loudspeaking — non-loudspeaking
- L Call lamp
- M Microphone
- H Loudspeaker
- S Privacy switch
- R Potentiometer

The exchange is called when either of the microphone wires La2, Lb2 is connected to La1 through pressing of one of the number buttons. The code combination thus transmitted to the microphone wires will be seen from the table.

a = full-wave current, b = positive half-wave current, c = negative half-wave current

Comb. no.	1	2	3	4	5	6	7	8	9	0
La2	a	a	c	c	a	a	b	b		
Lb2	b	b	b	a	a	a	c	c		



S is open (fig. 7) and repeated tones are heard in the loudspeaker H at the same time as lamp L lights. The call is accepted through momentary breaking of the loop La1, Lb1 with key A. At the end of conversation the station is automatically returned to privacy condition.

On a call to a station switched for direct access, in which case contact S is closed, lamp L lights and only one tone is heard, after which connection is established. No operation of keys is required.

### Speech Circuit

When the intercom is standing on the desk, the microphone is connected to La2, Lb2 via the hook switch K and preamplifier F, and the loudspeaker to La1, Lb1 via K and the series resistor R. When the intercom is raised, the microphone is connected to La1, Lb1 via K and pad T1, and the microphone now functions as receiver. The loudspeaker is connected to La2, Lb2 via K, pad T2 and amplifier F. The loudspeaker now functions as microphone.

### Voice Control and Clearing

Switching between *speaking* and *listening* is electronically controlled by the voices of the conversing parties<sup>2</sup>. The two parties therefore have their hands free during conversation. In the case of high noise level in the environment of the receiving station, button A can be used for manual speech control. The button is depressed for speaking and released for listening.

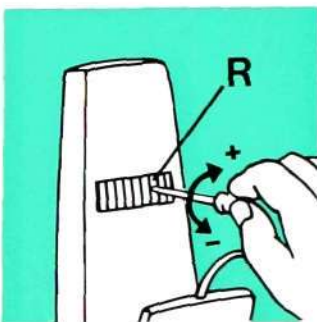
During conversation the call lamp is alight on both stations until one of the parties clears the call by pressing button B, whereupon loops La1, Lb1 and La2, Lb2 are both broken.

### Adaptation to Room Acoustics

The speech transmission of the ERICOM used in an AVF 404 system is adapted to function satisfactorily in a normal soundproof office room with reverberation time up to about 0.7 s. Some rooms, however, have a longer reverberation time. There is then a risk that the direction of speech in the connecting circuit amplifier is reversed owing to the reflected signal picked up by the microphone. This causes the speech to be chopped up. To adapt the ERICOM to such rooms as well, the loudspeaker circuit has been furnished with a variable series resistor, the potentiometer R (fig. 8). An increase of the resistance then diminishes the loudspeaker output, and thus the signal picked up by the microphone, and chopping of the speech is prevented.<sup>2</sup>

Fig. 8

Individual adjustment of the intercom to the room acoustics is done with potentiometer R. Max. volume is obtained when R is fully disconnected, i.e. in the far right-hand position



## Acoustics

As ERICOM 30001 must work with other instruments in the AVF 404 system, the transmission requirements are defined.

An interesting observation has been made, however, since the marketing of AVF 404 instruments started. It has been found that people generally, when using an intercom, speak at a sound level of about 75 db, whereas earlier instruments were generally designed for 65 db. The consequence is that the sound from earlier intercom telephones appears to be too high.

In the ERICOM the transmission level is lowered by about 6 db in relation to earlier instruments of the AVF 404 system. Since the dimensions of the ERICOM are considerably less than those of earlier instruments, the problem naturally arose of obtaining a sufficient loudspeaker output at a moderate acoustic coupling between microphone and loudspeaker.

The acoustic coupling between loudspeaker and microphone must be well defined, especially within the range 1000—2000 Hz, in order that the duplex circuit may function satisfactorily. A reasonable coupling requires a sufficient distance between the microphone and loudspeaker apertures, a sufficiently pliant mechanical attachment of the microphone and loudspeaker, as this determines the mechanical conduction of sound, and limited internal transmission of direct sound.

The loudspeaker has been provided with an unusually powerful magnet in relation to its size. The cone is fairly stiff with a pliant suspension and the base resonance is fairly attenuated. The major portion of the inside of the ERICOM functions as rear volume.

The microphone is placed at the top in its own pliant suspension and with closed rear volume, which is acoustically well screened off from the rear volume of the loudspeaker. The transmission characteristic has a slight rise between 1000 and 3000 Hz.

The total acoustic coupling is of the same magnitude as that of other AVF 404 instruments, i.e. - 80 db.

## ERICOM as Loudspeaking Instrument

The transmission level of the ERICOM, as already noted, has been lowered by 6 db in the base range below 1000 Hz compared with earlier standard instruments. The treble range has roughly the same sensitivity for the two types.

Room noise diminishes with the frequency. This means that the noise sensitivity of the ERICOM diminishes.

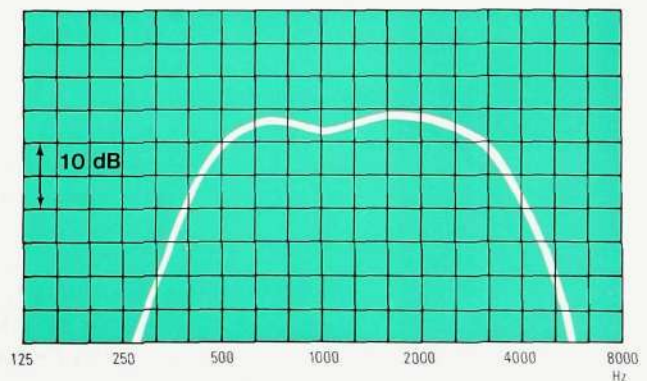
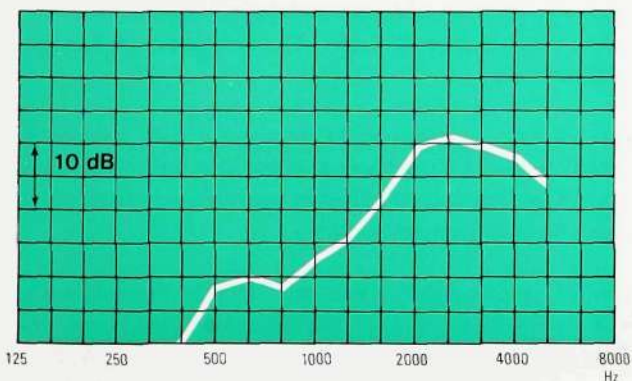
The sending sensitivity increases greatly as a function of the frequency (fig. 9). Thus the possibility for consonants at the beginning of words to reverse the direction of speech increases, which increases the intelligibility of these consonants by 5—10 per cent compared with earlier instruments (AVF 404).

Fig. 9 (left)

Frequency response for loudspeaking connection

Fig. 10 (right)

Frequency response for non-loudspeaking connection



## ERICOM as Non-Loudspeaking Instrument

When the loudspeaker is used as microphone, its frequency characteristic is practically linear.

The microphone used as receiver has a steeply falling characteristic. This is compensated, however, by the rising characteristic of the connecting circuit amplifier. The frequency characteristic for a connection between two non-loudspeaking instruments is shown in fig. 10. As will be seen, it is practically linear from 500 to 3000 Hz, which is fairly similar to the response of a non-loudspeaking instrument.

In conclusion it may be mentioned that the frequency characteristic of the ERICOM components, in combination with the connecting circuit, cooperate to produce a satisfactory result for both types of conversation.

The placing of the microphone at the top of the instrument means that the directional characteristic measured in the horizontal plane 30 cm above the desk for an instrument placed on a desk in a normal room varies only by 1 db. The placing of the loudspeaker with vertical radiation means that the deviation in the directional characteristic in the same horizontal plane is about 2 db. Measurement has been made with "pink noise". Used in a normal office, therefore, the ERICOM may be regarded as omnidirectional.

## Applications

Great care has been devoted to making the ERICOM simple and easy to use and well adapted to the existing intercom system. As earlier noted, the ERICOM is a one-piece instrument which functions as loudspeaking intercom when placed on a desk or in a wall holder. When it is raised from the desk, the hook switch switches over from loudspeaking to non-loudspeaking. When replaced, the instrument becomes loudspeaking again.

The number of buttons in relation to previous instruments has been reduced from 17 to 13, 12 of which are placed in a rectangular clearly surveyable keyset. The buttons are non-locking. The 13th, the *privacy button*, which is longer than the others, is a sliding fingertip switch. It is marked with a green and a red arrow. With the button in left-hand position the ERICOM is switched for privacy (green arrow). The lamp lens is so arranged that the red colour is not visible even in direct sunlight unless the lamp is alight.

Directions for use and list of numbers with space for 15 extensions and the user's own number are placed on the underside, protected by a transparent plastic sheet which can easily be withdrawn when alterations have to be made (fig. 11). One thus avoids the trouble of finding a place for the directions and list of numbers, as both are attached directly to the instrument.

The ERICOM is easy to place in its wall holder. The holder can be fastened to a vertical or horizontal surface.

Exchanges within the AVF 404 system can be strapped in such a way that the ERICOM may be used not only for digit selection but also for "Name" and "Add. facility calls". Up to 8 persons may be called by one-digit-selection, which according to our investigations is entirely adequate.

When using the ERICOM without the "name call" facility the numbering scheme of the extensions starts with digits 1—9. Digit 0 as first digit is reserved for "add. facility calls".

Fig. 11  
Underside of ERICOM with list of numbers  
and directions for use



Using the ERICOM with the "name call" facility, digits 1—8 are used for one-digit selection of 8 persons. Digit 9 as first digit is used as pre-selection button for all other extension numbers. Digit 0 as first digit is reserved for "add. facility calls".

The advantages of a small number of buttons with numerical and alphabetical notations is manifest. One thus obtains a simple and distinct directory of names, numbers and special services.

## Summary

The advantages of the ERICOM 30001 may be summarized under the following points:

- one-piece intercom both for loudspeaking and non-loudspeaking conversation
- well adapted both to offices and industrial premises
- its use is easy to learn
- simple mechanical structure and easy to install and maintain
- usable with AVF 404 system exchanges.

Through the use of modern electronics and electromechanics the ERICOM is an instrument which combines high reliability and good sound quality with low weight and volume.

## Technical Data

<i>Voltage levels:</i>	Outgoing microphone voltage measured on line side, max. 2 V
	Outgoing loudspeaker voltage measured on line side, max. 22 V
<i>Loudspeaker output:</i>	60—900 mW (depending on length of line and on the variable resistor R)
<i>Loudspeaker:</i>	300 ohms, dia. 64 mm
<i>Microphone:</i>	Dynamic, 200 ohms
<i>Microphone amplifier:</i>	Thick film hybrid cermet, gain 49 db, 10 mA supply
<i>Line data:</i>	The extension station is normally connected to max. 120 ohms (length of line 0—700 m) or, after bypassing of a resistor, to max. 240 ohms (700—1400 m)
<i>Dimensions:</i>	Width 75 mm Max. height 131 mm Max. length 255 mm
	When mounted in a wall holder the ERICOM projects 125 mm from the wall
<i>Weight:</i>	0.61 kg
<i>Colours:</i>	White, reddish brown, black

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# The Application of Dynamic Programming for Planning of Main Cable Networks

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UDC 519.64:621.395.741  
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*Ericsson Review No. 3, 1969<sup>1</sup>, contained an article describing the theory of dynamic programming for computer calculation of conduit and main cable network for a local exchange area. The present article deals with a practical application of this method.*

## Dynamic Programming

Dynamic programming, as applied in this case, is a rational method for obtaining optimal solutions. The principle of the method is briefly that, through stepwise suboptimizations carried out in accordance with a special pattern, one arrives at a final optimum.

Dynamic programming results in an extremely great reduction of the volume of calculation compared with that required for direct total optimization. The direct total optimization principle, which is that normally used, is in reality not usable for the planning method dealt with here, as it includes calculation of so many and such detailed data.

## Application of Dynamic Programming

Using the method of dynamic programming the computer determines the most economical choice of network construction by, inter alia, calculating the optimal number of stages of expansion within a lengthy planning period, with indication of the length of each individual stage. It also specifies the annual requirement of cable and conduit based on subscriber growth, existing network and the time-value of money. The method therefore leads to great savings in costs and work.

The method has been successively used in the planning of the Hervanta exchange area outside Tampere in Finland. The project was based on development studies, since these are well adapted to such planning. This method of study is dynamic in the sense that it recognizes the time-value of money and that it determines the additions to plant in such a way that the sum of the present value of outlays over a given planning period is as small as possible.

The necessary data for the project were provided by the Finnish Telephone Administration, whereas the computer calculations were carried out by LM Ericsson. The application of the method will now be considered on the basis of the Hervanta project.

## The Hervanta Area

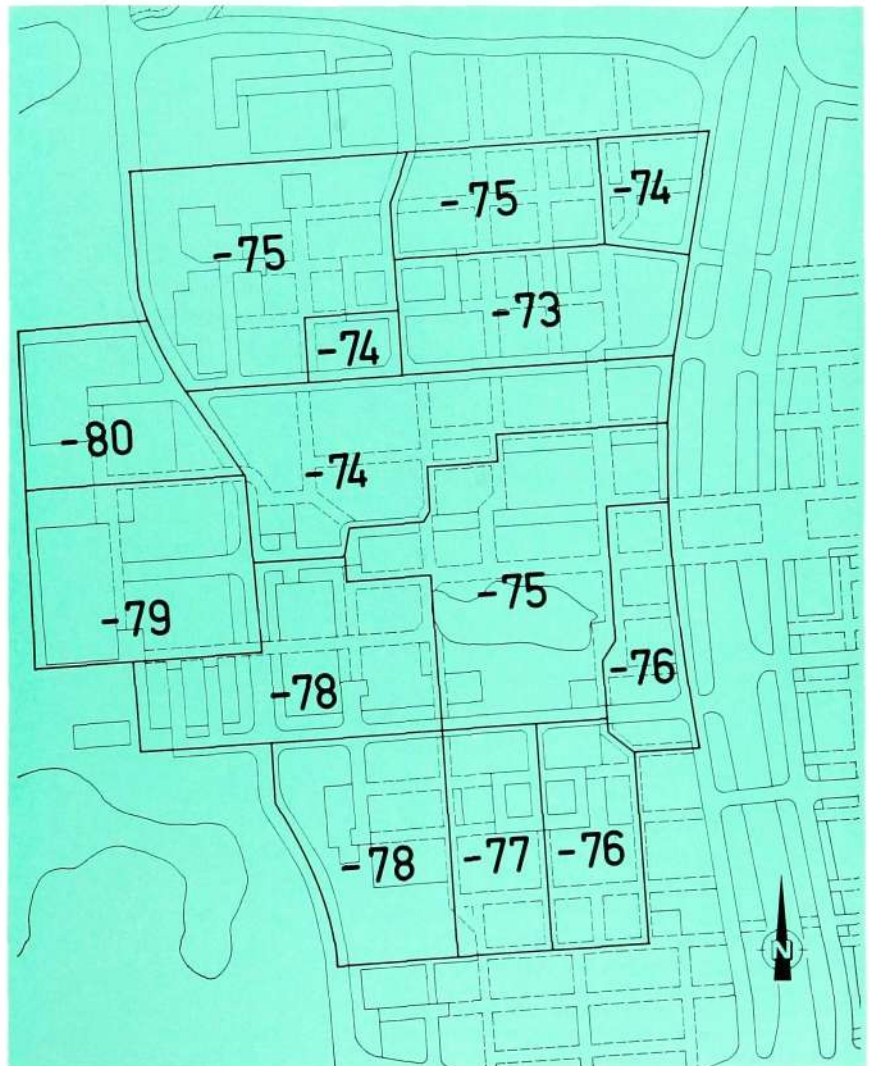
The Hervanta area, which is situated some 20 kilometres from Tampere, is a new area which in 1980 is expected to have some 32,000 inhabitants. It consists of a university area and of a commercial and residential area. The residential area comprises both one-family houses and multistorey buildings.

The commercial and residential area, which is the subject of this study, is situated to the west of the main thoroughfare (fig. 1).

## Assumptions for the Calculation

In the planning of the cable network for the Hervanta area it was necessary to take into account four variables to be fed into a computer, viz.:

- alternative main cable networks
- planning period
- costs
- subscriber growth



**Fig. 1**  
Map of Hervanta. The numbers indicate the years in which it is expected that each area will be developed

**Table 1**

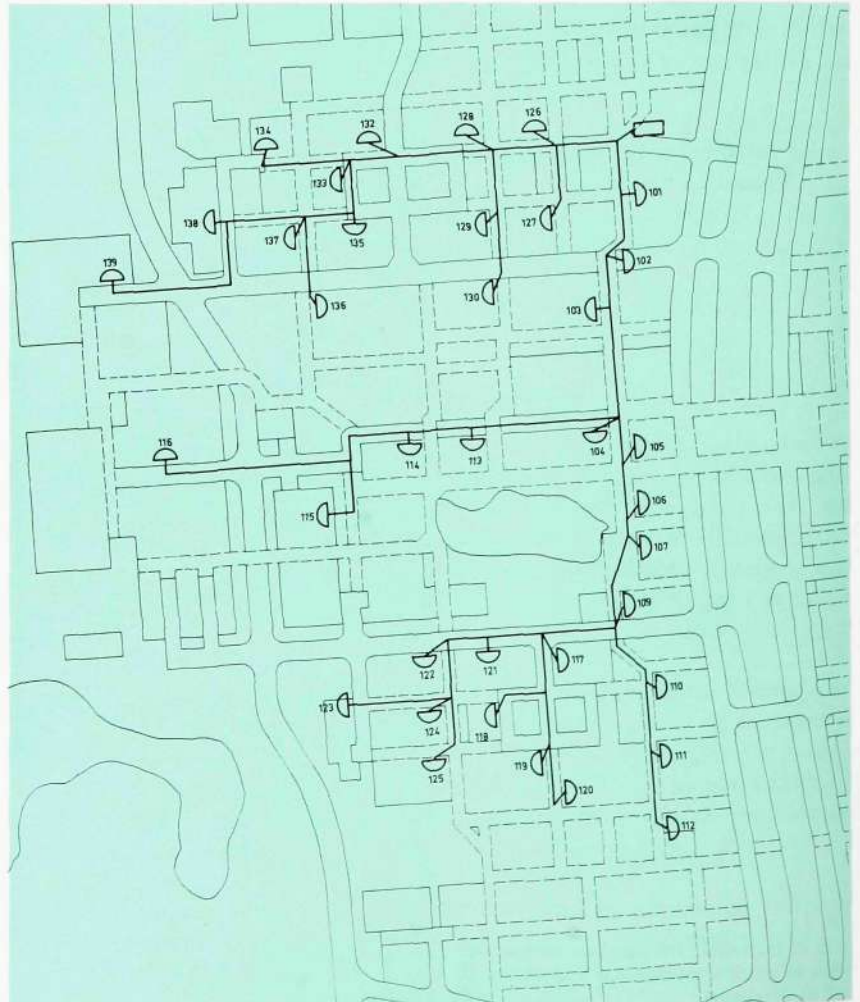
Network matrix exemplifying the input to the program. If spare ductways are desired on a cable run, this is indicated by a minus sign in front of the number of ductways

PRIMARY POINT	SECONDARY POINT	LENGTH OF CABLEROUTE IN METERS	NETWORK-MATRIX					
			SPARE PAIRS AT T=0	STUMPED PAIRS AT T=0	STUMPED PAIRS WANTED	DEAD PAIRS AT T=0	DEAD PAIRS WANTED	SPARE DUCTWAYS AT T=0
1	2	290	0	-0	-0	-0	0	-1
2	101	0	-0	-0	-0	-0	0	-0
2	3	130	-0	-0	-0	-0	0	-1
3	102	0	-0	-0	-0	-0	0	-0
3	4	128	-0	-0	-0	-0	0	-1
4	103	0	-0	-0	-0	-0	0	-0
4	5	140	-0	-0	-0	-0	0	-1
5	104	0	-0	-0	-0	-0	0	-0
5	6	108	-0	-0	-0	-0	0	-1
6	105	0	-0	-0	-0	-0	0	-0
6	7	125	-0	-0	-0	-0	0	-1
7	106	0	-0	-0	-0	-0	0	-0
7	8	80	-0	-0	-0	-0	0	-1
8	107	0	-0	-0	-0	-0	0	-0
8	9	145	-0	-0	-0	-0	0	-1
9	1080	142	-0	-0	-0	-0	0	-1
1080	108	0	-0	-0	-0	-0	0	-0
9	109	91	-0	-0	-0	-0	0	-0
10	110	0	-0	-0	-0	-0	0	-1
10	111	126	-0	-0	-0	-0	0	-0
11	111	0	-0	-0	-0	-0	0	-1
11	1120	130	-0	-0	-0	-0	0	-1
1120	112	0	-0	-0	-0	-0	0	-0
5	12	246	-0	-0	-0	-0	0	-1
12	113	0	-0	-0	-0	-0	0	-0
12	13	166	-0	-0	-0	-0	0	-1
13	114	0	-0	-0	-0	-0	0	-0
13	120	150	-0	-0	-0	-0	0	-1

### Main Cable Network

Table 1 shows the necessary data for the network matrix with division cabinets as shown in fig. 2 (alternative 3). For purposes of optimization the corresponding data for two other alternatives with approximately the same total length of cable runs and number of division cabinets but with different cable routes were fed into the computer.

Input: Data for three alternative cable construction schemes.



**Fig. 2**

One of three alternative cable construction schemes. The map comprises only part of the exchange area. From the telephone exchange in the upper right-hand corner the main cable network extends to the numbered cable division cabinets

**Table 2**

**Subscriber forecasts for the division cabinets in fig. 2 during the 25-year planning period. Year 1 = 1973, year 2 = 1974, etc.**

Cabinet no.	Year																								
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
101	169	221	277	333	384	435	466	487	502	512	518	523	528	533	538	543	548	553	559	564	569	574	579	584	588
102	-	192	250	314	377	435	493	528	551	569	589	586	592	598	604	609	615	621	627	633	638	644	650	656	662
103	-	-	179	231	293	352	406	460	493	514	531	543	557	572	588	583	589	574	579	585	590	596	601	606	612
104	-	-	-	204	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
105	-	-	-	78	102	127	151	177	200	214	225	231	235	238	240	243	245	247	250	252	254	257	259	261	264
106	-	-	-	78	102	127	151	177	200	214	225	231	235	238	240	243	245	247	250	252	254	257	259	261	264
107	-	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
109	-	-	-	112	153	182	220	251	283	307	321	331	337	341	344	348	351	354	358	361	364	366	371	375	378
110	-	-	-	110	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
111	-	-	-	114	148	180	221	258	292	313	326	337	343	347	350	353	357	361	364	367	371	374	378	381	385
112	-	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
113	-	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
114	-	-	-	20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
115	-	-	-	-	173	211	252	294	331	369	393	406	418	425	429	433	437	440	444	448	452	455	459	463	467
116	-	-	-	-	47	292	337	387	437	482	528	555	571	587	598	609	620	630	640	649	658	667	676	685	694
117	-	-	-	-	85	84	108	127	147	166	178	189	192	195	197	199	201	203	205	207	209	211	213	215	217
118	-	-	-	-	27	35	44	53	61	69	74	77	80	81	82	83	84	85	86	86	87	88	89	90	90
119	-	-	-	-	114	148	186	223	258	292	313	326	337	343	347	350	353	357	361	364	367	371	374	378	381
120	-	-	-	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
121	-	-	-	-	38	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
122	-	-	-	-	30	39	49	59	68	77	82	86	89	90	91	92	93	94	95	96	97	98	99	99	99
123	-	-	-	-	13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
124	-	-	-	-	28	37	46	55	63	72	77	80	83	84	85	86	87	88	89	89	90	91	92	93	93
125	-	-	-	-	33	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
126	49	59	107	123	137	153	168	182	191	197	201	204	205	207	208	210	211	213	214	215	217	218	220	221	223
127	48	67	78	94	108	123	131	137	142	144	146	147	149	150	152	153	154	156	157	159	160	162	163	165	166
128	25	32	115	145	177	210	237	262	278	288	296	301	304	307	310	313	316	319	322	325	328	331	334	337	340
129	68	89	111	134	154	175	187	195	201	205	208	210	212	214	216	218	220	222	224	226	228	230	232	234	236
130	-	82	80	101	121	140	159	178	177	183	186	188	190	192	194	196	198	199	201	203	205	207	209	211	212
132	-	-	70	91	114	138	159	180	197	201	207	211	214	216	218	220	222	224	226	228	230	233	235	237	239
133	-	-	33	43	53	64	74	84	90	96	96	98	99	100	101	102	103	104	105	106	107	108	109	110	111
134	-	-	91	96	101	106	111	116	119	121	123	124	124	125	125	126	126	126	127	127	128	128	129	129	130
135	-	60	77	97	117	135	153	161	171	176	179	181	183	185	187	188	190	192	194	196	197	199	201	203	205
136	-	-	-	-	20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
137	-	-	42	55	68	82	95	108	115	120	124	126	128	129	130	131	133	134	135	137	138	139	140	142	143
138	-	-	-	-	36	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
139	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

### Planning Period

The Administration had decided on a 25-year planning period (1972—1997), so that the sum expressed in the present value of the costs of the various stages would have to be minimized during this period.

Conduit was to be constructed only on one occasion during the planning period. For extension of a cable run, therefore, the corresponding conduit would have to be so dimensioned as to cover the demand during the remainder of the period.

Input: *Planning period = 25 years.*

### Subscriber Growth

During the period 1973—1980 it was planned that the Hervanta area should be developed in the order of sequence shown in fig. 1. Based on the available statistics the Administration had drawn up subscriber forecasts for the entire planning period. Table 2 shows the subscriber growth in the primary cabinets for the main network shown in fig. 2.

Input: *Subscriber forecasts for each primary cable cabinet.*

### Costs

#### Method of cable construction

Three methods of cable construction may be used in each of the main networks, namely cable in conduit, armoured cable buried directly in the soil, and cable on wall brackets in underground shelters.

#### Cable and conduit

Abbreviations: Fmk = Finnish marks, m = metres, n = number of pairs, p = number of ductways.

The costs of cable and conduit have been specified by the Administration as set out in table 3. For adaptation to the programming method, cost functions consisting of fixed costs (Fmk/m) and variable costs (Fmk/m · n or Fmk/m · p) are derived from the table by analysis in accordance with *the method of least squares*. For each cost function (C) so calculated, a calculation has also been made of the correlation (R) which describes the relation between each cost func-

tion value and the corresponding value in table 3. From the satisfactory values of (*R*) it is apparent that the method of least squares gives a virtually exact result.

The calculated cost functions for cable and conduit and the correlation are presented below.

Armoured buried cable  $C = 26.58 + 0.075 \times n$  (Fmk/m)  
 $R = 0.9995$

Paper-insulated and lead-sheathed cable  
 0.4 mm in conduit and shelters  $C = 8.50 + 0.072 \times n$  (Fmk/m)  
 $R = 0.9997$

Plastic ducts  $C = 25.93 + 7.67 \times p$  (Fmk/m)  
 $R = 0.9962$

Table 3

Data for construction of the cost functions provided by the Finnish Telephone Administration. The number of pairs and number of ductways indicate the standard sizes used. In some parts of the network 20 and 30 pair cables are also used

The fixed cost for armoured buried cable (26.58 Fmk) shown above includes the cost of asphaltting, namely 10 Fmk.

	No. of pairs	Cable price	Joining		Digging and laying		Administration Work supervision			Total		
			Work	Material	Work	Material	Drawing	Transport	Contract			
<b>Armoured buried cable 0.4 mm</b>												
	50	5,98	0,98	0,17	6,52	1,89	0,50	2,02	1,17	19,23		
	70	7,51	1,10	0,17	6,52	1,89	0,50	2,02	1,17	20,88		
	100	9,83	1,22	0,21	6,52	1,89	0,50	2,02	1,17	23,36		
	150	13,52	1,40	0,22	6,52	1,89	0,50	2,02	1,17	27,24		
	200	17,40	1,65	0,24	6,52	1,89	0,50	2,02	1,17	31,39		
	250	20,86	1,83	0,25	6,52	1,89	0,50	2,02	1,17	35,04		
	300	24,52	2,07	0,31	6,52	1,89	0,50	2,02	1,17	39,00		
	400	32,05	2,50	0,36	6,52	1,89	1,00	2,02	1,17	47,51		
	500	39,48	2,93	0,41	6,52	1,89	1,00	2,02	1,17	55,42		
	600	45,97	3,36	0,44	6,52	1,89	1,00	2,02	1,17	62,37		
	800	60,05	4,21	0,47	6,52	1,89	1,00	2,02	1,17	77,33		
	1000	74,14	5,12	0,54	6,52	1,89	1,00	2,02	1,17	92,40		
	1200	87,48	5,92	0,60	6,52	1,89	1,00	2,02	1,17	106,60		
	1600	113,17	7,38	0,67	6,52	1,89	1,00	2,02	1,17	133,82		
<b>Cable 0.4 mm in conduit</b>												
Mean distance between joints 128 m												
	50	4,91	0,98	0,15	3,56	0,15	0,50	0,88	—	11,13		
	70	6,55	1,10	0,15	3,56	0,15	0,50	0,88	—	12,89		
	100	8,74	1,20	0,19	3,56	0,15	0,50	0,88	—	15,22		
	150	12,28	1,40	0,19	3,56	0,15	0,50	0,88	—	18,96		
	200	15,73	1,65	0,21	3,56	0,15	0,50	0,88	—	22,68		
	250	19,03	1,83	0,22	3,56	0,15	0,50	0,88	—	26,17		
	300	22,59	2,07	0,28	3,56	0,15	0,50	0,88	—	30,03		
	400	29,58	2,50	0,33	3,56	0,15	1,00	0,88	—	38,00		
	500	36,12	2,93	0,38	3,56	0,15	1,00	0,88	—	45,02		
	600	42,86	3,36	0,41	3,56	0,15	1,00	0,88	—	52,22		
	800	56,37	4,21	0,44	3,56	0,15	1,00	0,88	—	66,61		
	1000	70,12	5,12	0,51	3,56	0,15	1,00	0,88	—	81,34		
	1200	82,94	5,92	0,57	3,56	0,15	1,00	0,88	—	95,02		
	1600	107,51	7,38	0,64	3,56	0,15	1,00	0,88	—	121,12		
<b>Plastic ducts</b>												
Mean distance between manholes 128 m												
	No. of ductways	Tube-price	Digging and laying		Manholes:				Administration Work supervision			Total
			Work	Material	Work	Material	Accessories	Cov. + frame	Drawing	Transport	Contract	
	4	19,20	7,60	6,00	2,44	11,00	0,53	2,48	1,80	5,06	5,63	61,74
	6	28,80	8,70	6,00	2,44	11,00	0,53	2,48	2,10	5,36	5,93	73,34
	9	43,20	11,20	6,00	2,44	11,00	0,53	2,48	2,70	6,06	6,83	92,44
	12	57,60	12,30	6,00	2,44	11,00	0,53	2,48	3,00	6,86	7,63	109,84
	15	72,00	14,60	6,00		31,30		2,48	3,60	7,76	8,63	146,37
	20	96,00	17,30	9,50				2,48	4,20	9,56	10,63	170,37
	24	115,20	19,20	9,50		39,30		2,48	4,50	12,56	14,13	216,87
	30	144,00	23,20	10,50				2,48	5,40	15,06	16,63	256,57

## Terminal costs

The costs of connecting a cable pair to a division cabinet and to the exchange side of a main distribution frame are called terminal costs, which in this case amount to 3.89 Fmk in the division cabinet and 1.05 Fmk on the M.D.F.

Input: *Fixed and variable costs for cable and conduit, terminal costs, cable and duct sizes in accordance with table 3.*

## Internal rate of interest for costing purposes

The internal rate of interest was fixed by the administration at 13 %.

Input: *Internal rate of interest 13 %.*

## Method of Calculation

The number and duration of the extension stages within the 25-year planning period decided upon must be so determined as to yield a minimum present value of the future costs.

The number of possible methods of extension for the 25-year period is

$$2^{25-1} = 2^{24} = 16,777,216$$

but, as a result of the dynamic programming principle employed, the economic

optimum is attained after only  $\sum_{i=1}^{25} = 325$  calculations.

The economical extension periods are determined by means of a dynamic calculation algorithm constructed in accordance with the dynamic programming theory. The following chain of reasoning is employed.

If the planning period (the plan horizon)  $T = 1$  year, there is only one way of making the extension, namely for one year's requirement, and if  $T = 2$  years one can either extend for one year at a time or for two years at a time.

For  $T = 3$  there are four possibilities of extension, but only three additional cases need be examined since the preceding calculations already show the best method of extension for  $T = 2$ .

For  $T = 4$  there are 8 possibilities of extension, but only four need be investigated since one already knows the best method of extension for  $T = 2$  and  $T = 3$ .

Fig. 3 illustrates by way of example the calculation procedure for the planning

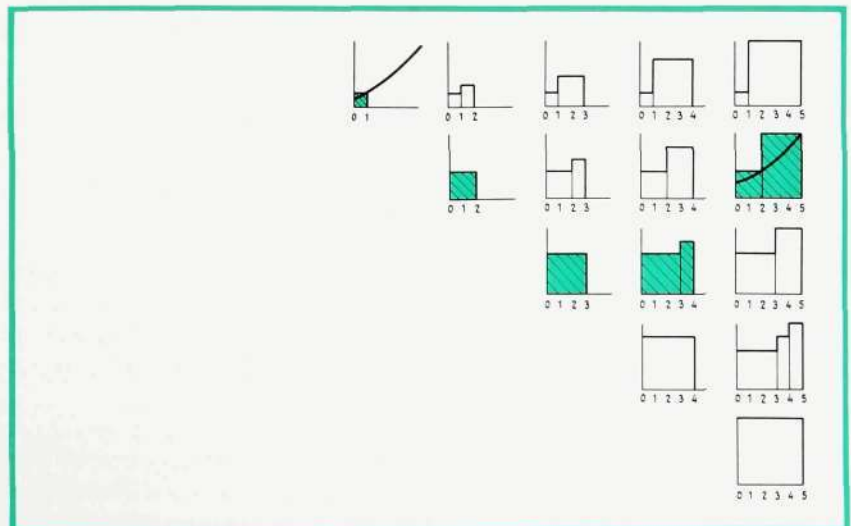


Fig. 3

Procedure for calculation of economical intervals of extension using dynamic programming

Shaded areas correspond to minimum extension (or provision) costs

period  $T = 5$  years with one year's interval between calculations. Mathematically the calculations are expressed by the following formula:

$$N(0t) = \min [\min N(0x) + N(xt)] \quad (t = 1, 2, \dots, T) \quad 0 \leq x < t$$

where

$N(0t)$  = present value of extensions during the period  $0-t$

$N(0x)$  = present value of extensions during the period  $0-x$

$N(xt)$  = present value of extensions during the period  $x-t$ .

The dynamic programming method results in a great reduction in the required number of calculations compared with examination of all theoretical possibilities. This is clearly evident from the following table.

Number of calculation intervals	Number of calculations	
	Dynamic programming	All theoretical possibilities
10	55	512
20	210	524, 288
30	465	$2^{29}$
40	820	$2^{39}$

## Output from Computer

### *Tables with data*

Output from the computer takes place in plain language and in easily legible tabular form. Since all printed results are exact, the tables can be directly and conveniently converted into a cable network plan. Printed data include:

- number and length of extension periods
- detailed specifications of cables and conduit to be installed each year on the various runs
- summary of installation costs with present value during the planning period.

Optimal solutions for the three alternatives of interest in this case are printed out in conjunction therewith.

It should be noted, however, that new calculations should be made before each new extension stage, so that in most cases it is necessary to present a detailed specification solely of the first stage. For the remainder of the period a summary of the calculated investments is presented in such case.

There follow a few examples of outputs. Table 4 shows for each year, among other data, the necessary number of pairs per route, table 5 shows the situation in the nodes of a network after each extension interval with indication of number of dead pairs, stumped pairs, spare pairs connected to cabinets, and joined and





For every cable run in fig. 4 the cable size and year of installation have been indicated, the year of installation always being calculated to occur one year before the need arises. For cable in conduit each cable run is marked by two Roman numerals. The left-hand numeral indicates the necessary number of ductways to cover the extensions during 25 years, including one spare ductway, and the right-hand numeral indicates the number of ductways for special purposes (e.g. coaxial cable for closed circuit television) which the Administration desires to have in reserve.

### *Choice of Network*

For the three alternatives the printout resulted in the following optimal costs, expressed in present value, which were calculated on the total costs during the 25-year period.

Alternative 1 = 673,000 Fmk

Alternative 2 = 563,000 Fmk

Alternative 3 = 512,000 Fmk (figs. 2 and 4)

Alternative 2 is 10 % and alternative 1 more than 30 % more expensive than alternative 3.

The calculation points clearly to alternative 3 and the Administration need budget only 512,000 Fmk to cover the entire 25-year period.

For further investigations of alternative networks these results may provide some guidance in finding, if possible, still cheaper alternatives.

### *New Calculation per Stage and Maintenance Costs*

Before each new extension stage, as already mentioned, the stage should be recalculated using up-to-date forecasts and possibly corrected costs.

If the new forecast shows a considerably higher demand than that on which existing conduit was calculated, the costs for replacement of existing cables by larger cables should be weighed against the costs for extension of conduit.

The maintenance cost in each case should be carefully considered when deciding between the two alternatives. Armoured underground cable, for example, after burial, proves to be about 2 % cheaper than cable in conduit, but its maintenance cost is higher. This may even exceed the price difference for buried cable.

### *Summary*

Of the apparently equivalent three alternatives the computer output showed that one alternative was 30 % more expensive and another 10 % more expensive than the most economical one.

As the printed results are exact, these can be directly converted into a complete cable network plan, which is a valuable aid for planning of equipment orders and drawing up the installation program.

As basis for a long-term financial estimate one obtains a budgeted figure for the annual investment requirement.

The planning method is convenient in use and, owing to the dynamic programming, the computer operations, and so the computer time, are reduced to a minimum.

## Reference

RAPP, Y.: *The Use of Dynamic Programming for Planning of Extensions of Conduits and Main Cable Networks in a Local Exchange Area*. *Ericsson Rev.* 46 (1969): 3, pp. 102—112.

# Modem ZAT 2400 for Data Transmission

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UDC 681.327.8:  
621.395.126  
LME 8152

*The increased use of data processing has created a great demand for rational methods of transmitting data. Today the telephone network is utilized to a considerable extent. In order to transmit digital information via a telephone channel it is necessary to use modems, i.e. equipment which on the send side converts data information in the form of binary d.c. pulses to voice frequency signals (modulator) and on the receive side carries out the reverse process (demodulator).*

LM Ericsson has developed and is marketing the modem types standardized by CCITT for serial transmission of data at 200, 1,200 and 2,400 bit/s. In the following article a brief description is given of the modem equipment for the data signalling rate of 2,400 bit/s, which has been given the designation ZAT 2400, fig. 1. This equipment, which in the main consists of integrated circuits, is built up on a modular basis and can thus be equipped to provide different operational facilities. Among other things the equipment can be provided with an equalizer in order to make possible traffic over lines with poor transmission quality.

**Fig. 1**  
Modem ZAT 2400 mounted in a case. A mains switch, with a signal lamp built in, is mounted on the front of the modem

In the design of the modem equipment special attention has been paid to the problems that arise in the multi-point networks that are often encountered in connection with data communication.

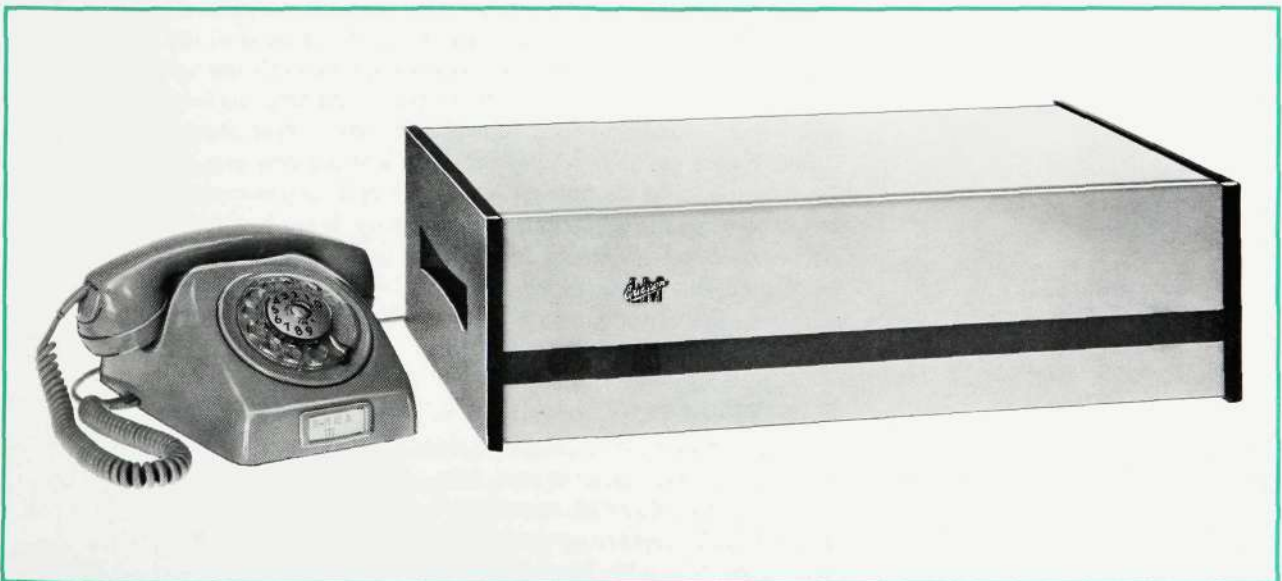
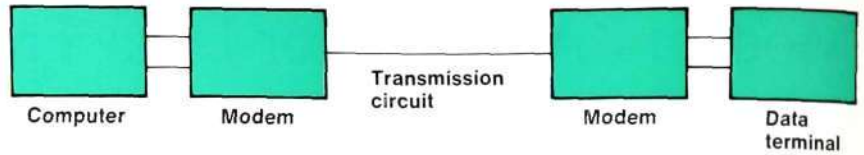


Fig. 2  
Block diagram of a data circuit



## Range of Application

It has been shown that ZAT 2400 can be used in many types of data communication systems. Besides its limited complexity, which gives reasonable costs and good reliability, the equipment offers a relatively high transmission speed without any extreme demands on the quality of the transmission lines. The equipment also has good start characteristics, i.e. a short synchronizing time.

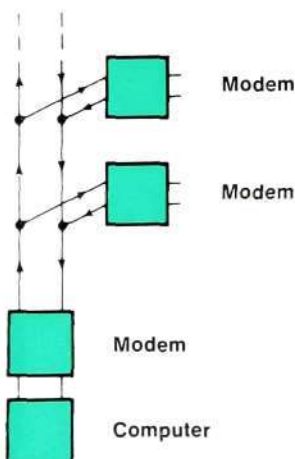
ZAT 2400 can be used

- for traffic between computers
- in data collection systems, for example for remote feeding of data. The system is often combined with the remote control of processes.
- in data communication systems where the information for a whole company or an administrative unit is stored in a central computer and where enquiries and updatings can be made via, for example, display unit terminals. Examples of this are seat reservations, bank transactions etc. In these and similar cases the use of a relatively high data signalling rate is justified not only because of the amount of data that must be transmitted, but also because the time between the enquiry and the answer should be as short as possible.
- in certain systems where from the point of view of, for example, line costs it can be justified to bring together geographically adjacent low speed channels to form one or a number of high speed channels for communication with a distant computer.

Fig. 2 shows a block diagram of a communication link between a computer and a data terminal. In this case a leased point-to-point circuit is used as the transmission medium.

In order to reduce the line costs in systems where many terminals are to communicate with a central computer, and where it is a question of a limited amount of data per call, for example the previously mentioned system for seat reservation, a number of data terminals can be allowed to use the same communication link. An example of a multi-point circuit is the network configuration, designated multidrop, shown in figure 3. As only one terminal can send at a time the communication is controlled by the central computer via a special calling system (polling), whereby one terminal at a time gets permission to send. In order to reduce the time for a scanning cycle it is essential that the modems have short synchronizing times. A multidrop network makes special demands on line equalization. This is dealt with in more detail below under the heading of "Equalization".

Fig. 3  
A multidrop circuit where several remote stations exploit a common telephone channel for communication with a central computer



## Specification

Modem ZAT 2400 is designed in accordance with CCITT recommendations V24 and V26. It is intended for synchronous operation at data signalling rates of 2,400 bit/s over leased two-wire and four-wire telephone lines. ZAT 2400 is also adapted for operation over the general switched telephone network. The method of modulation is differential four-phase modulation, and the data information is

Dibit	00	01	11	10
Code A	0°	90°	180°	270°
Code B	45°	135°	225°	315°

Fig. 4  
The relation between the data information and the phase shift of the line carrier for code alternatives A and B. The data bits are grouped and dealt with in pairs (dibits)

encoded by means of phase changes of the outgoing carrier in accordance with two alternative coding arrangements, A and B, that are defined in fig. 4. Fig. 5 shows a modulation example in accordance with code alternative A.

ZAT 2400 can be equipped with an FM modulated backward channel for speeds of up to 75 bit/s in frequency multiplex with the data channel. The backward channel can be used for sending acknowledgement signals and the like. Alternatively the equipment can be provided with single or double sets of equalizers for equalizing the group delay distortion and attenuation distortion of the line.

## Function

The build-up and function of the modem are illustrated by the block diagram of fig. 6.

The equipment is limited on one side by an analogue interface for connection to the telephone line and on the other by a digital interface. Across the digital interface, data signals, timing signals and control signals are exchanged between the modem and the data processing equipment on CCITT interchange circuits numbered 101, 102 etc. In addition, for testing and control purposes, a national interface has also been included in the equipment for connection of an external control unit.

The modem can be divided up into

- a modulator
- a demodulator
- common equipment consisting of a line unit with line transformers and control logic, mains unit for the power supply via the a.c. mains supply and a clock unit. The clock unit contains a crystal controlled oscillator out of which all the necessary frequencies in the system are generated.

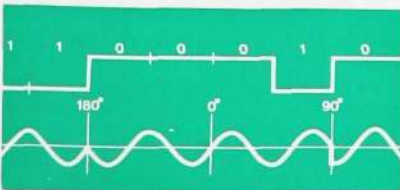
## Modulator

The data signal to be transmitted comes in on interchange circuit no. 103 (fig. 6), and is converted in the encoder, via logic circuits, to a phase-shifted signal. In the output amplifier this signal is filtered and shifted to another frequency band and also given a suitable level before being sent out on to the line via the line unit.

## Demodulator

The signal received from the line is fed from the line transformer to the input amplifier, in which interference outside the signal spectrum is suppressed, and in which the signal is shifted to a higher frequency band, amplified and clipped. For the phase detection that follows, a local reference signal is generated in the carrier synchronizer by means of a loop that is locked in phase. This reference signal and the clipped signal from the input amplifier constitute the input signals to the phase detectors, the outputs of which, the baseband signals, are converted in the decoder to the original data signal. This signal is taken out on interchange circuit no. 104. The modem receiver also provides the data processing equipment with receive timing, on interchange circuit 115, and an indicating signal, on interchange circuit 109, that provides an indication when the carrier comes in from the line. The demodulation method with a clipping stage gives the receiver good level and start characteristics.

Fig. 5  
Idealized picture of four-phase modulation in accordance with code alternative A. When the modulation is differential there is no need for an absolute phase reference in the system  
Upper curve — the data signal  
Lower curve — the line carrier



## Equalization

The telephone network has been developed for the transmission of speech, which puts less stringent demands on the quality of the line than data transmission, particularly at high signalling rates. The group delay distortion and attenuation distortion that is encountered on many telephone circuits can often be particularly troublesome for data transmission.

In order to make it possible to transmit at a data signalling rate of 2,400 bit/s over lines that are unfavourable from the point of view of distortion, the ZAT 2400 modem can be provided with an equalizer unit. This unit makes possible compensation of various forms of linear line distortion. Choice of suitable equalization is made via U-links on the front of the unit. In order to simplify the choice, the equalizer is provided with an indicator circuit, the output signal of which is a measure of the transmission quality.

Fig. 6  
Block diagram of the ZAT 2400 modem



Normally the equalizer is fitted on the receive side of the modem, but problems arise in the case of multidrop networks (fig. 3). In such cases the equalizer in the central modem would need to be readjusted when a new distant station was called. If all the equalizers are placed on the send side the same problem arises. ZAT 2400 offers an attractive solution, it being possible to equip these modems with two equalizers, one on the send side and one on the receive side. By equipping the modems at the distant stations with two equalizers an optimum equalization of the whole network is obtained.

## Mechanical Construction

The equipment is mounted in a 19" shelf of the type that is used for stored program controlled telephone exchanges<sup>1</sup>. In offices etc. the shelf is contained in a suitable case (see fig. 1). The mechanical construction of the units (printed board assemblies) is identical with that used for the PCM system<sup>2</sup>, fig. 7, and

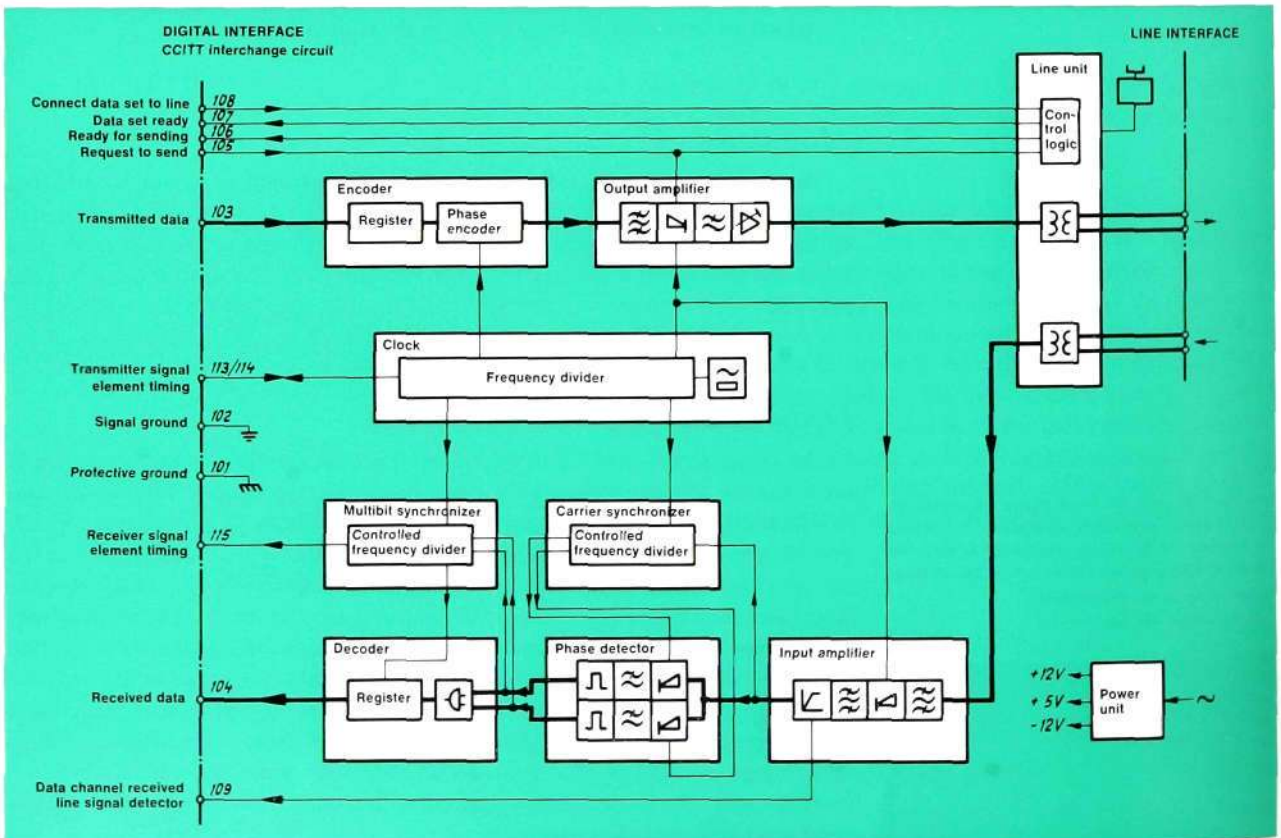




Fig. 7

A unit with integrated circuits.

The front of the unit is used for strapping and measuring purposes. The straps are made with U-links (a), which connect together corresponding points on the underside and top side of the board.

A special test cord (b) is used for connecting a measuring instrument to the test points on the front of the board. The board is removed from the shelf with an extraction tool (c) which fits into a hole in the front of the board

the units are accessible when the front plate is removed, fig. 8. The method of construction, with plug-in type units, each of which forms a complete functional unit, provides a high degree of flexibility. Thus the modem can readily be equipped to suit any particular application. The adjustment of the send level and the choice of the code alternative, A or B, is carried out by means of U-links on the front of the unit.

Fig. 9 shows the rear of the equipment with the cover plate removed. Under the cover plate there is a strapping field, which is strapped for the particular equipment version, and on which any other straps are made that depend on the particular application.

The external connections are taken to connectors that are readily accessible at the rear of the modem. Connection to the telephone line is made via a plug and cable that is connected to a screw type terminal block.

The data equipment is connected to the modem via a 25-pole connector of an approved type. Connectors are also provided for connecting a telephone and a control unit.

## Maintenance and Fault Finding

Measures have been taken to reduce maintenance. A large part of the equipment has been made digital and great care has been taken over the choice of components.

If a fault occurs, the faulty unit can be traced by exchanging units and the faulty unit can be replaced without any additional adjustments being required. A large number of test points, which are protected against short-circuit, are provided along the front of the units for carrying out test measurements.

The modem's central position in a communication system can be exploited for locating faults on faulty data circuits. In the ZAT 2400 modem the line or the data wires can be looped with U-links in the strapping field. In this way it can be determined whether a fault is in the data processing equipment, the modem or the telephone line.

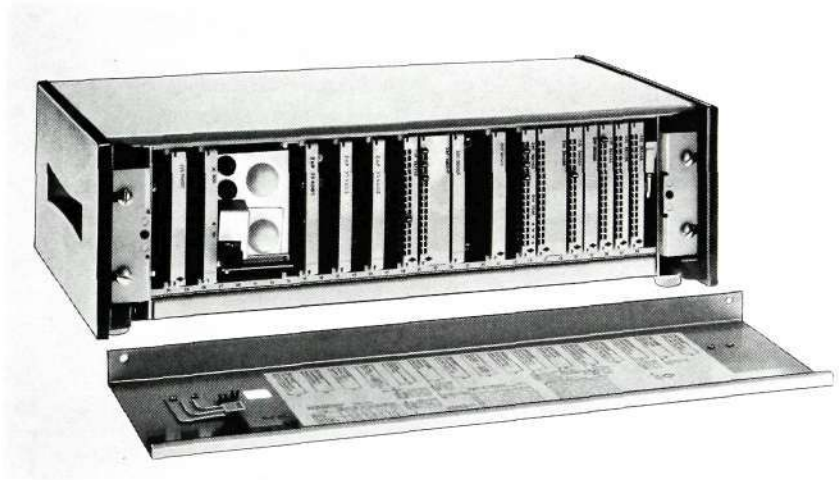
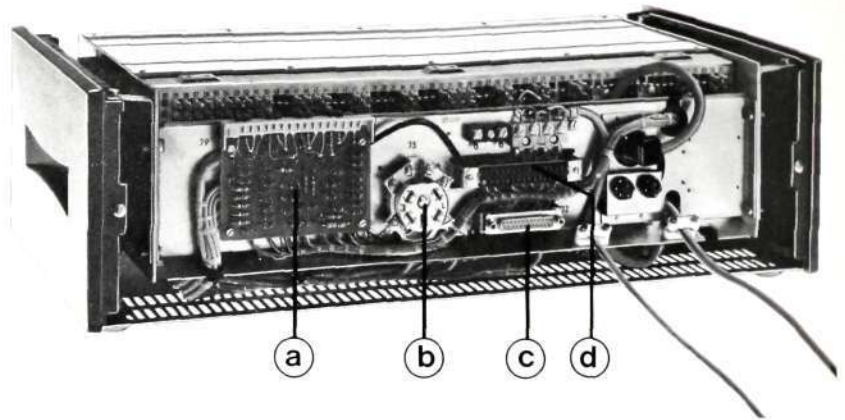


Fig. 8

Modem ZAT 2400 seen from the front with the front plate removed. The version shown includes a backward channel. The unit extractor is kept on the inside of the right-hand shelf upright. On the inside of the front plate there is a block diagram that shows the positions of the units, the test points and the straps. The front plate is also used for storing the test cords

Fig. 9

The modem equipment seen from the rear with the cover plate removed. At the rear there is a strapping field (a), connectors for connecting a telephone (b), data processing equipment (c) and a control unit (d). The connections to the mains supply and the telephone line are made via plugs and cables



## Summary

ZAT 2400 has come into use in a considerable number of data communication systems because this modem

- has great flexibility, which is achieved through the modular design with plug-in type units that form complete functional units, and a centrally placed strapping field, which makes it possible to adapt the equipment for any particular application.
- can be used even on telephone lines with unfavourable distortion, due to the fact that it is possible to include an equalizer in which different types of equalization networks can be selected.
- is particularly suitable for multi-point networks as a result of the short synchronizing time and the possibility of equipping two equalizers in order to obtain the optimum transmission quality.
- is easy to install thanks to the large dynamic range of the receiver and the ease with which the send level can be adjusted.
- simplifies fault location in the data communication system, because of the facility whereby the line side and the digital side can be looped.

## Technical Data

### *Line Interface*

Types of line	2-wire or 4-wire
Impedance	600 $\Omega$ or 800 $\Omega$
Modulation method	Differential 4-phase, code alternatives A or B
Nominal line frequency	1800 Hz
Send level	0 to - 17.5 dBm in steps of 2.5 dB
Receive level	- 3 to - 27 dBm or - 3 to - 43 dBm

### *Digital Interface*

Data signalling rate	2,400 bit/s
Level, impedance	In accordance with CCITT recommendation V24
Synchronizing time	5 to 15 ms

### *Power Supply*

AC voltage, nominal 110, 127 or 220 V (48 to 65 Hz)  
Power consumption 40 VA

### *Climate*

Temperature 0 to + 45° C

### *Dimensions*

Shelf 120 × 225 × 482 mm  
Case 150 × 285 × 520 mm  
Weight when mounted in a case 13 kg

### *References*

1. REJDIN, A.: *Construction Practice for Electronics Equipment in Stored-Programme-Controlled Telephone Exchanges*. Ericsson Rev. 47 (1970): 2, pp. 50—59.
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# Remote Measurement of Subscriber Lines

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UDC 621.398:621.395.126.2  
LME 1548

*Remote measurement of subscriber lines and telephone sets has hitherto been done usually on physical circuits, using traditional measurement technique and within a limited range. Today, with automatic operation within increasingly large areas — often with many unattended exchanges and centralized maintenance — one needs to be able to measure subscriber lines from a central point in the area irrespective of the length of line and type of junction. L M Ericsson have therefore designed a remote measuring equipment with which all information for carrying out the measurement is provided by v.f. signalling.*

*The author describes the measuring procedure and also to some extent the design of the equipment.*

## Facilities and Methods

L M Ericsson's remote measuring equipment permits rapid, accurate and complete measurements on subscriber lines and associated telephone sets. With this equipment a connection to any subscriber line within an administrative district can be set up from a central maintenance centre. With the measuring and control equipments one can then carry out measurements and perform the following tests:

- a) Check whether the subscriber's line is free, engaged or nonmeasurable. If engaged, the test operator can enter the line by issuing a special order. As soon as the test circuit has been established, a lamp lights on a console (fig. 1).
- b) Measurement of extraneous voltages with division into three classes.
- c) Measurement of insulation resistance.
- d) Measurement of the capacitance between the a and b wires with division into three classes.
- e) Setting up of test calls from the tested subscriber number to the central remote measuring equipment.
- f) Measurement of dial speed with division into five classes.
- g) Connection of ringing current and current feed to the subscriber.
- h) Transmission of *howler tone*, i.e. a tone which informs the subscriber that he has forgotten to replace his handset.
- i) Reversal of polarity of the subscriber's a and b wires.
- k) Removal of holding condition due to failure of the calling subscriber to replace his handset or of the equipment to clear the line.

The following results are obtained through lamp indications:

*Quick check* of subscriber lines is initiated by a control order which automatically starts the series of measurements listed under b)—e). Extraneous voltages and insulation resistances, here divided into three classes, are shown separately for the a and b wires and between these wires.

*A more accurate check* of the insulation resistance is made by means of separate measurement orders for the a wire, b wire, and between these wires. Separate orders are also required for high-impedance and low-impedance measurements. The result in both cases is divided into 10 classes, from 5 k $\Omega$  to more than 300 k $\Omega$  in high-impedance and from 0 $\Omega$  to 5 k $\Omega$  in low-impedance measurements. The results of the latter category can be used for rough determination of the location of the fault.

For *data processing* the measured values can be obtained from the storage relay set, which stores the results provided by the lamp indications on the console. On clearing of the test circuit the results are then fed to a perforated tape for printout or data processing. The perforated tape contains the subscriber's number, time of the measurement, statistical code keyed, if any, measurement and control orders keyed, and results in numerical code.

The *junction circuits are not included* in the test circuit since the measurements are made by a special unit included in the individual equipment for each exchange. This unit is metallically through-connected to the subscriber's line.

## Additional Equipment at Individual Exchanges

Each individual exchange can be equipped with a unit to permit remote measurements of three different DC voltages and of ringing and mains voltage, for monitoring of buzzer tone and for check of the alarm transmission system of the exchange.

For remote control of ten different functions, such as connection and disconnection of different items of equipment, opening of door, starting and stop-



**Fig. 1**  
Console forming part of the remote measuring equipment

ping of traffic meters, the individual exchanges can be equipped with an additional relay set. The carrying out of a given order is acknowledged by a buzzer tone.

## System Units

The order transmitter and result receiver, PR-A, is placed in the maintenance centre and the order receiver and result transmitter, PR-B, at each individual exchange (fig. 2). They are connected to the respective exchanges as ordinary subscriber lines. The number of PR-A and PR-B required depends on the traffic load. If more than one PR-B is required for a 10,000-line group, for example, they are connected as PBX subscribers with common call number.

From a console with keyset (fig. 1) the PR-A is programmed with the subscriber number and the necessary 2-digit control order. The keyed subscriber number is analysed by PR-A, which determines the *service number* to PR-B and sets up the connection to the latter on the normal switching paths. PR-A then directs the setting-up of the test connection via FIR-P and the B exchange to the wanted subscriber. Up to five consoles can be connected to one PR-A.

All types of junction circuits can be used between the exchanges, while all signalling after connection to PR-B is done with voice frequency. Such signalling is required for setting up of a test connection to a subscriber, for control orders from PR-A and result transmission from PR-B.

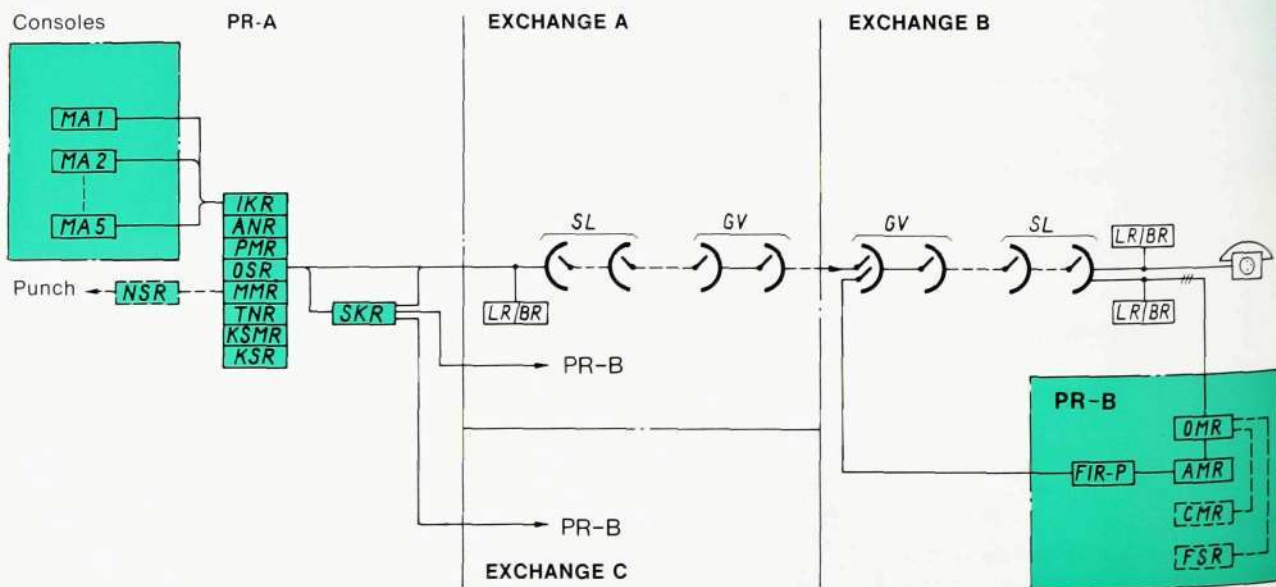
When PR-A is connected to the central exchange in a city exchange system and PR-B is installed at adjacent city exchanges, it is economically warranted to equip PR-A with a quick connection relay set SKR. Via this relay set PR-A is then connected on three wires directly to PR-B. Much time is thereby gained, since no regular connection need be set up to PR-B.

The PR-B program is determined by the control order received. When this program has been run through, a new control order can be issued within permissible series, which is supervised by PR-A.

Fig. 2

Connection of PR-A and PR-B of the remote measuring equipment to a multiexchange network

MA	Console
IKR	Connecting relays for max. five MA
ANR	Analyser
PMR	Program store
OSR	Order transmitter and result receiver
MMR	Store for results of measurements
TNR	Service number relay set
KSMR	Connecting relays for KSR
KSR	Code sender (MFC)
SKR	Quick connection relay set
NSR	Connecting and recording relay set for tape punch
OMR	Order receiver and result transmitter
AMR	Measuring equipment for subscriber's line
CMR	Supervisory equipment for voltages, tone and alarm system
FSR	Remote control relay set
FIR-P	System-adapted test circuit to the exchange



## Signalling Principles

Subscriber's number and control order are transmitted from the console to PR-A in 2/5 code. The B number may contain a maximum of 10 digits, which may include for example a zone prefix with dial tone between it and subscriber's number.

The service number of PR-B is sent to the A-exchange register in the form of decadic pulses.

When the connection has been set up between PR-A and PR-B, all signalling between them is effected with voice frequency, different frequencies being used in the two directions. PR-A sends a control order, and normally also the subscriber's number in the form of decadic v.f. signals, while it sends order cancellation and forced release in the form of signals of fixed duration. At exchanges with MFC signalling, however, the subscriber's number is sent in MFC. PR-B acknowledges these signals and the signalling is thus effected in compelled sequence.

PR-B sends the result in the form of decadic v.f. signalling, which is acknowledged by PR-A, so that compelled sequence is ensured in this case as well.

## Different Types of B Exchanges

PR-A and PR-B are system-independent, with the exception of FIR-P, which constitutes a test outlet to the B exchange and is adapted to the existing exchange system.

In order that PR-B may serve several 10,000-line groups in the same building — including also different exchange systems — it has 10 test outlets. To these outlets can be connected up to the same number of FIR-P, which can be adapted to the existing system. Depending on the number series, PR-A will then add a third digit to the control order, so that PR-B can select the correct test outlet and thus function as a test group selector with 10 outlets (fig. 3 a).

For adaptation to ARF 50 and ARF 101 there are FIR/GV-P with 10-outlet group selector function (fig. 3 b) and, for adaptation to AGF, GVR-P has 20 outlets (fig. 3 c).

A FIR-P/GV-P for 100 outlets is intended for very small exchanges. It permits setting-up of a test connection to a desired subscriber line entirely outside the selector stage of the exchange (fig. 3 d). The same equipment can be used also for step-by-step exchanges (fig. 3 e).

## Mechanical Design

The equipment is made up of conventional relays and electronic components mounted on ROA printed circuit boards. These relays and boards are placed on BCH relay sets for mounting on BDH racks.

PR-A is usually placed on a rack together with the PR-B associated with the same exchange. In other exchanges PR-B is placed on a rack for miscellaneous relay sets.

The console is desk-mounted and has a flexible cable which plugs into a jack. The maximum distance between the console and PR-A may be about 200 m.

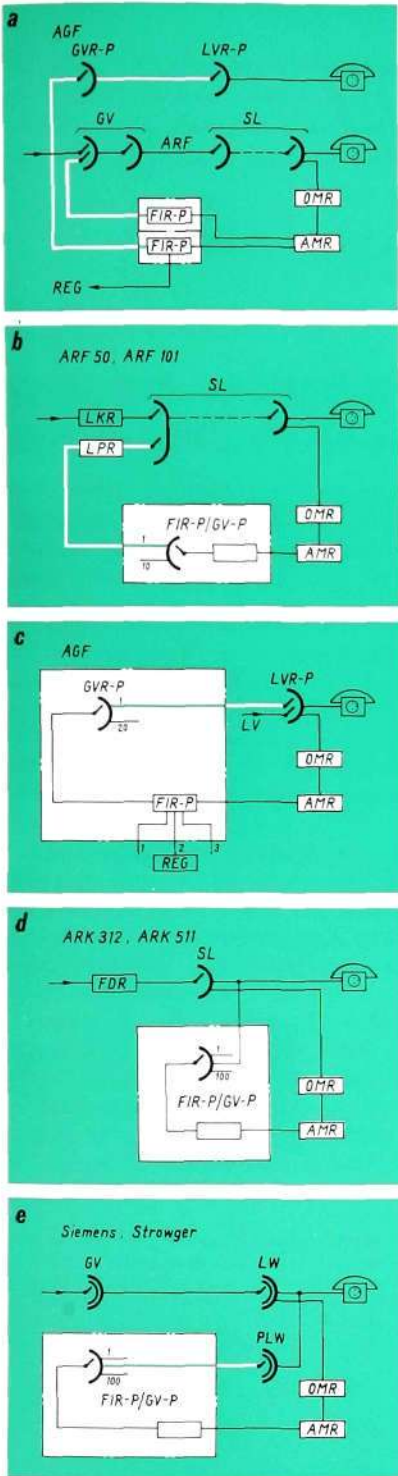


Fig. 3 a—e  
Connection of PR-B to different exchange systems

## Concluding Remarks

Through the introduction of remote measurement of subscriber lines considerable savings in staff can be effected, travel to unattended exchanges is reduced to a minimum, and fault repair is facilitated and made more effective. This has been confirmed by administrations which have acquired experience of the remote measuring equipment.

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# ERICSSON *News*

from All Quarters of the World

## *Seventh International Teletraffic Congress: shift to SPC, PCM and TDM questions*

*The Seventh International Teletraffic Congress, ITC 7, was held in the new Riksdag Building in Stockholm, June 13—20, 1973. The hosts for the congress were the Swedish Telecommunications Administration and L M Ericsson together with Siemens AB, Svenska AB Philips and Standard Radio & Telefon AB.*

The teletraffic congresses are under the supervision of International Advisory Council, the chairman of which is Professor Arne Jensen, Denmark. Dr. Christian Jacobæus of L M Ericsson is also a member of the Council and was chairman of the Organization Committee for ITC 7.

The congress was attended by 328 delegates from 30 countries, chiefly telecommunications engineers, statisticians and mathematicians from telecommunications administrations, industry and universities.

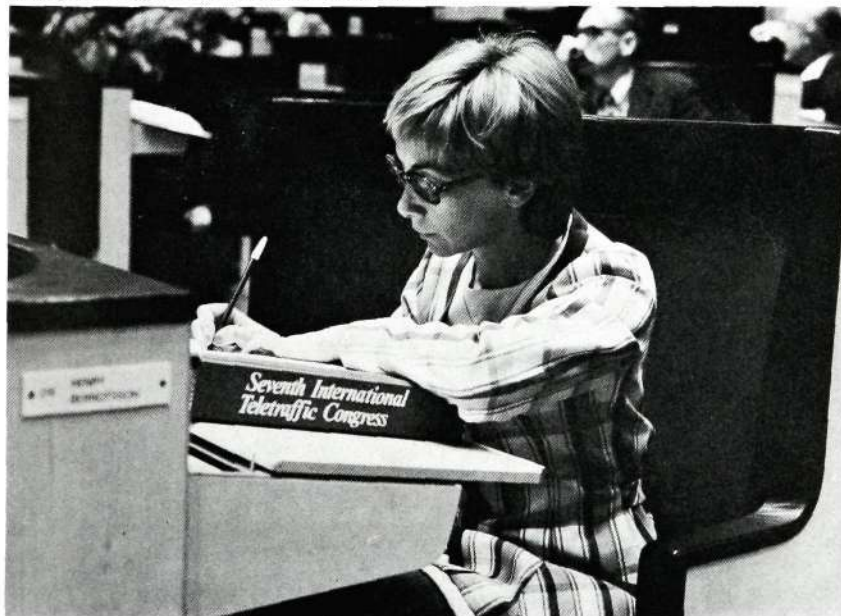
During the six working days 132 papers were presented and discussed within the subject-field of the congress — application of the theory of probability to traffic theoretical and traffic engineering studies related to telephony, telex and datacommunication.

The papers varied in type from purely theoretical studies at the basic research stage to practical investigations relating to current telecommunications traffic problems. Compared with earlier congresses there has been a shift in the field of application, with a considerably greater number of papers devoted to SPC (stored program control), PCM (pulse code modulation) and TDM (time division multiplex) questions. Some ten papers were delivered from the Swedish Telecommunications Administration and L M Ericsson.

The papers and their discussions will be published probably at the end of the year.

At the invitation of the Australian Post Office the next congress will be held in Australia in 1976.

One of the few women delegates at the congress was Dr Maria Netto Costa from the Portuguese Telecommunications Administration.



## New generation of PABX's

A stored program controlled electronic PABX system, ASD 551, is being developed by ELLEMTEL (a company jointly owned by L M Ericsson and the Swedish Telecommunications Administration for research and development of advanced electronic telephone systems).

A prototype of ASD 551 is undergoing laboratory tests this autumn, and next autumn the first exchange will be placed in operation at ELLEMTEL.

ASD 551 can be built in sizes from about 100 to 600 extensions. A 600-line exchange is accommodated on seven racks of new type, including space for the equipment required for all special services. The racks are interconnected by cabling which plugs into the preceding rack. This facilitates new installation as well as extension of existing equipment. Both pushbutton and dial telephones can be connected to the exchange.

All components are mounted on printed circuit boards which plug into shelves, the shelves being plugged into the rack. The switches consist of matrices of reed relays. Minirelays are used in the traffic-carrying devices. Other components are chiefly bipolar integrated circuits of TTL type, but thick film circuits and discrete components are also used.

On the new operator's console for ASD 551 the conventional alphabetical signs have been replaced by symbols which are easier for the operators to learn and work with.

Other advantages of the new PABX are that it requires less space than conventional types and is easier to install. The stored program control provides great flexibility as regards special services, extensions of the exchange and adaptation to different marketing and signalling conditions.

An operator's console for the new electronic exchange ASD 551.



## **"Human Factors" a new feature at this year's Maintenance Conference**

The 1973 Maintenance Congress was held during the period May 21—25 at L M Ericsson, Stockholm.

There were 58 delegates from Denmark, Finland, the Faroe Islands, Greenland, Iceland, Norway and Sweden. Altogether 14 telecommunications administrations were represented.

This was the first conference since 1971 and it was therefore natural that new subjects should be on the agenda. It was particularly "human factors" within operation and maintenance which, judging from the lively discussions, appeared to be a matter that is starting to interest telephone people in general. Within L M Ericsson it has earlier been decided that all engaged on the design of systems and products, and with their handling and documentation, shall to a greater extent than hitherto pay attention to the human factor in the encounter with technology.

Views concerning the laying of cables for reduction of operational disturbances and maintenance problems were dealt with, and in conjunction therewith the Swedish Telecommunications Administration invited the delegates to a demonstration of the cable tunnel network in Stockholm.

Experience from SPC telephone exchanges was presented from several quarters — not solely from participating European administrations but also from the USA.

The PCM (Pulse Code Modulated)

systems were also dealt with in several addresses, and points of view concerning both installation and maintenance were discussed.

Among the new features from L M Ericsson in the telephone exchange field may be mentioned a new generation of traffic route testers (TRT m 70) for supervision of the reliability of telephone plant. This will be dealt with in a future article in Ericsson Review.

L M Ericsson's AGF system (500-line selector) attained the age of 50 years this year, which was noted in a very interesting paper read at the conference. Anyone who may have believed that older exchanges are starting to be scrapped came to realize that this is by no means the case. The work on maintenance of the very oldest AGF exchange of the Swedish Telecommunications Administration, which was presented in figures, hardly differs in magnitude from that for more modern equipment. The concluding remarks of the lecturer were also a tribute to the designers of the system.

## **Antenna equipment from LM Ericsson for space satellite**

L M Ericsson will be sharing a satellite contract amounting to 130 Mkr signed by the European Space Research Organization with the STAR consortium. STAR, consisting of 15 companies in 10 European countries, is to manufacture Europe's first geostationary scientific satellite GEOS, which will be launched in 1976 for various radia-

tion investigations. It will have a life of two years.

L M Ericsson, Swedish member of the STAR consortium, has been assigned the task of furnishing the GEOS satellite with antenna equipment for telemetering of scientific data to the earth. Its share of the contract amounts to about 3 Mkr.

## **Selective reconnaissance radar**

A selective reconnaissance radar for the Swedish Army is at present being manufactured in prototype form at L M Ericsson's MI Division, Mölndal. The new reconnaissance radar, called PS-70/R, can be mounted on a standard military truck and permits detection of approaching enemy aircraft even at a very low height. The manufacture of prototypes is expected to be completed next year.

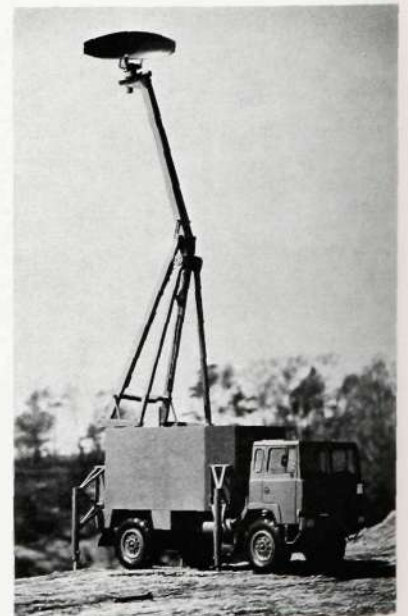
As the radar station works with pulse doppler technique, it can distinguish between indications from mobile and fixed objects. The freedom as regards siting obtained with this technique has been further increased through the mast arrangement for the antenna.

The pulse doppler technique has earlier been used within the Swedish Air Force for the fighter version of the Viggen aircraft.

The new reconnaissance radar was exhibited this spring at the International Aviation Exhibition in Paris, where it aroused a certain interest.

**Mobile reconnaissance radar for Swedish Army. In operation the radar aerial is a bit above the ground and can therefore detect enemy aircraft even at a very low height.**

Maintenance Conference at L M Ericsson, May 1973.



## Push-button telephone data terminal at Danish hospital

A PABX supplemented by a mino-computer has been placed in service in the X-ray department of the municipal hospital at Aarhus in Denmark. The telephones are of push-button instead of dial type, which permits their use as data terminal. By combination of the telephone system with a computer the collection and filing of patient data is facilitated.

Patients referred to the hospital X-ray department carry with them a reference card to the examination room. The card shows from which department they have been referred, what examinations are to be made, and personal data such as personal number and the like. These data are keyed into the computer by a nurse from a push-button telephone. The nurse then receives spoken instructions from the computer concerning the additional information desired. This is done via a Vocoder speaking machine.

The doctor who thereafter carries out the examinations notes on the reference card his diagnosis in code form, possibly with a written diagnosis as well. When all examinations have been made, the note is delivered to a nurse who possesses a visual display terminal. By means of the personal number the data earlier keyed from the push-button telephone are now shown on the visual display and checked. Diagnoses are added to the patient data, which are sent on to magnetic tape for filing.

**An X-ray nurse at Aarhus hospital in Denmark feeds in patient data to a minicomputer with pushbutton telephone. While doing so she receives spoken instructions from a Vocoder announcing machine.**



This is an example of how an automatic telephone system can be combined with a computer. Merely through the fact that push-button telephones can be used also as simple data terminals they will, when more generally introduced in telephone networks, permit a wider access to computers for a number of new services.

This Danish system was developed, manufactured and installed by L M Ericsson in cooperation with the Jutland Telephone Company.

## Intercom system for 1800 extensions at Kockums

Kockums in Malmö, one of the largest shipyards in the world, has ordered a very extensive intercom system from L M Ericsson Telemateriel AB. It is an exchange of type AKD 491 which, when installed to full capacity, will have 1800 extensions with 58 connecting circuits.

In the first stage 1150 intercom stations of the new type, ERICOM 30001, which has both loudspeaking and non-loudspeaking function, are to be installed. The ERICOM stations are intended primarily for offices and workshops. Three hundred exclusively non-loudspeaking stations are also to be installed for use on board ships under construction.

The Kockums order includes equipment also for a considerable extension of the internal cable network. The total value of the order is about 1.8 Mkr. The equipment is to be completed for putting into service after the 1974 vacation.

## Longest CTC railway in the world

What is said to be the longest CTC-section of railroad line in the world was commissioned this summer by the Swedish State Railways. It was then that the last stage of the more than 1700 km line between Narvik and Norrköping was linked into the CTC system.

CTC (Centralized Traffic Control) means that the traffic is directed from a central office from which train movements can be followed on a track diagram. From the CTC office orders can also be issued to the remote controlled stations concerning operations which were earlier performed by the local dispatcher. The introduction of CTC brings a great saving of staff, as no dispatchers are required at the stations.

CTC has now been introduced over a considerable portion (2964 km) of the commercial railway network of the Swedish State Railways. From ten CTC offices throughout the country nearly 300 railway stations are under remote control and the system is being extended still further.

At the CTC Office in Stockholm, from which a very high density of train traffic is directed, the routine issuing of orders is automated through the use of computers. An electronic train description system provides information concerning the descriptions of train running in the area. Stored-program-controlled train dispatching is also employed. This implies that the timetable and data of track usage are stored in the computer memory. The computer then selects the most appropriate routes and automatically transmits controls for their establishment.

The CTC systems have been developed by L M Ericsson in close consultation with the Swedish State Railways.

Sweden has been a pioneering country in the use of CTC. It is therefore natural that railway administrations which intend to introduce CTC visit Sweden to study the results attained.

For this purpose, some time ago a delegation from the Italian FS Railway, headed by Sr. Antonio Liverani (head of the Signal Division), visited L M Ericsson and the Swedish State Railways. They were shown over the CTC installations at Stockholm Central Station and in Gothenburg, and in Denmark the installations at Roskilde and on the Copenhagen suburban lines.

## Carl Jensen In memoriam



*Carl Jensen, founder of Dansk Signal Industri A/S and its former president, died on April 3, 1973, at the age of 69 years.*

*Carl Jensen was a graduate marine engineer and for some years immediately after graduation he sailed on the Danish America Line boats.*

*With his fertile brain, enterprise and mechanical bent he felt an urge for more creative work.*

*On October 1, 1930, therefore, Carl Jensen founded his own firm, Dansk Signal Industri, which he led until in 1935 he came into contact with L M Ericsson's Signalaktiebolag, which at that time was looking for a Danish subcontractor for supply of equipment to an electro-mechanical interlocking plant at Fredericia.*

*As a result of this cooperation DSI was reformed into a joint stock corporation with Carl Jensen as president.*

*During Carl Jensen's time DSI expanded very considerably, and many new types of equipment saw the light of day.*

*During the last two years before his retirement Carl Jensen acted as consultant to the Board for the planning of the company's new administrative and manufacturing premises at Avedøre Holme.*

*During his retirement, despite several years of severe illness, Carl Jensen followed with interest the development of DSI, and we, his colleagues, will always remember him as a just and good employer.*

F. Loell

## Major Orders

### Oman

In the face of stiff international competition L M Ericsson have received an order for the delivery and installation of a new nationwide telephone system, valued at about \$16m. Among other items the contract includes telephone exchange equipment, telephone sets, local and trunk cables, carrier equipment and radio links. This is the first order received by L M Ericsson from Oman.

### Algeria

L M Ericsson have received an order worth about \$5.7 m. for the delivery and installation of telephone switching equipment for five cities in western Algeria, including Oran. This is L M Ericsson's first substantial order from the Algerian PTT.

### India

L M Ericsson have received an order from India for crossbar exchange equipment for use in New Delhi. The value of the order is about \$3 m. and is significant in being the company's first for telephone switching equipment from that country. Financing of the order has been arranged through the World Bank.

### Iraq

The Iraq PTT has signed with L M Ericsson a contract for cable and line equipment for about \$6.5 m. The equipment ordered will be used for expansion of the local line networks in the country, primarily in the cities of Baghdad and Basra. This is the biggest order from Iraq received by the company for this kind of equipment.

### Panama

L M Ericsson have received an order for exchange equipment for 69,500 lines from the Panama State Telephone Operating Company IRHE. The delivery of this equipment is to be completed by 1977.

## Atomic time and solar time to a thousandth of a second

The Swedish Telecommunications Administration at Farsta has designed a new time signal which was brought into use on August 1. The new time signal, which is electronic, indicates the time within an accuracy of a thousandth of a second. The previous time signal has an accuracy of a tenth of a second.

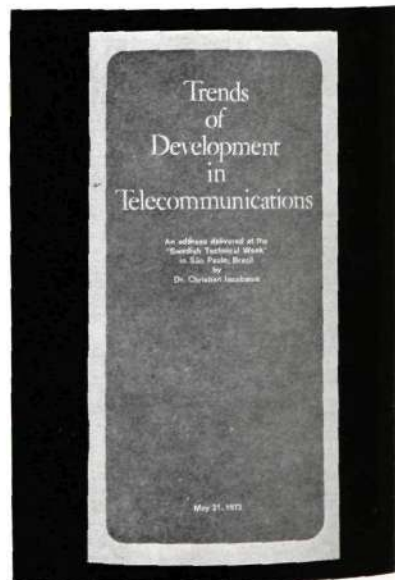
Another essential difference is that the new time signal, during the first 15 seconds after the minute signal, delivers coded information indicating the difference between solar time and atomic time. The relation between solar time and atomic time was earlier notified by a verbal message in conjunction with the transmission of the time signal.

## New publication on telecommunications

"Trends of Development in Telecommunications" is the title of the address delivered by Dr Christian Jacobæus, Technical Director of the Ericsson Group, at São Paulo during the Brazil-Sweden Technical Development Week, May 21—25.

The address has been reproduced in its entirety in an English language edition which can be obtained from the Group's Information Division under address:

Telefonaktiebolaget L M Ericsson  
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TELEFONAKTIEBOLAGET LM ERICSSON

# ERICSSON

4  
1973

# Review





# ERICSSON REVIEW

Vol. 50

No. 4

1973

RESPONSIBLE PUBLISHER: CHRISTIAN JACOBÆUS, DR. TECHN.

EDITOR: GUSTAF O. DOUGLAS

EDITORIAL STAFF: FOLKE BERG,

BO SEIJMER (ERICSSON NEWS)

EDITOR'S OFFICE: S-12625 STOCKHOLM

SUBSCRIPTIONS: ONE YEAR \$1.80; ONE COPY \$0.60

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# ITC — The International Teletraffic Congresses

CHRISTIAN JACOBÆUS, TELEFONAKTIEBOLAGET LMERICSSON, STOCKHOLM

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*The Seventh International Teletraffic Congress (ITC 7) was held in Stockholm in June 1973. It was 18 years since the first of these congresses was organized in Copenhagen. They have now become an established institution within the world of telephony and are considered important and of significance both for administrations and industry.*

*This paper describes the origin of the congresses and their development hitherto.*

The main aim of teletraffic research is to establish rules and methods for the dimensioning of telecommunication systems. During the manual period and the first decades of the automatic era it sufficed to use fairly simple rules of thumb. The nature of telephone traffic was then not sufficiently known and in many cases the mathematical tools which were later to prove necessary were also lacking.

The first two decades of the century saw the birth of traffic research as a science through the work of the Dane *A. K. Erlang*. He introduced the classical concept of *statistical equilibrium* as a mathematical description of telephone traffic. Erlang's formulae laid the foundations for the future work within this science. Traffic research has attracted the interest both of engineers and mathematicians. It soon proved also that administrations and industry had a growing need for and interest in correct dimensioning methods. It was found that large sums could often be saved by this means, while at the same time a certainty was achieved that the traffic could be handled without troublesome bottlenecks.

## The origin of the teletraffic congresses

In the late forties and early fifties it became clear to many of those working on traffic theory questions that closer contact between researchers in the field would be of great value. A meeting at which people could present their work, where ideas and experience could be exchanged, and, not least, where personal contacts could be made, was considered to be greatly desirable.

In the autumn of 1953 an organizational committee was formed consisting of

*E. Brockmeyer*, Denmark

*C. Jacobæus*, Sweden

*A. Jensen*, Denmark

*L. Kosten*, Holland

*N. Rodenburg*, Holland

The committee considered that Denmark should be host nation for the first congress in view of the decisive contribution made within telephone traffic research by A. K. Erlang. Denmark also undertook with enthusiasm to organize the first teletraffic congress. It was held in Copenhagen on June 20—23, 1955, and was attended by 69 delegates from 13 countries. Twenty-six papers were presented and discussed.

A report entitled *The First International Congress on the Application of the Theory of Probability in Telephone Engineering and Administration* was published in the Danish telecommunications journal TELETEKNIK, English edition, Vol. 1, No. 1, 1957. The report contains certain papers in their entirety and summaries of the contributions which had already been published in various journals.

The delegates considered generally that the congress had been very successful and fruitful and it appeared self-evident that future congresses should be arranged. Teletraffic congresses have since been held every third year. The attendance at and contributions to various congresses are shown in table 1.

At the first congress a council entitled the *International Advisory Council (IAC)* was set up. From the start IAC has been composed of researchers from the leading countries within the field. The chairman has throughout been Professor Dr *Arne Jensen*, who has also played the greatest part in drawing up the lines for the congresses; more than any other he has set his mark upon them.

The responsibility for the organization and arrangement of the various congresses has rested with the host countries. Through great generosity on the part of administrations and industry in the various host countries the congresses have always been very well organized. Highly appreciated programmes for the wives of delegates have been a common feature. All events, as also the congresses themselves, have been free of charge to the delegates.

## Programmes of the congresses

The programme of the first congress was defined in the very title: *Application of the Theory of Probability in Telephone Engineering and Administration*. In the papers presented at it there was a strong emphasis on different sections of traffic research such as gradings, link systems, queueing theory and traffic measurements. These fields have, of course, been the main subject of discussion at all congresses, but new types of problems created by the accelerating development within telecommunications and different questions solved chiefly by opera-

**Table 1**  
Data of delegates and papers at the International Teletraffic Congresses

The reference numbers refer to the list of publications contained in the bibliography

	Place	Time	Delegates		Papers		Reference No.
			Number of delegates	Number of countries represented	Number of papers	Number of countries represented	
ITC 1	Copenhagen	June 20—23, 1955	69	13	26	8	1
ITC 2	The Hague	July 7—11, 1958	93	15	31	11	2
ITC 3	Paris	September 11—16, 1961	134	20	48	12	3
ITC 4	London	July 15—21, 1964	179	22	60	11	4
ITC 5	New York	June 14—20, 1967	159	20	80	17	5
ITC 6	Munich	September 9—15, 1970	310	30	108	19	6
ITC 7	Stockholm	June 13—20, 1973	328	30	130	20	7, 8, 9

tions research methods have acquired an ever greater scope. It is also natural that there has been some shift away from the original problem fields, since many of the fundamental problems within traffic research have now found acceptable solutions.

The change of emphasis is illustrated by the fact that the Stockholm congress was greatly concerned with such fields as network optimization, satellite systems, network management, traffic-reliability problems, simulation methods, forecasts and planning, questions of norms, data communication and data networks.

## Congress procedure

At the first congresses, when the number of papers was still limited, it was possible within the time available for the congress to let each author read his paper (or, if very long, a summary of it). Thereafter followed discussions. From the New York congress onward, however, the papers became so numerous that a partially different procedure had to be adopted. Separate sessions were arranged for each particular field. The contributions were divided into two groups, "read" and "non-read". The former were presented during about 10 minutes in concentrated form by their authors, while the latter were presented by a speaker. The speaker, who was usually a specialist within the field, also led the discussion. Speakers have often played a great role through the emphasis on essentials that they could give to the discussions.

At the New York congress a new order was introduced as regards the production and distribution of papers. Until then each author had usually produced copies of his paper in advance and sent them to the delegates direct or via the organizers of the congress. As from the New York congress the authors have written their papers in the form of an original submitted to the congress organizers, who thereafter undertake their duplication and distribution.

At the New York congress and, more systematically, at the Munich congress so-called "invited papers" were also introduced. Reviews within different subject fields were presented by specialists. These papers have often constituted valuable sources of knowledge concerning the main features of the development within the respective spheres.

## The role of the teletraffic congresses in the development of telecommunications

Telecommunications have developed very rapidly during the period since the second world war. A greatly increased demand for telecommunication services within public administration, industry and homes has necessitated systems with better properties and greater capacity. At the same time the advent of the semi-conductors in particular has provided us with new opportunities to meet these requirements. It is perhaps too much to say that traffic research and operations research have played a decisive role in this development. But the economic considerations have in most cases been based on work done within these sciences. This has, of course, been especially important in a period of rapid expansion. The traffic congresses have been a very substantial means for stimulation of activity within these fields. At the congresses the researchers have been able to present their work and have them expertly criticized by interested colleagues. Ideas for new research tasks have appeared. Not least, the congresses have often stimulated researchers to present their contributions earlier than they would otherwise have done. The congresses as assembly point for all traffic researchers of the world have become important for the establishment of personal contacts. These were hopes held by the original organization committee and which, one

must say, have been fulfilled to a high degree. The generous support given by administrations and industry to the congresses is also a sign of the realization of their great significance.

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# Seventh International Teletraffic Congress in Stockholm, June 1973

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UDC 0613:621.395.31  
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*The Seventh International Teletraffic Congress, ITC 7, was held in Stockholm in the new parliament building on June 13—20, 1973, at the invitation of the Swedish Telecommunications Administration, Telefonaktiebolaget LM Ericsson, Standard Radio & Telefon AB, Svenska AB Philips and Siemens AB. The first congress of this kind was held in Copenhagen in 1955 and they have thereafter been held every third year.*

*ITC 7 gathered 328 delegates representing 30 countries. Altogether 130 papers were presented. This congress was thus the largest of its kind hitherto, both in number of delegates and in number of papers.*

The subject-field for ITC is the *Application of the Theory of Probability to Telecommunication Research, Engineering and Administration.*

The first international teletraffic congress was held in Copenhagen in 1955 at the initiative of Professor *Arne Jensen*, and to a large extent under his leadership. The choice of Denmark as the place for the first congress was natural, as modern teletraffic theory had been founded by *A. K. Erlang*.



Fig. 1  
The opening session of ITC 7 in the new parliament building in Stockholm

At the first congress an *International Advisory Council (IAC)* was formed in order to advise and give guidance concerning the organization of the international teletraffic congresses. IAC has included representatives of the leading countries within the field. Its chairman is Professor Arne Jensen.

Since the Copenhagen congress new congresses have been held at three-year intervals at The Hague, Paris, London, New York, Munich, and now in Stockholm. The next congress is to be held in Australia in 1976.

The organization of the congresses has been undertaken by a committee from the host-country for each congress.

The initiation and development of the congresses are dealt with in a separate article in this issue of *Ericsson Review*<sup>1</sup>.

## ITC 7 — General Arrangements

An Organizing Committee, with *Dr Christian Jacobæus* as chairman, was established for ITC 7 in the autumn of 1970. This committee had the main responsibility for the organization of the congress. A Technical Committee was appointed to draw up the programme of sessions and for grouping of the contributions. The technical committee consisted of Swedish members and of a reference group of foreign researchers who could be consulted on doubtful questions.

The congress was held in the plenary hall of the Swedish Parliament, which was kindly placed at the disposal of the congress. These premises proved admirable for the needs of the congress.

Country	Delegates	Contributions
Australia	5	2.5*
Belgium	5	1
Brazil	4	—
Bulgaria	1	1
Canada	9	3
Denmark	14	4
Finland	5	4
France	10	4
F. R. of Germany	37	19
Greece	2	1
Hungary	5	3
Indonesia	1	—
Ireland	2	—
Israel	1	—
Italy	31	6
Japan	7	7
Mexico	1	—
Netherlands	11	4
Norway	25	14
Poland	1	—
Portugal	1	—
South Africa	1	—
Spain	17	7
Sweden	48	7.5*
Switzerland	10	1
Thailand	2	—
Tunisia	1	—
United Kingdom	31	9
USA	36	20
USSR	—	12
Yugoslavia	4	—
<b>Total</b>	<b>328</b>	<b>130</b>

**Table 1**  
Number of delegates and contributions from each country

\* 0.5 owing to a joint paper from Australia and Sweden.

At the opening session addresses were presented by Dr *Christian Jacobæus*, L M Ericsson, *Bengt Furbäck*, Assistant Undersecretary to the Minister of Communication in the Swedish Government, *Bertil Bjurel*, Director General of the Telecommunications Administration, and Professor *Göran Borg*, Royal Institute of Technology, Stockholm.

A consistent theme in the addresses was the importance attached to the congress for promotion of an exchange of research results, methods and ideas between representatives from administrations, universities and industry. Both the formal exchange during the sessions and the informal exchange outside them have a great value for those responsible for these questions in their respective organizations.

The speakers welcomed the fact that so many delegates had accepted the invitation to Sweden and hoped that the congress would come up to their expectations.

## Review of Contributions to ITC 7

A brief account is given below of the main subjects dealt with by the congress, which were as follows.

- Special sessions
- Subscriber behaviour and traffic measurements
- Switching networks and gradings
- Network questions
- Data communication, SPC and TDM systems
- Traffic theory and statistical problems
- Queueing theory with applications
- Simulation

For those interested in a more detailed account reference is made to *Report on the Seventh International Teletraffic Congress in Stockholm, June 13—20, 1973*, Ericsson Technics No. 3, 1973.

### *Special Sessions*

There were altogether 24 sessions, four of which may be denoted as special. The first of these comprised a single paper entitled *Conny Palm and Teletraffic Theory* presented by Professor Arne Jensen and dealing both with Palm's life and with his work. As is known to the majority of readers, Conny Palm was a Swedish researcher who during the thirties and forties published a number of highly qualified papers, particularly within the field of teletraffic. A review was presented of Palm's doctoral thesis from 1943, which not only contained results of great significance for teletraffic theory but was also of great importance for the general theory of stochastic processes. The paper also contained a summary of Palm's many publications within the field of accuracy of measurements. As an example of Palm's contributions outside the field of teletraffic, finally, a report was given of what is today known as Palm's model of the machine interference problem.

One session was devoted to reports from two committees appointed at the previous congress. One of these is working on documentation of the contributions to the earliest congresses. For it is only since the fifth congress that the complete contributions have been collected in the form of »Proceedings», whereas from the first four congresses there are only more or less detailed summaries available. The second committee, which is working on educational questions within the particular subject-field, presented an account of a world-wide questionnaire organized with the aid of CCITT.

A special session was devoted to the cooperation between ITC and CCITT, particularly the work done within Working Party XIII/2 (Traffic Engineering).

The task is to find the best forms for stimulating ITC people to study questions of interest to this Working Party, and for the Working Party to make use of solutions derived within ITC.

The fourth special session, *Final panel discussion*, is dealt with below.

### *Subscriber Behaviour and Traffic Measurements*

The papers in the *Subscriber Behaviour* session were divided into two main fields, presentation of measurements of real traffic and presentation of analytical models for subscriber behaviour. Within the latter field the question of repeated call attempts, of very great importance for telephone systems, was dealt with.

Several papers dealt particularly with the question of call processes and their effect on the systems. One paper presented points of view concerning new norms both for call-carrying devices and for slow and fast common control devices.

A number of papers reported results from measurements of real traffic in networks with high load, others from measurements of international telex traffic. In the latter case the effect of the time differences on the traffic distributions was dealt with. Systems for data collection, fundamental analysis and forecasting were also presented.

### *Switching Networks and Gradings*

A number of contributions were devoted to the calculation of congestion in link systems. Among the methods used are combinatorial analysis, iterative methods, simulations, exact and approximate calculations making use of equa-

**Table 2**  
Sessions at ITC 7.  
C = Chairman  
S = Speaker

1973-06-13	1973-06-14	1973-06-15	1973-06-18	1973-06-19	1973-06-20
11. <i>Opening session</i> C: C. Jacobæus	21. <i>Simulations</i> C: B. Wallström S: J. A. Povey	31. <i>Switching networks II</i> C: K. Rodhe S: B. Canceill	41. <i>Overflow and smooth traffic</i> C: R. Wilkinson S: G. Lind	51. <i>Forecasting and economic considerations</i> C: E. Böhm S: K. Rahko	61. <i>CCITT</i> C: E. P. G. Wright S: R. Chapuis
12. <i>Conny Palm's work</i> C: L. Kosten	22. <i>Traffic theory</i> C: B. Wallström S: A. Descloux	32. <i>Queueing systems I</i> C: K. Rodhe S: Ch. Grandjean	42. <i>Network planning</i> C: R. Wilkinson S: A. Lotze	52. <i>Network engineering</i> C: E. Böhm S: M. Anderberg	62. <i>Network management</i> C: E. P. G. Wright S: D. Haenschke
13. <i>Subscriber behaviour</i> C: H. Beastall S: G. Wikell	23. <i>Switching networks I</i> C: R. V. Relsted S: J. E. Villar de Villacian	33. <i>Common control systems</i> C: A. Jensen S: A. Elldin	43. <i>Computers and SPC systems</i> C: W. S. Hayward S: W. T. Duerdoth	53. <i>Special problems</i> C: R. Syski S: D. Bazlen	63. <i>TDM-switching systems</i> C: S. Kuhn S: A. Myskja
14. <i>Statistical problems</i> C: H. Beastall S: V. Beneš	24. <i>Gradings</i> C: R. V. Relsted S: E. Behlendorff	34. <i>Queueing systems II</i> C: A. Jensen S: L. Lee	44. <i>Data traffic</i> C: W. S. Hayward S: H. Inose	54. <i>Traffic measurements</i> C: R. Syski S: G. Timperi	64. <i>Final panel discussion</i> C: I. Tänge S: C. W. Pratt
				55. <i>Reports from ITC committees</i> C: A. Jensen	

tions of state, and equivalence methods. The effect of the hunting method on the traffic-handling capacity and the processor load, as also the significance of different link arrangements for the sensitivity of the systems to skew loading and overloading, had been thoroughly studied.

Modern advanced mathematics, such as graph theory and abstract algebra, had come into use for the study of non-blocking systems and of rearrangeable networks. Studies had been made of switching networks which are less common from the topological aspect, among which binary and nodal networks, and of systems for batch switching. Using a mathematical technique analogous to that employed within information theory, one author presented a method for calculating upper limits for the required number of cross-points in a system.

Within the field of gradings presentations were given of weighting methods and of exact and approximative calculation methods making use of equations of state. Both loss systems and delay systems had been studied.

### *Network Questions*

The first problem in the dimensioning of telecommunication networks, the input data, was dealt with in a number of papers. Various possibilities of obtaining the necessary traffic matrices from measurements were discussed. Methods were also presented for making forecasts of the traffic distributions in a network.

Common dimensioning methods for telecommunication networks were presented in a number of papers. These methods relate chiefly to parts of telecommunication networks in which optimization is not required. Special simplifications of the traffic theory were made in some papers in order to simplify manual treatment.

Optimization of telecommunication networks was dealt with in several papers. One of them presented the optimization procedure for determining the number and locations of exchanges and boundaries for exchange areas in arbitrary networks. The primary intention of this paper was to treat the problems existing in metropolitan networks. Another paper dealt with the analogies between teletraffic and road networks.

The very important question of non-coincident busy hours in large international telecommunication networks was dealt with in some papers. Of special interest are the problems arising on the introduction of telecommunication satellites in the network.

Another very important field is Network Management, i.e. methods for continuous supervision and control of an alternative routing network. Comprehensive results of the effects of Network Management on traffic handling in the long distance network in the USA were presented. Some other papers dealt with different methods of introducing Network Management.

The overload capacity of telephone exchanges and networks was dealt with in some papers. Different types of overload were discussed, and a presentation was given of how, for instance, subscriber behaviour and time releases affect the overload capacity.

### *Data Communication, SPC and TDM Systems*

The *Data traffic* session opened with a paper dealing with the impact of the growing need for data communication on the planning of the British telecommunication network. Analyses were presented also of a military digital integrated network with saturation routing and priority for certain calls, and of queueing problems relating to concentrators in data communication systems.

The *Computers and SPS systems* session opened with a paper analysing the response times for jobs handled in a computer making use of time-sharing. Dif-

ferent methods of queueing disciplines were generalized. Another paper presented a penetrating analysis of problems relating to storage hierarchies in computers.

Other papers at this session dealt with problems relating to telephone and data communication systems controlled by a central processor. Different strategies were considered for scanning of the peripheral units of such systems. In a SPC system working with different priority levels it is of interest to introduce a control system which guarantees correct processing of already accepted calls by limiting to some extent the acceptance of new calls. One paper presented a control system of this kind with satisfactory characteristics.

A number of papers at other sessions dealt also with data communication systems. A study was made, for instance, of systems with alternative routing and star-shaped switching networks with queueing systems at the sources and at the common central unit.

One session was entitled *TDM-switching systems*. In a paper at this session digital switching networks with partial access pulse shifters were optimized for different types of switching, being thereafter compared in respect of the cost for gates and memories. In another paper the cost of the switching network was minimized in respect of availability. A digital switching network with the time-space-time configuration and a queueing problem in TDMA networks were also dealt with.

A digital switching network without internal congestion, in which there is both wide-band and narrow-band traffic, was analysed in one paper. A special interest exists for the case with limited availability to outgoing routes.

### *Traffic Theory and Statistical Problems*

The *Traffic theory* session opened with a review of the application of the theory of stochastic processes to problems of traffic theory and traffic engineering. In one paper an analysis was presented of traffic processes based on data obtained through the scanning method.

Three contributions dealt with an interesting expansion of the traffic theory in which attempts are made to construct models describing how the occurrence of faults affects the traffic in telecommunication systems. Among other things new quality criteria of significance for the assessment of different systems were discussed, attention being paid at the same time to traffic and reliability aspects.

A number of papers dealt with problems relating to superposition of different kinds of traffic. Such problems exist, for example, in alternative routing networks. One author presented the solution to the problem of determining the call congestion for the different categories of traffic on superposition of fresh traffic onto another type of traffic (e.g. smoothed or degenerated).

One session devoted to statistical problems opened with a broad survey of the statistical problems which arise in measurements both of real and simulated traffic. The important problem of the accuracy of measurement of the traffic intensity on an overflow route was also dealt with.

A method was presented for continuous supervision, by measurement of traffic intensity, that the number of subscribers connected to a line concentrator will not exceed the optimum number from the load aspect.

Finally one author made a critical examination of the common method of estimating by means of test calls the congestion to which subscribers are subjected.

## *Queueing Theory with Applications*

One of the sessions on queueing systems opened with a survey of the development of the queueing theory from its start in Erlang's investigations at the beginning of the century. One paper presented a study of a system of queues in series. The distribution of the total delay in the system for a given customer (or a given call) was specially considered. A new method was presented also for dealing with certain queueing problems which was applied to a system with priority.

The second session on queueing systems included a paper on problems arising at enquiry and fault clearing centres. Another question dealt with was dimensioning problems relating to the number of manually served positions in PABX's and the drawing up of optimal duty lists in manually served departments.

In the *Common control systems* session some papers also referred to queueing problems. An analysis was presented of the problem of determining intervals for time releases, and also methods for comparing marker systems by considering intensities and frequencies of traffic peaks which cause overloading of the system.

## *Simulation*

Owing to the increasing complexity which characterizes new equipment within the telecommunication field today, simulation has become an increasingly important aid in assessing the traffic carrying capacity of telecommunication plant. This was clearly apparent from the large number of papers in which the problems dealt with were solved by means of simulation. To save computer time it is desirable to find effective simulation methods; and, to facilitate programming work, simulation languages especially constructed for teletraffic problems can be of great assistance.

One session was devoted to these questions. A new method was presented for use in simulation of the statistical technique known as sequential analysis, which implies that the program itself, in successive simulation steps, finds the traffic flow which in the simulated system leads to a given congestion. As regards simulation languages, the TETRASIM language devised at Norsk Regnesentral expressly for simulation of telephone systems was presented.

## *Final Panel Discussion*

The last session had the form of a final panel discussion. One representative each from industry, administrations and universities had been invited to open the discussion by presenting their views on the work of the congress and their desires for the future. The meeting was then declared open for contributions by other delegates.

It was pointed out that during the 18 years of ITC's existence there had been both a revolutionary technological development as well as an enormous quantitative development within the field of telecommunications. The telephone network now covers practically every part of the world, a circumstance which is more and more increasing the significance of the work of CCITT. Such important fields as data and video transmission have also come into being during this period.

In order to cope with the development which is accelerating in extent and complexity, and to ensure the maximum possible usage and reliability, and the optimum economy and adaptation to the environment, increasing attention has been directed to traffic theory as being the most important tool for the analysis

of communication systems. The present congress has shown that ITC can successfully deal with all these different problems.

The extensive studies that have been made of dimensioning, planning, forecasting and supervision of large hierarchical networks were considered to be of great value. In this context, and also as regards traffic measurement and processing of traffic data, economic aspects of the traffic work have also been put forward. Here one notices that competition exists between simplified methods and more advanced methods for the use of which computers are necessary. One of the speakers thought that the trend would be in the direction of interactive terminals which permit the traffic engineer to use advanced methods. Simplified methods and tables will then be used only when the quality of available data does not justify other methods.

The use of computers in telecommunication plants and the introduction of data communication networks have been important new fields for the traffic engineers. Several papers have dealt with problems in conjunction with *on-line* processing and with algorithms for *time-sharing* systems. Queueing problems in computer memories and at the interface between low-speed terminals and high-speed connections have also been presented. Questions arising in conjunction with transmission at different speeds have also been brought up. All of this indicates that the traffic engineers are now prepared to deal with the problems which will be encountered in the organization of an integrated communication system.

For the development of different types of terminal equipments further studies within the field of subscriber behaviour may bring great improvements both in system configurations and in the man-machine interface.

Accounts were given of several new, usually approximative methods for calculation of the congestion in gradings. The same applies to link systems, within which field a number of mathematically advanced papers dealing with the topology of the switching networks were presented. In conjunction with the non-blocking systems both in the strict and in the wide sense the absence of Russian delegates was regretted, as much work has been done within this field in the Soviet Union.

The large number of contributions in which the problems dealt with were solved by means of simulation shows that this technique is now indispensable. The importance of effective simulation methods and of simulation languages specially adapted to telecommunication system was emphasized.



Fig. 2  
Dr Christian Jacobæus, L M Ericsson, Chairman of the Organizing Committee for ITC 7, and Dr Clem Pratt, Australian Post Office, spoke at the farewell dinner. Dr Pratt is representative of the organisers of ITC 8 to be held in Australia in 1976

Naturally some critical comments were also made, which was a matter that the arrangers had expressly desired. Someone considered that, even if an increasing interest has been devoted to SPC and data traffic questions than at earlier congresses, it would have been desirable to have still more contributions within these fields. There was considered to be an unbalance between these contributions and those dealing with the soon classical question of the design of and calculation of congestion in gradings.

At the same time as appreciation was expressed for the work done on the planning of junction networks, the great importance of network and exchange planning within metropolitan regions was pointed out. Within several of the largest cities of the world the service is becoming greatly impaired. Even if a few contributions within this field had been presented at the congress, the question is so important that great attention should be directed to it.

The mathematically advanced queueing theory was considered to be necessary for the fundamental advances within the teletraffic field, but desires were expressed for less splitting-up into a number of detailed cases and a more general approach to these problems.

The special problems of the developing countries were also touched upon. Most of the contributions to the congress, perhaps all, take as their starting point the conditions which normally exist within the industrial countries. How much of this is applicable to countries with often extremely overloaded networks, long waiting lists, serious economic problems and a lack of traffic data? ITU sends out its experts to assist many such administrations, and we should also take upon ourselves the responsibility for these questions concurrently with those relating to the tidily dimensioned world we have seen in most of the contributions to this congress.

It was stated that, among the fields to which attention should be paid at coming congresses, apart those mentioned above, there should be in the first place network management and mobile communications. As regards data transmission networks, important problems of switching technique remain, as well as such questions as separate data transmission networks versus networks integrated with the speech transmission network, hierarchical versus non-hierarchical networks etc.

The panel as a whole expressed satisfaction with the organization of the congress and emphasized the value of this opportunity for traffic engineers from the whole world to meet and exchange experience and to discuss common problems both during and outside the sessions.

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# Stored-Program-Controlled Register System ANA 30 for Crossbar Exchanges

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*To meet the requirements which will be placed on automatic telephone exchanges within the foreseeable future a stored-program-controlled register system ANA 30 has been developed for control of crossbar exchanges. With this system the SPC, stored program control technique, can be flexibly introduced both in existing and in new crossbar exchanges.*

The first public local exchange of crossbar type ARF was placed in service in 1950 and ARF exchanges are today serving subscribers in 50 countries. The ARF system has throughout held a leading position among the public local exchange systems in the world, not least owing to the continuous improvement both in its operation and maintenance.<sup>1, 2</sup>

The constantly increasing size and complexity of telephone networks create a need for continued improvements in order, among other things, further to centralize and refine the operational and maintenance functions, using remote control from a central point in the local network. An increased capacity for digit analysis for advanced traffic routing, more flexible charging and the possibility

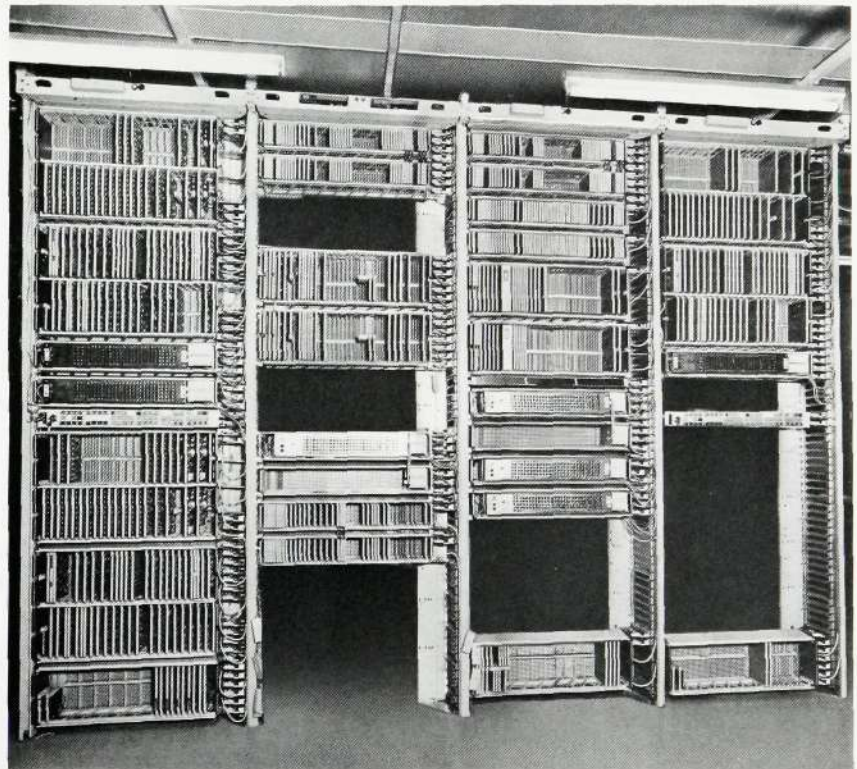


Fig. 1  
ANA 30 equipment in Mundelstrup telephone  
exchange, Denmark

of introducing new classes of subscriber services such as abbreviated dialling etc. are some other desires of today and tomorrow.

In order to be able to meet these and other needs flexibly in existing and new crossbar exchanges, a stored-program-controlled register system ANA 30 has been developed, made up of the most modern semiconductor components of integrated type. The system is designed to take over and to greatly extend the functions of the earlier register organization. ANA 30 can both be used to increase the level of facilities for existing ARF exchanges up to that for the stored-program-controlled exchanges by replacement of the existing register organization and can be incorporated as an integrated part in new crossbar exchanges. When ANA 30 has been introduced in a crossbar exchange for local traffic, the type designation of the exchange is changed to ARE.

## Basic Principles

Register system ANA 30 is based on SPC technique. In the other parts of ARE the well tested relay and selector technique of the ARF system are retained.

In system ARE the advantages of the SPC technique are fully utilized since ANA 30, apart from the register functions, also carries out marker functions which are subject to frequent change, i.e. route analysis, route selection, determination and analysis of A and B subscriber categories, and line selection within PBX groups. ANA 30 thus controls *all essential* parts of the connection.

In the relay and selector equipment of ARE the functions are retained which have a minimum need of alteration and the transfer of which to ANA 30, therefore, would involve no gain. Such functions are call identification, selection of circuit within a given route and switching path through the selector stages, test of B subscriber condition, supervision during conversation, and clearing.

Through the combination of a small and easily handled stored-program-controlled register system and of the documented low-maintenance ARF system an ARE exchange requires a minimum of maintenance. The advantages of centralization and remote control of the operational and maintenance functions are thus even more apparent.

Owing to the structure of the ANA 30 system an existing ARF exchange can be modernized to form an ARE system for a moderate expenditure. The same level of facilities can thus be introduced simultaneously in an entire area containing older ARF exchanges. Otherwise one would be forced either successively to introduce new exchanges with the higher level of facilities, with the disadvantage and injustice to subscribers that this involves, or it would be necessary to replace exchanges before their mechanical life had run out.

## Facilities and Services for the Telephone Administration

### *Metering*

In the basic form of ANA 30 the metering of calls takes place in the normal manner. But as the A number, B number, A subscriber category and, if necessary, also the identity of the link circuit are temporarily stored, the possibility exists of introducing additional metering equipment without electromechanical subscribers' meters.

### *PBX Facilities*

In an ARE exchange with incoming registers a PBX equipment can be introduced which offers the following advantages over and above those possessed by ARF:

- Extremely simple PBX connections with solderless termination of only one test wire to the PBX equipment.
- Great flexibility, with common PBX equipment for a 10,000-line group within which the PBX lines can be freely distributed.

## *Introduction of Future Signalling Systems*

Since several different signalling systems are used in telephone networks, it is important that ANA 30 permits the introduction of such systems through the addition of simple signalling devices and programs.

Through the use of SPC technique in ANA 30, the system can for a moderate expenditure also be adapted to future signalling systems, e.g. for signalling on a common channel (CCS), should this be required on the national plane.

## *Digit Analysis Capacity*

ANA 30 has a digit analysis capacity which covers all practical requirements. This greatly increases the traffic routing facilities, making the junction network cheaper and permitting direct routes between exchanges in different zones, etc.

## *Services Remotely Controllable from Operational and Maintenance Centre*

With a fully developed system the following functions can be remote-controlled from an Operation and Maintenance Centre.

*Traffic measurement and statistics* including normal erlang measurements on units within ANA 30 and, in addition:

- occupation counting per device
- measurement of mean holding time
- measurement of call congestion
- measurement of time congestion (time when all devices in a group are occupied)
- collection of statistical network data
- measurement of traffic dispersion

*Alterations of traffic routing*, such as temporary rerouting, rerouting to an operator or an automatic answering equipment, and alterations in the numbering scheme.

*The maintenance functions* are very comprehensive; among other things, reports of faults discovered through built-in checks are stored in an operation and maintenance processor and transmitted on command to the Operation and Maintenance Centre. The system also allows supervision of fault rate, congestion ratio, blocked devices, etc.

## *Services Remotely Controllable from the Central Subscribers' Office*

From the Central Subscribers' Office, which is also common to the entire area, arrangements can be made for full or partial barring of service to subscribers and restoration of the service, an interception service can be connected and disconnected, a faulty subscriber line can be marked, and other optional subscriber categories can be connected and disconnected.

## **Subscriber Services**

Apart from the subscriber services offered by an ARF exchange with register organization ANA 11, such as pushbutton dialling, indialling to PABX, different levels of restricted service, tracing of malicious calls, etc., examples are given below of some other subscriber services.

### **Abbreviated dialling**

With this facility the subscriber need dial only a single-digit or two-digit code number even on international calls.

## Hot line

A connection can be set up from a telephone reserved for this purpose to a predetermined number simply by raising the handset.

## Subscriber Service Centre

A Subscriber Service Centre can be established which is common to an entire area. From the economical, and often too from the transmission point of view, it is advisable to concentrate to the Centre such equipment as is required for more complicated subscriber services. Apart from advanced interception services, the following additional services for example can be established at such a Centre:

- *Follow me*, which implies that all calls to the subscriber can temporarily be redirected to another number.
- *Automatic waking service*; the subscriber can order the service from a push-button or dial telephone, after which he is automatically rung up at the desired time.

## System Structure

The hardware of ANA 30 contains data processing equipment, interface, and input and output units (I/O units). The software consists of program and data. Fig. 2 shows the ANA 30 hardware and the relay and selector equipment of ARE.

The data processing equipment contains processors, central stores and multiplexors. In it is stored, the software and the data processed in accordance with given programs. Modular build-up is applied throughout with plug-in printed circuit boards as smallest units, which permits economical adaptation to the desired capacity.

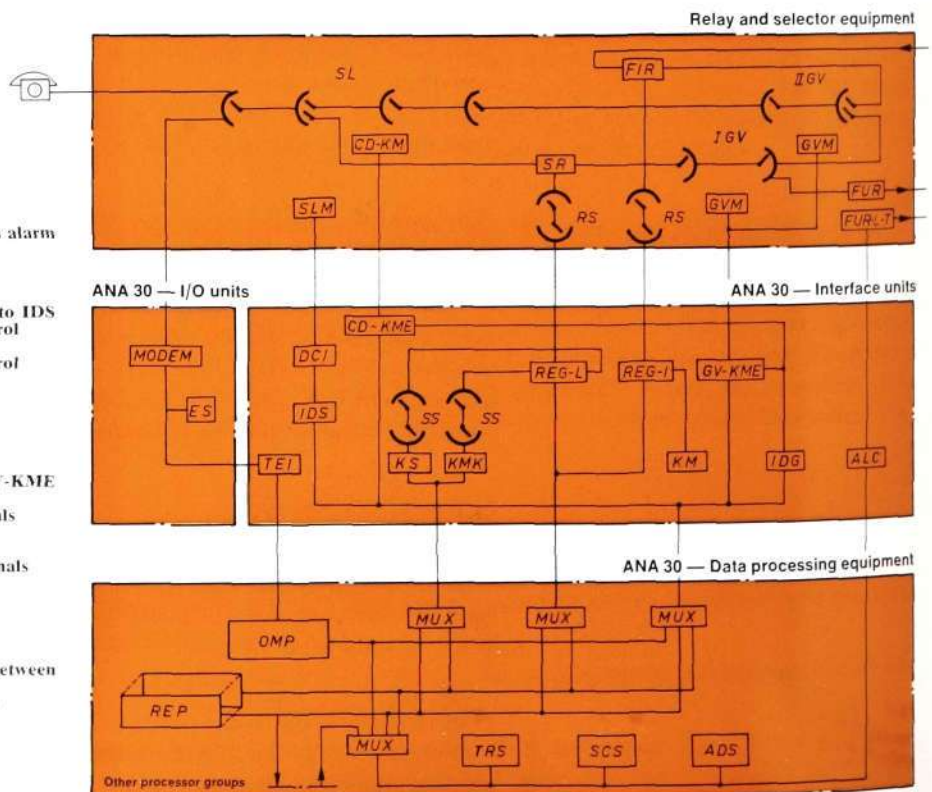
Fig. 2

### ARE exchange, trunking diagram

FIR	Incoming junction circuit
SL	Subscriber stage
CD-KM	Code receivers in SL stage
HGV	Second group selector stage
IGV	First group selector stage
GVM	Group selector marker
SR	Link circuit
SLM	SL marker
FUR	Outgoing junction circuit
RS	Register finder
FUR-L-T	Outgoing junction circuit with alarm signal function

DCI	Unit for connection of SLM to IDS
CD-KME	Unit for transmission of control signals to CD-KM
GV-KME	Unit for transmission of control signals to GVM
ES	Electrical typewriter
IDS	SLM identifier
SS	Sender finder
REG-L	Local register
REG-I	Incoming register
IDG	Unit for identification of GV-KME and CD-KME
KS	Code sender for register signals
KMK	Code receiver for pushbutton dialling
KM	Code receiver for register signals
TEI	Terminal interface unit
ALC	Alarm control unit

MUX	Multiplexor for interwork between processors and other units
OMP	Operational and maintenance processor
REP	Register processor
TRS	Translation store
SCS	Subscriber store
ADS	Abbreviated dialling store



*The interface units* usually carry out conversion between data information and electrical signals for direct communication with the relay and selector equipment of the exchange. Certain equipment carries out also other defined functions.

*The I/O units* can be selected among electrical typewriters, display terminals, tape readers and tape punches, and provide the operation and maintenance staff with a convenient means of communication with processors, memories and interface units via the special operation and maintenance processor in ANA 30. Operators can easily change subscriber data written into the relevant memories in ANA 30, e.g. on connection or disconnection of interception service.

*The software* is divided into small strictly limited units, so that a change of function usually affects only one unit. The total program volume is small compared to that for a SPC system, the data processing equipment of which also performs all marker functions.

Owing to the limited program volume and the small modules the potential expansion provided by the SPC technique can be effectively utilized as the need arises.

Through the use of software, changes which in the conventional technique are effected with a soldering iron can instead be effected by change of data codes in the memories of the data processing equipment.

## Data Processing Equipment

The following account will be concerned with the processors, multiplexors and central stores of the data processing equipment.

### *The Processor*

The processors of ANA 30 were developed especially for this system and carry the type designation APN 110. The processors can also be used in other contexts for which high requirements are placed on performance. The processor is small

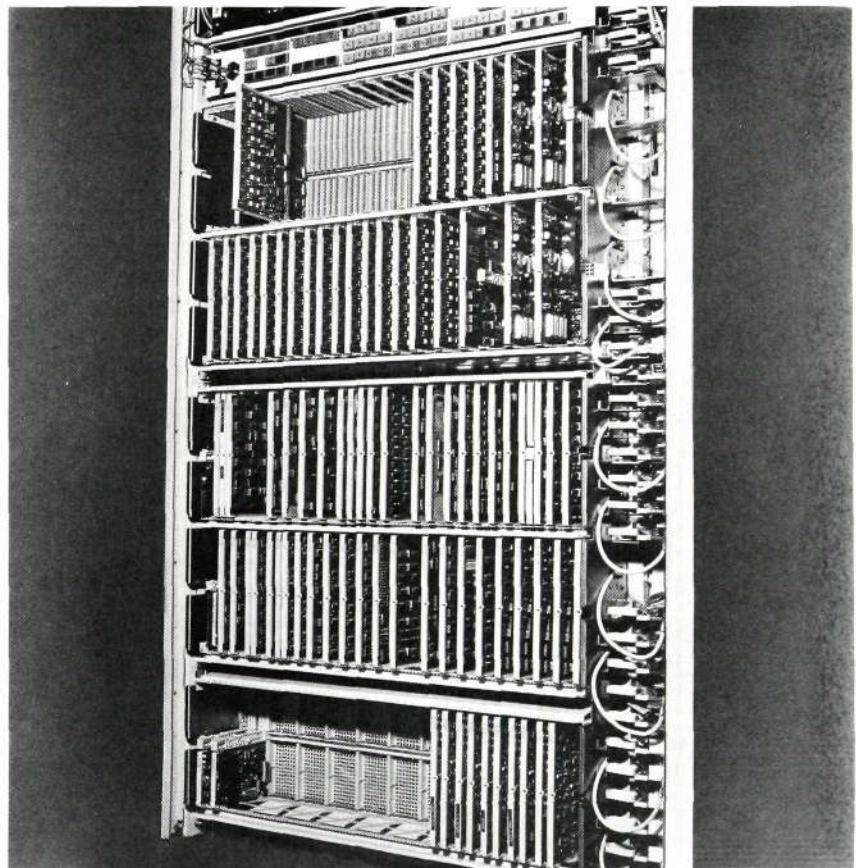


Fig. 3  
Operational and maintenance processor  
OMP in ANA 30

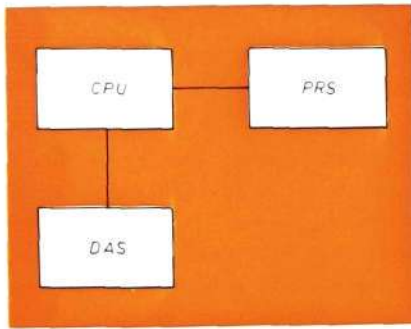


Fig. 4

Processor APN 110

CPU Central processing unit  
 PRS Program store  
 DAS Data store

(fig. 3), requires little program volume (approx. 8K 16-bit words), has short operational times, requires few instructions for logic decisions, and offers high reliability.

APN 110 is used in ANA 30 for two entirely separate functions, namely as register processor REP and as operation and maintenance processor OMP. In both cases the processors are of identical construction, but the programs differ.

The processor consists of a program store PRS, a data store DAS and a central processing unit CPU (fig. 4).

The program store PRS stores the relatively permanent traffic programs and the operation and maintenance programs in permanently programmed read-only memories mounted on plug-in boards. PRS is divided into program store pages, each of which is addressed by its corresponding program number. Each page contains 256 words of 16 bits plus a parity bit. The extension module is 512 words or two pages. After being programmed the read-only memories, which are of semiconductor type, retain the input program even if the voltage disappears. If a change or addition to the program is required, a preprogrammed printed circuit board is simply plugged in. For laboratory testing, however, random access semiconductor memories are used to facilitate the meticulous testing of the new design or variant.

The data store DAS is made up of random access MOS (Metal Oxide Silicon) memories and stores temporary data such as A number, category and B number, which is erased after completion of a connection. DAS is also divided into pages. Each page contains 128 words of 8 bits plus a parity bit and one such page is allotted to each register. The extension module is 8 pages and the maximum size of the store is 64 pages.

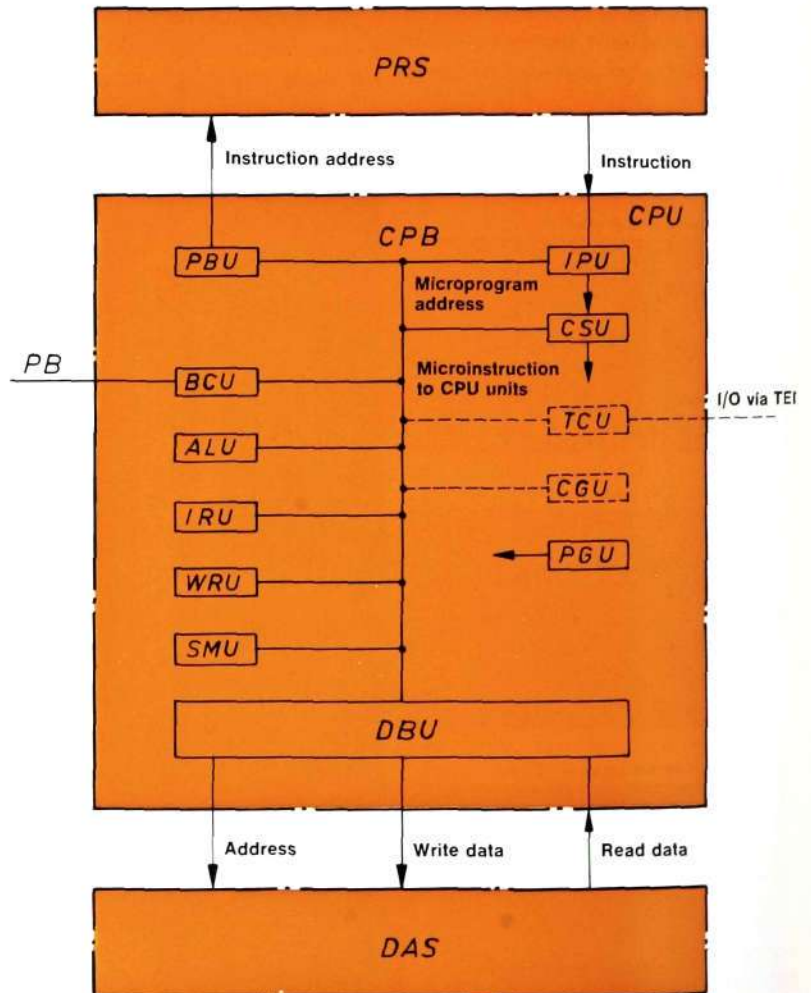


Fig. 5

Central processing unit CPU

PRS Program store  
 CPB Internal processor bus in CPU  
 CPU Central processing unit  
 PBU Program store buffer unit  
 IPU Instruction pretranslation unit  
 CSU Control store unit  
 PB Processor bus  
 BCU Bus control unit  
 I/O Input and output units such as teleprinter, display terminal, tape reader, tape punch or data modem  
 TEI Terminal interface unit  
 TCU Terminal communication unit, only in OMP  
 ALU Arithmetical and logical unit  
 CGU Character generator unit, only in REP  
 IRU Index register unit  
 PGU Pulse generator unit  
 WRU Work register unit  
 SMU System monitor unit  
 DBU Data buffer unit  
 DAS Data store

The central processing unit CPU consists of a number of functional units interconnected over an internal processor bus (CPB) (Fig. 5). It reads instructions from PRS and successively executes the tasks or operations indicated by the instructions. These may consist of, for example, transfer of data from

- CPU to DAS for temporary storage
- DAS to CPU for further processing or storage
- CPU to the central stores for indication of address
- the central stores to CPU for reception of information corresponding to the respective memory function
- CPU to interface units for operation, digit transmission etc.
- interface units to CPU for call discovery etc.

On the data received by CPU the instructions also trigger arithmetical and logical operations which are often followed by program-controlling operations leading to selection between different branches in the program. Each of these operations constitutes a basic element in the control functions for, for example, a phase of a connection.

When CPU executes one of the normal instructions of the program store, it converts the instruction into individually combined microinstructions, normally 4—8 in number and having a word length of 24 bits. They are used internally within the central processing unit and permit a flexible modular division of the latter into delimited functional units. This, in combination with the interconnection of the units over a common bus, increases the adaptability to new requirements and simplifies routine testing and fault tracing.

### *Central Stores*

The central stores, which normally are common to a 10,000-line group, consist of the translation store TRS, the subscriber store SCS and the abbreviated dialling store ADS. The stores contain alterable control information. To simplify the work of addressing of the processors these stores are equipped with special logic units which combine partial addresses into entire addresses, translate decimal into binary code, hunt for a stated address in the store, etc.

The initial size of the various stores is 4K9 ( $4 \times 1,024$  words of 8 bits plus 1 parity bit) and they are extended in modules of the same size. The stores are made up of ferrite cores with voltage supervision and therefore retain stored information even if the voltage disappears. They have a read and write cycle time of 2 microseconds.

Individual data for each type of store are set out below.

The translation store TRS contains exchange-dependent data on routes, tariffs, interpretation of MCF signals, etc., has short holding times and is duplicated on grounds of reliability.

The subscriber store contains subscriber category data, has a varying holding time and, on grounds of reliability, is partially duplicated.

The abbreviated dialling store ADS is used as required and contains special subscriber data relating to abbreviated dialling etc.

### *Multiplexor MUX*

The processors interwork with the central stores and interface units via a bus system. Each processor is connected by its own bus to a duplicated multiplexor MUX on each of the racks which contain units with which the processors interwork (Fig. 6). MUX ensures that only one processor at a time is connected to a unit on the rack in question.

## Processor Grouping

The processors in ANA 30 are combined into groups, each containing max. six register processors REP and one operation and maintenance processor OMP. The interwork between the OMP and REP in the groups is achieved through the fact that the translation store TRS temporarily stores data sent between these units in both directions.

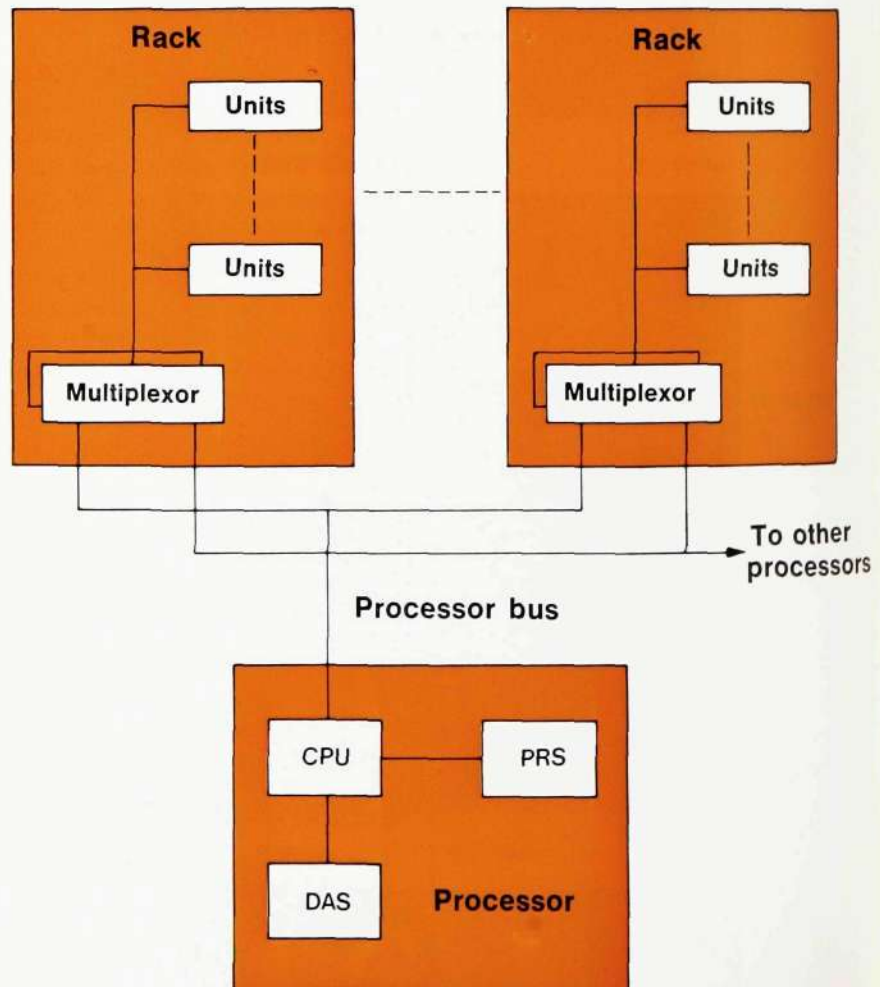
Each REP can serve 60 registers, so that a full processor group handles  $6 \times 60 = 360$  registers, which often suffice for 40,000 subscribers.

To cover the traffic handling requirements also for very large and heavily trafficked exchanges in an economical way, interworking can be arranged between up to four processor groups. This is achieved through the fact that processors belonging to different groups can handle one another's tasks. Each processor group has its own central stores and its own OMP. When a processor is to transmit a task or an answer to another group, the task or answer is written into its own TRS. The message is then transferred to TRS in the receiving group and read out by the receiving processor.

## Interface Units

For communication with the relay and selector equipment of the exchange there are the following interface units (fig. 2):

*Local register REG-L* is a simple interface equipment between SR and REP. *Incoming register REG-I* has essentially the same functions between FIR and REP.



*Identifier IDS* transfers the A number and SR identity from SLM to REP and has DCI as interface unit.

*Identifier IDG* transfers the identity of the connected code receivers to REP.

*Code receivers GV-KME* and *CD-KME* transfer information between REP and GVM and between REP and CD-KM respectively.

*Sender finder SS* interconnects registers with code senders and code receivers.

*Code senders KS-MFC*, code receivers *KM-MFC* and ditto for *pushbutton code KMK* have their logic functions allocated to REP's program.

In an ARE exchange GVM, CD-KM and SLM also differ in certain respects from the corresponding units in ARF.

### *I/O Units*

To facilitate communication between the operational staff and ANA 30, this takes place via advanced I/O units. Up to four such units can be connected via interface equipments for direct or remote-controlled communication with the operation and maintenance processor OMP. The I/O units can, as noted, be selected among electrical typewriters, display terminals, tape readers and tape punches. For remote-controlled communication over fixed or temporarily established connections a modem is required.

### *Software*

The main functions of the software are to control the setting up of the connections and to enable the operational and maintenance personnel to make changes

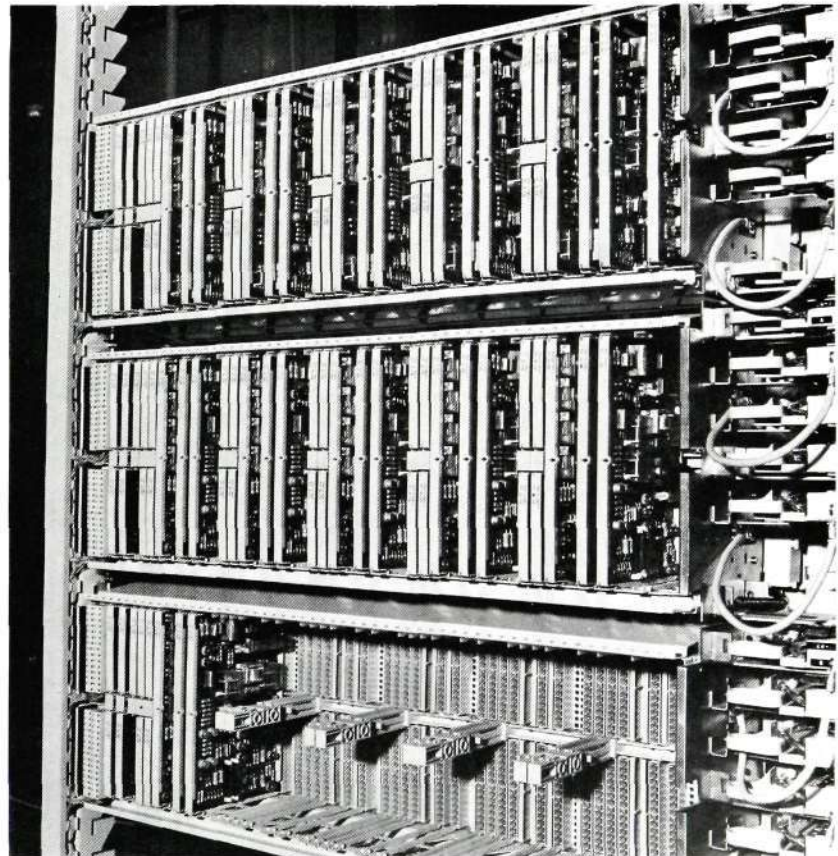


Fig. 7  
Local and incoming registers in ANA 30,  
REG-L and REG-I

in and additions to the control functions and to exercise effective supervision in a simple manner.

The software consists of programs in the program store and of data in the data store and the central stores.

### *Program Instructions*

The programs are made up of about 30 different instructions. Each such instruction consists of a 16-bit word divided into an operational portion and a parameter portion. The former determines the type of operation and the latter specifies in detail, if required, the type of operation and often contains also an address and a constant.

As already mentioned, the central processing unit CPU converts the instructions read by it from PRS into microinstructions.

### *Data*

Data are distributed to areas. The data store DAS contains, for example, 60 register areas, each of which contains temporary data associated with a connection in which the corresponding register takes part. These data are elements of varying size and each element stores an information unit. If such a unit consists, for example, of one digit, the corresponding element contains four bits.

To give some concrete examples, the storage of data may relate to digits, the condition during a pause in a switching process, the number of a program to be processed by CPU, the address of a unit, etc.

### *Programs*

The programs are written into the program store PRS with one program per page of the store. There are about 30 programs for REP and about 35 for OMP. Some typical REP programs are used for

- monitoring of switching processes in local registers
- monitoring of switching processes in incoming registers
- reception of dial pulses
- reception of pushbutton signals
- analysis of dialled number
- operation of group selectors
- transmission of MFC
- reception of MFC.

REP contains only one program of each type, but some programs can be multiutilized up to 60 times for program functions or phases associated with 60 registers during a primary interval. This is made possible through the fact that the program number can be stored simultaneously in all register areas in the data store. A monitor program then connects the program to the time slot corresponding to the respective register area. (See also under Principles of Program Processing below.)

The individual programs have well defined functions but interwork with one another in such a way that at a desired time a program can call another program for the exercise of functions not included in the calling program. These properties of the programs simplify the introduction of new and changed functions.

A program may be said to fall into phases so adapted that each phase can be processed in a time slot, which greatly contributes to simplification of the system. In some phases of the switching process it is advantageous that phases in two independent programs are processed simultaneously, which is also possible.

## Principles of Program Processing

The primary interval both of REP and OMP is 8 milliseconds. Only REP will be dealt with below, as the principles for OMP are identical. Each primary interval is divided into time slots of 120 microseconds per register and 800 microseconds for communication with OMP. During the 61 time slots in a primary interval those phases are processed which correspond to each of the 60 registers and to that part of the OMP communication required at that particular time for the respective registers and for OMP (Fig. 8).

The successive stepping of the primary intervals, so that one phase after another shall be connected to its time slot, is controlled by the data store together with the monitor program of the processor. This is facilitated by the fact that each time slot corresponds to one page in the data store. When all time slots within a primary interval have been processed, a transition takes place to the next interval and so on in an unbroken sequence. When the first phase for, for example, a given traffic case in a register has been processed in its given time slot, the subsequent phases for the register are successively connected to the same time slot in subsequent primary intervals until all phases of the program have been processed. The central unit then switches in another program which has been called by the processed program.

The division into fixed time slots means that the programs need not administer a complicated time distribution, which greatly simplifies the programs and the programming work. This avoids the necessity for certain programs of lower urgency to wait too long in case of a high processor load. An assumption for the use of this principle is that the composition of the software functions in each individual processor is simple. This is fulfilled by ANA 30 through the retention of electromechanical control for functions which do not gain by being transferred to SPC technique.

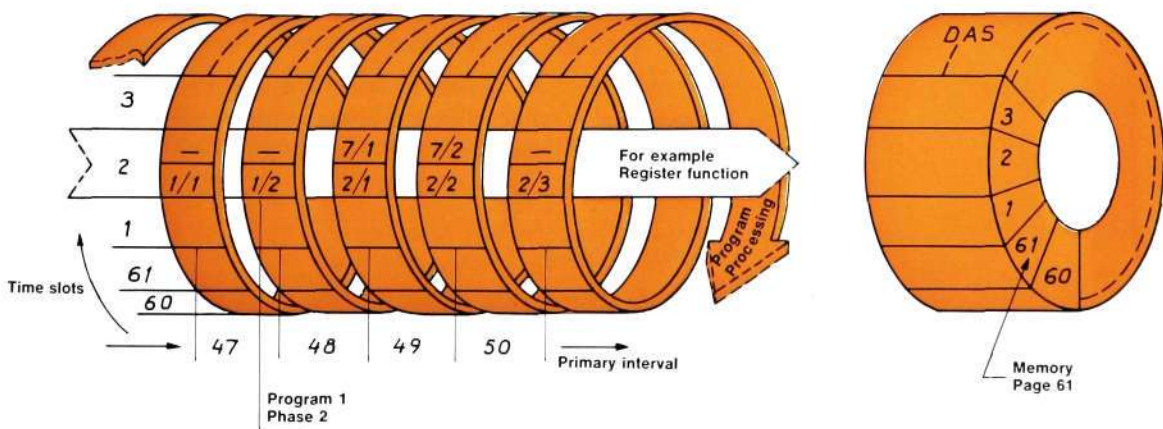
## Central Store Functions in Cooperation with Register Processors

To illustrate the similar principle of operation of the central stores the subscriber store SCS may be taken as example.

SCS contains subscriber category data and, on economical grounds, consists of two parts. Part 1 contains data relating to all subscribers and part 2 supplementary data for subscribers with special category combinations.

As already mentioned, SCS has a logic unit. REP informs this unit of the subscriber number concerned and at the same time orders reading in part 1. The logic unit converts the number into an internal address, which selects the category code and the latter is converted by REP to standard format. From the read-out data REP decides whether they suffice or whether further information is required since the subscriber has a special category combination. In the latter

Fig. 8  
Program processing in recurrent time slots



case REP sends an order to SCS for reading in part 2. From a number of lists the logic unit of SCS hunts for the particular subscriber's number; each such number exists only on one list. Each list contains subscribers with identical category combination and starts with a heading of three 8-bit words which indicate the subscriber combination in question.

### *Reliability*

Apart from the reliability guaranteed by careful selection of components, advanced modular structure, duplication of units where required etc., ANA 30 offers the following features.

In the case of a fault in a processor the first processor in the group can interrupt its work and take over the entire function of the faulty processor. In regular operation the first register processor will then serve as many registers as, without essential disturbance, can be inoperative during the period required for repair. Should a fault arise in the first processor, the second processor blocks new calls to it and releases any subscribers in register position.

In each unit there are circuits for time supervision, parity check, etc. In the case of a fault in duplicated memories, multiplexors or central interface units, the processors are automatically switched over to an intact unit.

All faults and measures associated with them can on command be printed on an electric typewriter or shown on a display terminal at a suitable point in the Operational and Maintenance Centre.

### *Programming Aids*

As programming aids special programs have been written for the loading of the program, translation and subscriber stores. A clear line writer printout is also obtained, which is of assistance for operation and maintenance. The printout can be supplemented, if desired, by the designer's explanatory comments. These programs are run on commercial computers.

## Operation and Maintenance

One of the great advantages of ARE is that the operation and maintenance functions can be remote-controlled from an Operation and Maintenance Centre and from a Central Subscriber's Office. These functions are available in the operation and maintenance processor OMP in the exchange.

### *Operational Functions*

*Changes of subscriber data*, for example connection and disconnection of a subscriber category, are remote-controlled through write-in to the subscriber store of the corresponding order on the electrical typewriter at the Central Subscribers' Office.

*Changes of exchange data*, for example rerouting, introduction of a new signalling plan and change of numbering schemes, are effected equally simply from a data terminal in the Operation and Maintenance Centre.

*Traffic measurement* adapted to the alternative routing networks, with measurement of traffic dispersion and several other detailed measurements the results of which can be transferred by remote control to the Operation and Maintenance Centre.

### *Maintenance*

L M Ericsson's maintenance method, CCM (Controlled Corrective Maintenance), has been successfully adopted by a number of telephone administrations, among which the Rotterdam administration, as described in an article in Ericsson Review<sup>3</sup>. The article reveals that only 0.075 man-hour per line and year is required for maintenance of the Dordrecht 20,000-line ARF exchange. System

ARE with ANA 30 permits a further development of the CCM method owing to the great reliability of the system and the fact that ANA 30 also offers the following facilities.

*Supervision of call congestion and of fault rates per route and per individual unit within ANA 30.* The result of the supervision can be read in the Operation and Maintenance Centre.

*Tracing of faults* in the individual units of ANA 30 is greatly facilitated as, in the data store, each unit has been allotted its electronic disturbance counter which can be remotely read from the Operation and Maintenance Centre. When a predetermined acceptable disturbance level has been exceeded for a unit, this is detected by its disturbance counter. Three classes of alarm according to urgency are transmitted from the exchange to the Operation and Maintenance Centre.

When the operator in the Centre receives an alarm, he connects to the relevant OMP and requests printout of the cause of the alarm with indication of the identity of the alarming unit and of the type of failure. A suitable measure on the part of the operator may be, for example, remote blocking of the faulty unit or remote marking of it for detailed supervision.

*Statistical network data*, which after suitable data processing provide important information concerning difficulties in other exchanges, can be collected from ANA 30 under remote control from the Operation and Maintenance Centre. The operational and maintenance processor can, from any selected register, record the B subscriber's number, end-of-selection information, selected alternative route, and the register signalling in the two directions. Analysis of these data in a computer can help to localize and eliminate bottlenecks and faults within the area.

### *Updating of ARF Exchange with ANA 30*

Ordinary ARF exchanges can be equipped with ANA 30 without disturbance of operation, the latter being installed and tested with a simulator before existing registers and other equipment are removed from operation. ANA 30 can also be installed in a different room from the remainder of the exchange.

The necessary changes and additions to markers and code receivers with associated rack cable are carried out in accordance with precise instructions. Relay sets are changed so that, simultaneously with their new functions, they retain their original functions. The rack cable is supplemented so that only one unit at a time need be removed from operation.

When ANA 30 is ready to be put into service, the new registers can be connected one at a time to share the traffic with the existing registers. Before this connection is made some of the new relay sets must be plugged into the prepared positions and those not needed removed. When all new registers have been placed in operation and a transition is to be made to the new signalling system between the register processors and the switching stages, the remaining relay sets are plugged into the marker and crossbar switch racks.

### *Degrees of Updating*

The flexibility of ANA 30 allows it to be introduced in a degree of updating which always ensures an optimal result.

### *Complete Updating*

A complete updating is illustrated in fig. 2. It is suited to new ARE exchanges and is characterized by the fact that the register processors

- control both local registers REG-L and incoming registers REG-I
- have access to GVM and CD-KM in order, via them, to exercise direct control of the GV and SL stages
- have access to SLM for transfer of the A subscriber's identity to REP on outgoing calls.

## Limited Updating

When ANA 30 is introduced in an existing ARF exchange, a limited updating is often advisable. Fig. 9, for example, shows a case without direct control of II-GV/GIV and SL stages, and fig. 10 a case also without direct control of the I-GV stage.

## Components and Construction Practice

ANA 30 is made up of integrated circuits including LSI, random access MOS memories in the data store, permanently programmed semiconductor memories PROM in the program store, ferrite cores in the central stores, monostable miniature relays and discrete electronic components. These components are mounted on printed circuit boards with plated wiring on both sides. The boards are of two sizes, single boards and double boards (fig. 11). The boards are plugged into one-level, two-level or four-level shelves with different possibilities of combination of single and double boards.

The shelves are plugged into jacks on the right of the racks. The racks are placed back-to-back whenever this is suitable from the operational aspect, otherwise they are placed singly.

## Power Supply

The relay and selector equipment in ARE is supplied in the normal way with  $-48$  V. ANA 30 as well is connected to  $-48$  V but also to lower voltages from  $-5$  V to  $+16$  V. These voltages are generated by stabilized DC/DC converters supplied with  $-48$  V. A converter is mounted either on a shelf for supply of an entire or half rack or consists of a printed circuit board plugged into the shelf carrying the equipment which it is to supply. The converters are duplicated and the standby converter automatically takes over the service if the output voltage from an operating converter diminishes or disappears.

## Summary

ANA 30 is throughout based on the stored-program-control technique, and in system ARE all advantages of this technique have been made use of. This applies not least to operation and maintenance with all their remote-controlled functions such as the possibility, on command from a typewriter, of altering the traffic routing, connection or disconnection of subscriber categories, etc. Im-

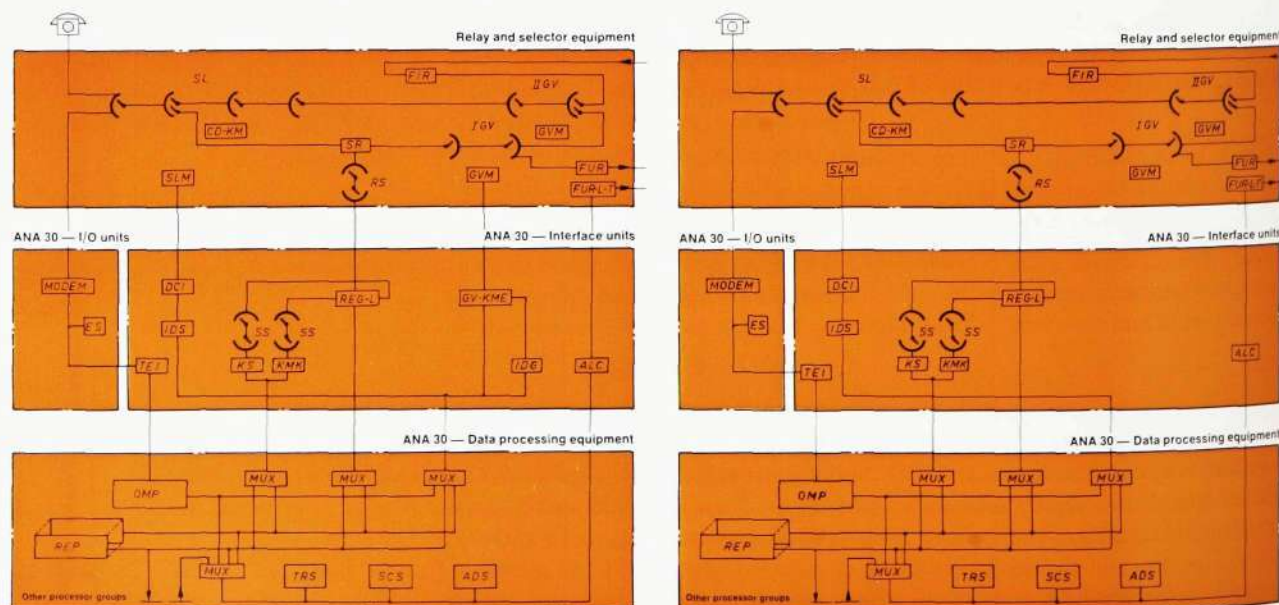
Fig. 9 (left)

Trunking diagram for ARE exchange without direct control of II-GV/GIV and SL stages

Fig. 10 (right)

Trunking diagram for ARE exchange without direct control of II-GV/GIV, SL and I-GV stages

FIR	Incoming junction circuit
SL	Subscriber stage
II-GV	Second group selector stage
CD-KM	Code receiver in SL stage
SR	Link circuit
I-GV	First group selector stage
GVM	Group selector marker
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FUR-L-T	Outgoing junction circuit with alarm signal function
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GV-KME	Unit for transmission of control signals to GVM
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IDS	SLM identifier
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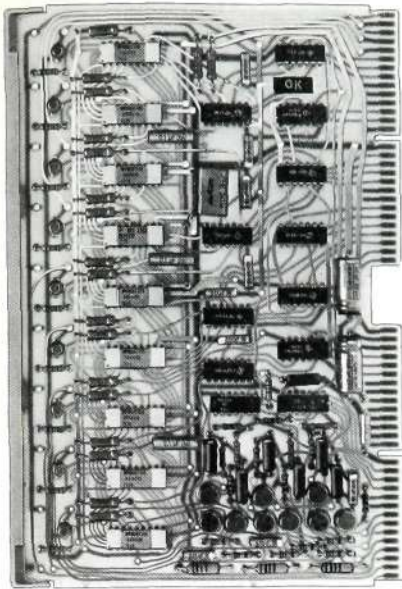


Fig. 11  
Double printed circuit board with plated  
wiring on both sides used in the data store

portant savings of personnel can thereby be made and at the same time subscribers are offered quicker service. The subscribers can also be allotted entirely new services such as abbreviated dialling etc.

As ANA 30 can be used both in new exchanges and for modernization of existing ARF exchanges, a network with L M Ericsson's crossbar switch exchanges at all points can be made equivalent, as the various exchanges can be given the same level of facilities whether they are old or new. The modernization of the ARF exchanges is also easily effected and does not disturb operation.

Owing to the simple structure and limited program volume of ANA 30 with time-shared program processing, the system is easy to operate and a change or addition can simply be effected, often through replacement or plugging-in of a new printed circuit board.

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# Manual Switchboard and Supervisory Desk for Modern Transit Exchanges

WALTER PEGERT, TELEFONAKTIEBOLAGET LM ERICSSON, STOCKHOLM

UDC 621.395.372:  
621.395.65  
LME 8341

*The increasing semiautomatization of international telephone traffic has led to a need for a new manual switchboard. L M Ericsson have therefore designed a switchboard based on a new technique and new components. The switchboard meets the requirements for manual operation both of national and international traffic, i.e. the operation shall take place with the greatest possible speed and reliability and with the least possible work on the part of the operator. The switchboard can also be equipped for rational use as enquiries and supervisory desk.*

The switchboard (Fig. 1) is designed throughout on the modular principle, which makes it easy to cater for individual requirements.

The switchboards are equipped with several new components, for example:

- Pushbuttons with built-in lamps instead of lever keys with separate lamps, which simplifies operation. The lamps can be duplicated for more reliable indication.
- Electrically zeroable period counters for up to 999 minutes (Fig. 2) which replace the earlier mechanically zeroable counters for max. 12 minutes.
- Digit indicators with light-emitting diodes and electronic control equipment for various subscriber indications such as calling and called number, category etc.



Fig. 1  
Manual switchboard with low vertical panel  
height 974 mm  
width 800 mm  
depth 817 mm

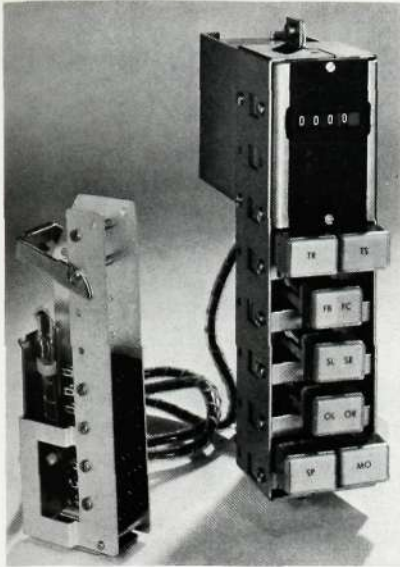


Fig. 2  
Switching set with electrically zeroable period counter and pushbuttons

Before the design work started, a thorough study was made of operators' working methods and reactions. Thereafter the switchboard was constructed on the most efficient possible functional principles without disregarding the desire for a modern exterior design. The placing of controls and indicators and the colour scheme have been important factors in this context.

## Design details

All units in the switchboard are of plug-in type and all wiring points are easily accessible, which reduces the costs of installation and maintenance to a minimum.

## *Skeleton switchboard*

The skeleton switchboard consists of welded, grey-enamelled rectangular steel tubes joined together by bars which are screwed to specially constructed brackets (Fig. 3). The assembled switchboard has snap-on covers and sides of dark-grey lacquered wood and the horizontal shelf is coated with hard-wearing plastic laminate.

The switchboard may be assembled as a single unit or combined in a suite. The cables are brought in from below and placed on a longitudinal runway at the bottom.

To satisfy a general desire the height of the switchboard can be adjusted  $\pm 2$  cm by means of floor screws fitted to the legs. Accessibility for cleaners is also satisfactory, as there is a roughly 10 cm free space between the floor and the bottom covers.

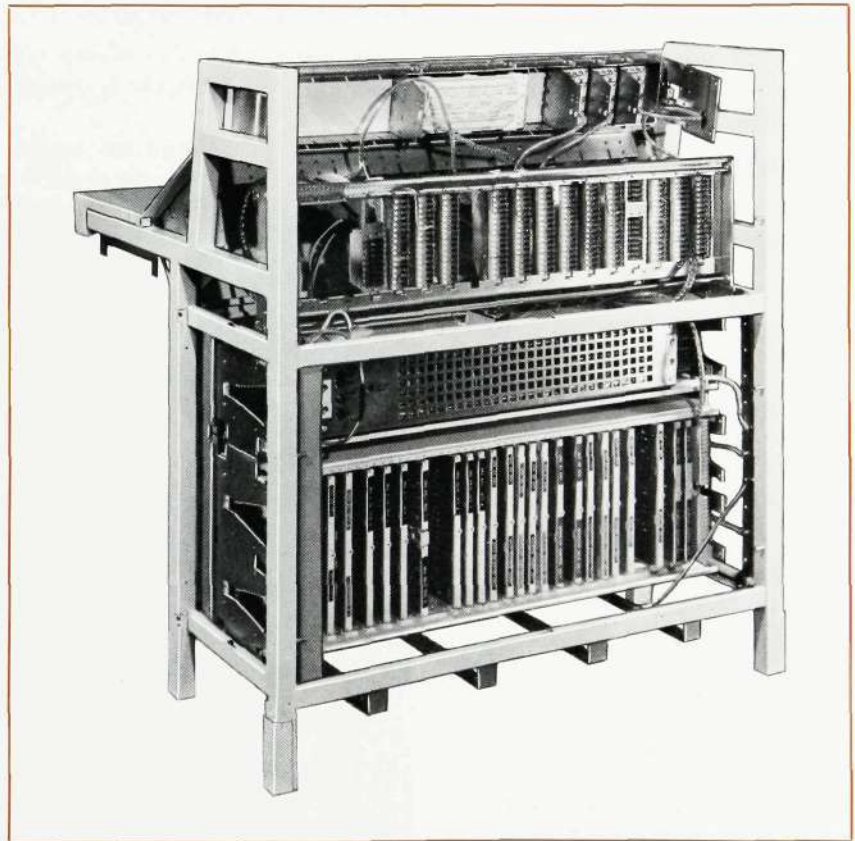


Fig. 3  
Switchboard section containing, from the top, a digit display, terminal field, power equipment and printed circuit boards for reception, storage and transmission of subscriber's number. The stored information is shown on the digit panel



**Fig. 4**  
Switchboard with sloping keyshelf. The middle figure shows a switchboard with low vertical panel added and the bottom figure with high vertical panel

### Operator's equipment

Each operator's position accommodates a maximum of eight switching sets (Fig. 2) and a position set. The components of the sets are wired direct to a 80-point plug.

In a supervisory desk the equipment is placed on one or two panels with the components directly wired to 80-point plugs (Fig. 5). An enquiries desk is provided with similar equipment adapted to the particular requirement.

### Switchboard layout

All units belonging to an operator's position or to a panel in a supervisory desk are mounted in a hinge-suspended frame. By releasing a catch the frame can be folded out to provide easy access to the units or panel from the underside for inspection and service. These frames are covered at the top with light-grey enamelled front plates with recesses for the components of the units or panels.

The front always consists of a section placed at an angle of 30° and containing a frame with units or panel. Above it, if required, a vertical section of equal or half its height can be mounted with space, for example, for indication panel, pigeonholes, instruments etc. (Fig. 4).

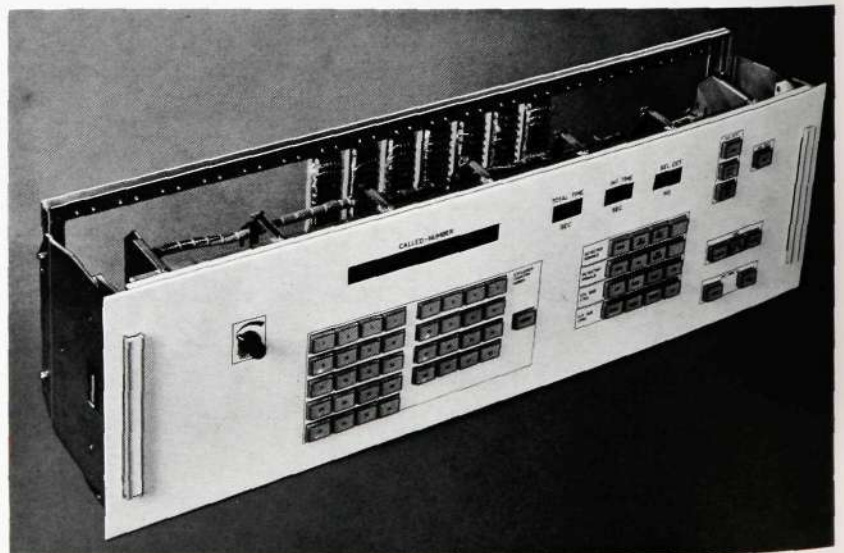
Below the operator's equipment there is a terminal field for connection of controls and exchange equipments. If electronic control equipment is required, for example for a digit display, the necessary printed circuit board shelves are mounted below the terminal field.

The headset or handset is connected to jacks placed on the left below the horizontal shelf. Instructions, personal belongings etc. are placed in a compartment on the right below the horizontal shelf.

### Reference installations

The new modular switchboard system, which has met with a great interest, permits rapid and effective operation of telephone traffic.

The new switchboard has already been delivered for several exchanges, among which the international ARM exchanges in the Caribbean Islands, Lebanon and Tunisia, and as supervisory desk for the international maintenance centres in Copenhagen and the Caribbean Islands.



**Fig. 5**  
Panel with controls and indicators

## Computer-controlled testing system developed by LM Ericsson

**LM Ericsson have developed a computer-controlled testing system to meet new and more stringent requirements for the design, production and installation of printed circuit boards and functional units, particularly in telecommunication systems.**

In the last few years there has been a greater production volume of printed circuit boards, at the same time as the requirements of reliability in functional testing have increased with the technical development; simultaneously the number of measurements on printed circuit boards has increased. The advent of the computer has brought a means for storage and control of large quantities of information and data and for their rapid processing.

The computer-controlled testing system that has now been developed can be used as an aid in the testing of equipment designs and as production aid for checking and fault tracing on printed circuit boards and functional units. Another field of application is reliability testing and accept-

ance tests of components and units. The product quality attained with the new testing system is high and uniform.

Other advantages are the shorter set-up and testing times and the flexible test program with built-in fault tracing routines.

The new system also allows simpler documentation routines and provides direct data for statistics.

The computer can serve 1—8 test positions. Each position has a maximum termination capacity of 512 test channels with program-controlled signal levels, loads and supply voltages, and a static and dynamic measuring system. The software consists of control programs, editor and object program. There is also a maintenance program for the system.



Test position in LM Ericsson's computer-controlled testing system. The positions are controlled by a central computer and each position comprises 5—7 racks containing, among other items, units for logic control, level and time measurement. In front of the racks is seen the test desk with the tester's alphanumerical display terminal and a fixture for objects to be tested — in this case printed circuit boards of type ROE.

## Major Orders:

### Ecuador

The state telephone administration in Ecuador has concluded a five-year agreement with LM Ericsson for the delivery of substantial quantities of telecommunication equipment. The contract is worth about \$18 million.

The contract covers all types of telecommunication equipment, among which telephone sets, telephone exchange equipment, cable, line equipment and transmission equipment.

### Venezuela

In the face of stiff international competition LM Ericsson received an order worth about \$6 million from the Venezuelan Telephone Administration, CANTV.

The order covers the delivery of multiplex equipment, i.e. equipment for long distance telephony. The entire project is being financed by the World Bank and will be one of the largest projects within long distance telephony financed by the World Bank.

The equipment ordered will double the capacity of the Venezuelan long distance network. It will be used both for new networks and for expansion of existing networks.

The delivery is to start at the year-end and it is calculated that all ordered equipment will be installed by 1976.

## From the Nine Month Report of the Ericsson Group 1973

■ Order bookings during the first nine months of 1973 amounted to \$1,069.9 million, an increase of 23 percent over bookings in the corresponding period of 1972. This increase was due largely to major orders from some of the Group's main European markets outside Sweden, from Latin America and from telephone administrations in Africa and the Middle East, including the recently opened markets in Algeria and Oman.

■ Sales rose from \$686.5 million to \$807.4 million, or by 18 percent.

■ The adjusted net income per share amounted to \$2.83, exceeding by 45 percent the adjusted net income for the first nine months of 1972 (\$1.95). For both periods the income per share has been based on the number of shares outstanding after the 1973 stock dividend.

# Technicians within the Ericsson Group discuss development questions

Technicians within the Ericsson Group from a number of countries gathered in Stockholm during a week in October for a conference on development questions — Engineering Development Council 1973, EDC 73.

Meetings of this kind are regularly arranged to maintain a mutual exchange of information between technicians of the Group in Sweden and abroad. There are many subjects to deal with and each new Council covers a special field.

L M Ericsson's marketing has for a long time been dominated by crossbar switch systems. It is clear, however, that future systems and improvements to them will be based on the printed circuit board principle. An extremely detailed coordination of all factors is necessary — from component selection and mechanical construction practice through manufacture to final testing of printed circuit boards and system units, as well as installation and maintenance. Documentation and design rules are other questions to which particular attention must be paid.

Great efforts and large amounts of money are expended on these development projects. They must therefore be carried out in such a way as to ensure the greatest possible efficiency and yield for the future.

A conference of this type provides a valuable exchange of information on new products and their adaptation to the conditions existing on different markets throughout the world. The significance of correct documentation and administration of development projects was emphasized by the participants.

Another aspect of this type of conference is that people from different



The chairman of the Council, Arne Rejdn (left), L M Ericsson, Stockholm, in discussion with his deputy, Mr Gunnar Svala, of North Electric Company, USA.

countries and subject spheres within a large enterprise have the opportunity to meet and get to know one another. This human aspect is important, not least for effective cooperation.

The conference on development questions was followed by a seminar dealing with improvements in the technique on which L M Ericsson's present production is based. Continuous modernization of the products manufactured at different factories of the Ericsson Group is important in order to compensate for increased costs.



During one of the days of the conference the participants of EDC 73 visited L M Ericsson laboratories and factories in Stockholm. Ulf Jerndal, head of printed circuit board manufacture at the Tellus factory, explains one phase in the manufacture.

## ERIPLOG — new method of laying of buried cables

L M Ericsson's Network Department in Stockholm has developed a new method and equipment for laying of buried cables. The ERIPLOG method extends the range of applications for a hydraulic excavator, so that direct ploughing-in of cable can be done even in difficult soil conditions.

The new equipment comprises two units, a rasp and a cable layer. The rasp is mounted in place of a shovel on the excavator; the cable layer is entirely separate and has a device to which the rasp is simply hooked during the actual laying. If the laying is obstructed by any object, e.g. a stone in the soil, the rasp is released and is thereafter used for removing the object, while the cable in the layer is entirely protected.

Excavators are indispensable for all buried cable laying. For minor jobs it is seldom profitable to use an additional machine specially equipped for burial of cable. The methods used hitherto for cable burial depend on the soil conditions, since there is often not sufficient grip for the wheels.

Using the L M Ericsson method the outrigger legs of the excavator can, in the case of difficult soil conditions, be placed against the soil and the hydraulic force of the grab can be used both for rasping and cable laying. Since the grab and rasp can also assist in movement of the machine over the terrain, the ground friction of the wheels is not a limiting factor. In this way cable can be ploughed down into practically any soil where a hydraulic excavator is usable.



Excavator with rasp for laying of buried cable by the ERIPLOG method. The cable layer is hooked underneath the rasp.

## Ministers from four countries visit LM Ericsson

During October L M Ericsson's head factory in Stockholm was visited in close succession by the Brazilian Minister of Communications, Hygino Caetano Corsetti, the Ecuador Minister for

Public Works, Rafael Rodríguez Palacios, the Irish Minister of Communications, Conor Cruise O'Brien, and the Malaysian Minister of Communications, Tan Sri Sardon.



During his visit to Sweden the Brazilian Minister of Communications, Hygino Caetano Corsetti (left), was the guest of L M Ericsson during two days and is here seen testing the first L M telephone from 1878 in the company of the President of the Group, Björn Lundvall. During these days the Minister visited L M Ericsson's development laboratories for stored-program-controlled telephone exchanges and the first exchange of this type at Tumba outside Stockholm, which has been in operation since 1968.

## Simplified materials handling in installation of telephone exchanges

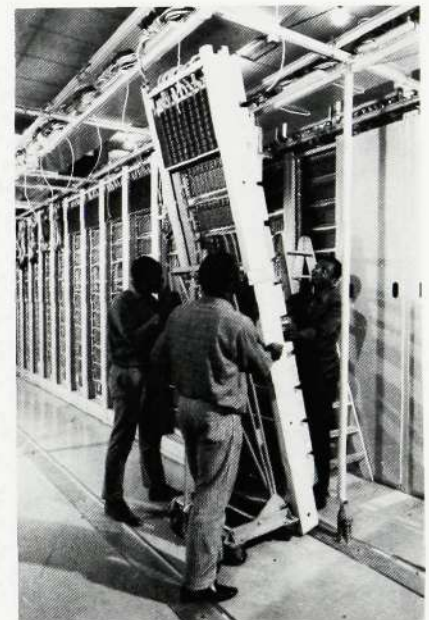
The personnel who install telephone exchanges often work under very difficult conditions. The working environment varies and the means of working in comfort and safety with rational aids are considerably less than, for example, on the factory side.

L M Ericsson's Installation Division in Stockholm has recently introduced two new aids which considerably simplify the handling of materials on site.

■ Wired racks weighing up to 300 kg can now be brought up and raised into their position in the suite with a hydraulic lift-truck. This lift-truck carries out the entire job without any manual hoisting. For manual hoisting at least 4—5 strong men are needed. The mechanization implies advantages not only for the personnel. The equipment is at the same time handled with far greater care, which means that its quality is not deteriorated and that less effort is needed for adjustment and testing work.

■ A small trolley has also been introduced. It is designed for transport both of boxes and various types of rack.

L M Ericsson's BDH racks are delivered with square transport plates and are stackable. Using two trolleys, up to six such racks can be transported at the same time. With its extra large wheels the trolley can easily move over thresholds, cable, floor ducts and similar obstructions.



A rack being placed in position with a hydraulic lift-truck. All manual hoisting is eliminated.

## Important IBM order for time recorders

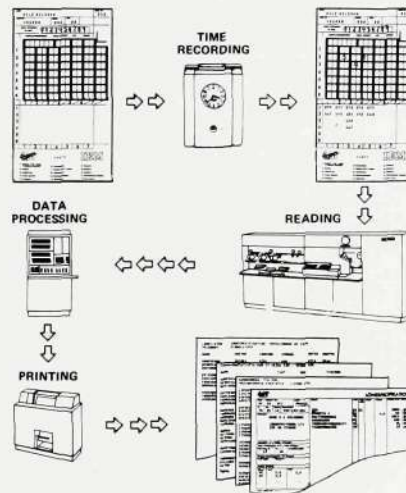
L M Ericsson's subsidiary in Germany has received an order for more than 300 time recorders for IBM, Germany. These time recorders will cover the requirements of the entire IBM administration, production units and branch offices.

23,000 IBM employees throughout the whole of Germany have flexible working hours which are recorded with L M Ericsson OCR time recorders. The time cards, which are stamped with optically readable characters, are read by an IBM 1287 optical character reader and then processed in a computer.

OCR signifies Optical Character Recognition and is a new technique within data processing, with an increasing number of applications. Recording of flexible working hours is a routine for which OCR is extremely well suited. Thousands of OCR time recorders of L M Ericsson make are already in operation and the interest for them on the market is growing significantly.

The method implies briefly that the time cards can be read directly by a computer after they have been stamped

and marked with exception codes if any. The system has both economical and practical advantages over other systems. Among its advantages are the access to an original document and to complete data for processing.



Routine for time recording with optical character recognition.

# Electrical voting system for Finnish parliament

A new electrical voting system was put into operation at the start of the autumn session of the Finnish parliament. Oy L M Ericsson Ab, L M Ericsson's Finnish subsidiary, undertook the installation and certain deliveries of equipment, while L M Ericsson Telemateriel AB, Stockholm, planned the installation and delivered the main part of the equipment. The voting system comprises the following units among others:

In the plenary chamber there are 200 control panels, one for each member of parliament. The members can correct their vote if they have pressed the wrong button by mistake. The member's panel also contains a microphone, a loudspeaker for listening to speeches in the chamber, and signal lamps which indicate the maximum speaking time and "important message from the telephone operator".

Recessed in the Speaker's desk is a control panel with pushbuttons for supervision of voting, a panel which shows the result of voting, and the necessary microphones and loudspeakers. The control panel also contains pushbuttons which enable the speaker to prevent sound distribution from the chamber or to limit it to the actual parliamentary building. By connecting a separate microphone the speaker can switch on all loudspeakers of the voting system so that important messages are heard in all official rooms in the building.

The central equipment of the voting system, which is placed on the lower

floors of the parliamentary building, counts the votes. The result of voting is shown on the result panel in the chamber and on a record panel which is automatically photographed by two cameras. The photograph shows the member's vote, the result of the vote, the number of the vote, the date etc. The record panel also contains a TV monitor for supplementary and explanatory particulars concerning the voting. A typewriter keyset for the latter particulars is recessed in the stenographers' desks.

The work of the stenographers is facilitated by a new tape recorder arrangement. Two of the tape recorders are in operation simultaneously — containing tapes for 7.5 minutes and 1.5 hours recording respectively. The tape recording is operated from the upper gallery by the parliamentary commissioner, who also has a control desk for switching on the members' microphones according to the Speaker's directions. He also has a mixer desk which automatically sets the correct sound level at the start of each speech.

The needs of the public in the gallery have also been taken into account through the provision of a large number of loudspeakers for increase of audibility. The press positions have sockets for tape recorders so that speeches by members can be directly recorded in the press gallery. The parliamentary sound distribution system is also connected to broadcasting equipment.



The chamber of the Finnish parliament viewed from the Speaker's control panel (right).

## First delivery of picture telephones from LM Ericsson

The first delivery of L M Ericsson's picture telephone system has now been made. Fifteen picture telephones and a video PAX have been delivered to the Spanish Telecommunications Administration CTNE, which intends to use them for field trials.

Field trials are already well under way in Sweden in cooperation between L M Ericsson and the Telecommunications Administration, and also within some of the Ericsson offices and laboratories in Stockholm. Some 180 persons are taking part in the internal field test.



One of the design departments participating in L M Ericsson's field test with the picture telephone system at the main plant in Stockholm has been visited by Mr J. J. Horzepsa (left) from AT & T (American Telephone & Telegraph) and Mr W. B. Cagle, Bell Laboratories. During the autumn these two gentlemen made a round trip to some European telecommunications administrations to hear about their experience with videotelephony.

## News from Rifa

■ A monolithic microcircuit which, without external components, can work with the existing battery voltages in telephony systems has been developed by AB Rifa, the components enterprise of the Ericsson Group.

■ In the capacitor field Rifa have developed a new type of highly stable styrene capacitors for carrier frequency filters and a resin-embedded tantalum capacitor designed especially with a view to mounting with integrated circuits. The new capacitors permit a saving of space of about 70 % compared with the present types with corresponding function.

For some years AB Rifa has been the largest Scandinavian manufacturer of electronic components. The company employs more than 1,700 persons in Sweden and has an annual turnover of 125 Mkr. Rifa components are made also in Australia, France and Mexico.

## Associated companies and representatives

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Telefonaktiebolaget L M Ericsson  
2. L M Ericsson Telemateriel AB  
2. L M Ericsson instruktionssteknik AB

1. AB Rifa  
1. Sieverts Kabelverk AB  
1. Svenska Radioaktiebolaget  
7. ELLEMTTEL Utvecklings AB  
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6. Soc. Telefónica del Perú, S.A.

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1. Telecommunication Manufacturers (Malaysia) SDN BHD

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1. Dansk Signal Industri A/S  
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6. Telephone operating company
7. Development company
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TELEFONAKTIEBOLAGET LM ERICSSON