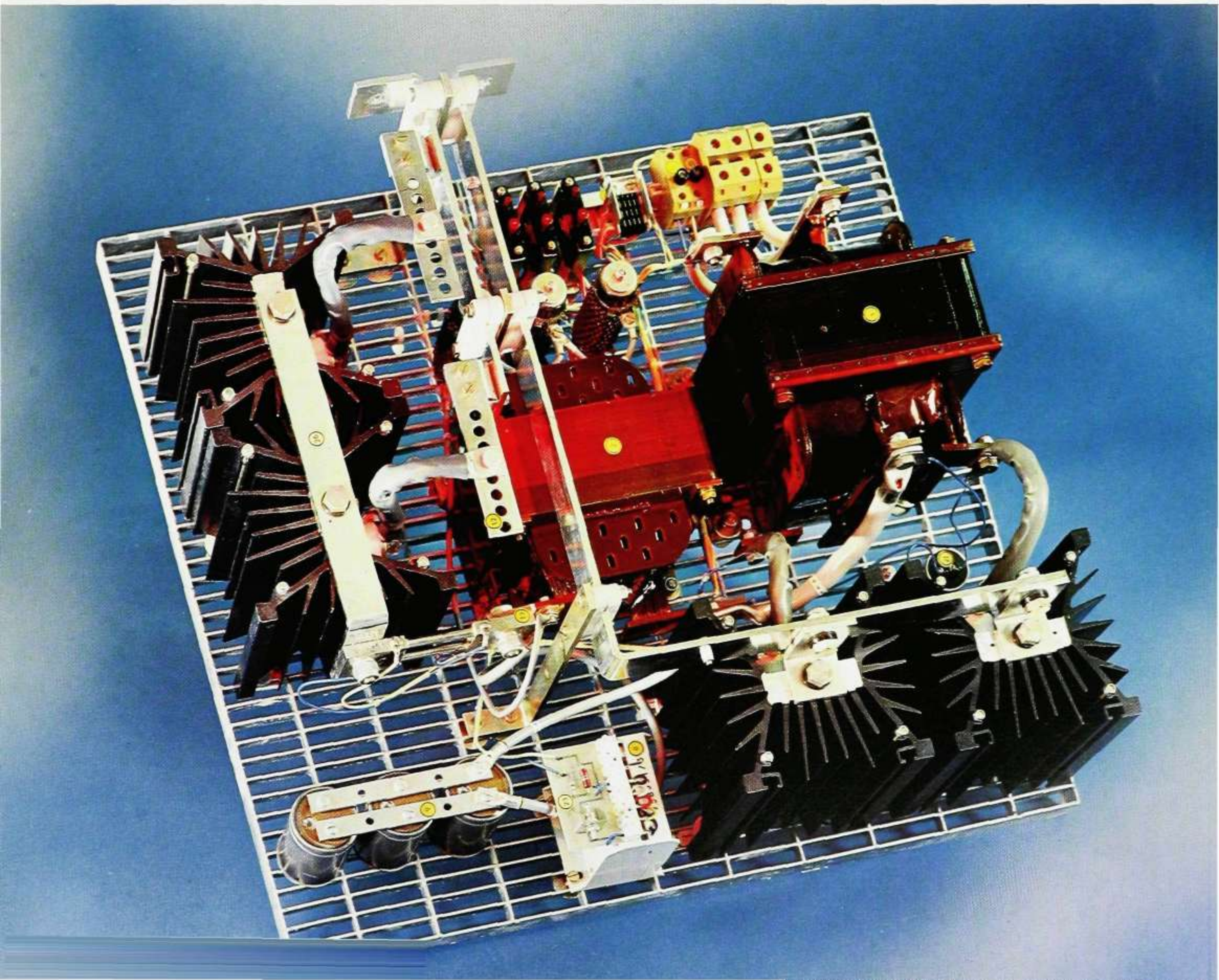
ERICSSON REVIEW

MAINTENANCE CONFERENCES AT LM ERICSSON
POWER SUPPLY SYSTEM WITH BOOSTER CONVERTERS
TELECOMMUNICATION EQUIPMENT FOR POWER STATION
TELEPHONE SYSTEM FOR POWER LINE NETWORKS
WORLDWIDE NEWS

1 1975



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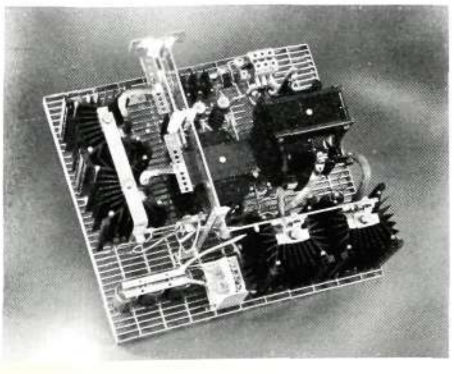

COVER

Module unit for a booster converter 140 A for the power supply of telex. The unit is mounted on a grating with the dimensions 650 × 600 mm

Maintenance Conferences at LM Ericsson, Stockholm

K. G. Hansson

Since 1956 fourteen maintenance conferences have been held at LM Ericsson in Stockholm. The aim of the conferences has been to contribute to a reduction of the operational costs and to give the manufacturer a basis for further rationalization and product improvements through an exchange of experience between customer and supplier.
Various maintenance methods and aids have been developed over the years. This is made clear if a comparison is made of the selection of subjects and headlines for the very great number of addresses that have been presented at the conferences.
What was the reason for initiating these maintenance conferences and what has been the result? The author attempts to answer these questions and also to summarize the impressions and experience of the customers and LM Ericsson. He concludes by mentioning something about the practical details in connection with the conferences.

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Background to the conferences

Telephone operating companies have for many years attempted to give their customers good service at the lowest possible operating costs. In this respect maintenance costs, which among other things are dependent on labour costs, have come to play an increasingly important role.

During the manual epoch the wages of the telephone operators was the major expense item, and it is thus quite natural that the development was aimed at cutting down the number of operators. This was done, for example, by making the switchboard multiples larger and larger and by attempting to simplify the work of the operators in every possible way. The operators carried out their relatively simple operations with great skill but is was of course impossible to avoid connecting wrong numbers occasionally, especially as the multiples became increasingly difficult to master. Failures were also very often caused by mechanical wear in plugs and jacks. For this reason the demand for a relatively comprehensive routine maintenance could not be neglected, fig. 1.

The transition to *automatic techniques* changed the picture completely, the subscriber then having to dial the correct number and the automatic equipment to carry out the logic operations in order to set up a call successfully. The current circuits and components of that time very often had less stable characteristics than those of today and the failure rate was relatively high. The automatic exchanges were usually manned and equipped with alarms and supervisory devices so that the exchange staff could help the subscribers both with the faults that the subscribers caused themselves and those

Fig. 1

A drawing from 1897 of a manual switch room built in 1886 by Stockholms Allmänna Telefonaktiebolag.

The mechanical wear on jacks and plugs was considerable. Hence maintenance work was fairly extensive

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occurring in the exchange equipment. Preventive maintenance was considered to be an obvious necessity. LM Ericsson's first 500-line selector exchanges were no exception in this respect. Administrations attempted to find the cheapest possible maintenance routines through a statistical follow-up of the operational results. LM Ericsson were given the opportunity of studying these results and in this way obtained extremely useful information, which it was possible to use as a basis for improving the characteristics of the 500-line selector system as regards maintenance routines. Categories of faults could successively be eliminated in this way and others, which had hardly been noticeable earlier, then came to light and could be dealt with.

The lessons learnt have since been exploited when developing components and automatic systems, and have resulted in a considerable increase in reliability. To a great extent it has been possible to gradually replace *preventive routine maintenance* by *corrective maintenance when required*. In connection with this the problem has arisen of organizing and controlling the maintenance methods so that the desired reliability could be guaranteed at the lowest possible cost.

At the beginning of the 1950's LM Ericsson started sending out service inspectors in order to establish better contact with the various administrations in maintenance matters. These visits were greatly appreciated by the administrations and it soon became apparent that there were so many different variations in maintenance routines and operational results that something ought to be done to establish standards and methods for a rational maintenance.

The administrations often had experience that was of great value when it became a question of attempting to formulate a maintenance policy. Thus in connection with the installation and putting into service of a number of large crossbar-switch exchanges for the Danish telephone company JTAS, it was found that after the centres had been run in for a number of years the failure rate was so low that it was soon possible to leave the exchanges unattended outside the normal working hours, and that it was only necessary to visit the small exchanges at regular intervals. An interesting observation in connecting with this was that the failure rate at an exchange was in direct proportion to the visit rate.

As a result of these observations LM Ericsson began to speculate about a completely new maintenance methodology, which was designated *controlled corrective maintenance.* Naturally the ideas had to be discussed with the administrations, because to a great extent it concerned their activities. LM Ericsson therefore took steps to arrange a maintenance conference in Stockholm during the early summer of 1956, to which delegates from the Scandinavian telephone administrations were invited.

The first conference

A total of 29 delegates from 13 Scandinavian administrations had accepted the invitation to attend the first maintenance conference.

The first paper to be presented at the Conference was read by the author of this article and was entitled "Maintenance economy" and had the following subheadings:

a. The position and importance of maintenance in a telephone administration's operating budget.
b. The distribution of maintenance costs on different parts of the automatized telephone network.
c. Maintenance costs and service requirements.
d. Rationalization paths to a cheaper maintenance.
e. Systematization of the work of the maintenance staff.
f. New operational methods.

The paper, which was in the nature of a manifesto, is given below almost in full.

When reading the paper one quite naturally finds that development has not stood still since 1956. Costs as well as other information concerning operation and maintenance may appear somewhat antiquated. However, the paper has been included in this resumé of the *history of maintenance conferences* because it constitutes an excellent reference from which to assess the development that has taken place in this field during the twenty years that have elapsed since then.

Maintenance economy

The telephone administrations, whose delegates we have great pleasure in seeing with us here, are exponents of a telephone culture at the highest level, and for a decade have made a point of offering their customers a first class telephone service. Hence it would be a very badly chosen occasion to begin to speak here about poor maintenance economy, neglected plant and inferior service.

But *in all honesty, gentlemen,* despite this is it not so that there are still reasons for combating the costs in the maintenance sector and for making further improvements to the telephone service?

The position and importance of maintenance in a telephone administration's operating budget

Let us devote a few minutes to a consideration of the economic role that maintenance plays in a telephone administration's operating budget. In terms of figures the amounts will presumably not be very high compared with other expenditure for new plant, the salaries of technical and administrative staff, costs of buildings, transport costs, power costs etc. But the major part of the maintenance costs consists of a fixed, anually recurring expenditure in the form of staff wages.

It may appear to be of little economic importance for a telephone administration if there are one or a few men more than are really necessary at a telephone exchange or out in the network. However, this is perhaps taking things somewhat too lightly. Let us consider an example.

A telephone administration has an automatic telephone exchange for 10,000 lines with six men on the duty chart solely for maintenance. The duty chart is drawn up for 24-hour manning of the exchange. Let us assume that the average annual wages for the staff is 15,000 SKr per man, including administrative and social costs etc. If we base our calculations on an exchange life of 30 years the capitalized labour costs for the maintenance staff with an interest rate of 6 % will be about 1,240,000 SKr.

It then turns out that the exchange functions equally well if not better with only three men and with manning restricted to normal working hours. The administration would then be able to invest 620,000 SKr in new equipment or, if there is no immediate need for extensions, some part of the rationalization gain could be used for supplementary equipment in the exchange or network in order to permit a further reduction of the staff.

In this connection one could quote other *examples illustrating the importance* of the maintenance costs for a telephone company's economy, but what has been said here can suffice for the time being. However, I cannot refrain from mentioning that in some parts of the world one can sometimes find telecommunication administrations with as many as 20 to 30 men in a 10,000-line telephone exchange. If in such cases it is the characteristics of the automatic system chosen by the administration in question that necessitate such a large maintenance staff, then it is really uneconomic to acquire this system demanding so much maintenance, even if the administration gets it for nothing.

The distribution of maintenance costs over different parts of the automatized telephone network

The costs that a telephone administration incur for the maintenance of exchanges and of the network and telephone sets, are aimed primarily at giving the subscribers a good service. The subscriber rarely knows what is done in this connection, but there is, however, one occasion when he comes in direct contact with the maintenance service, namely when he reports a fault. It is on these occasions that the subscriber forms an opinion of the grade of service provided by the administration. However, it is through these reports that the administration is able to get a conception of the role played by the different parts of the complete telephone installation as regards costs. It is of course debatable what statistical value one should accord fault reports from the subscribers. We can no doubt agree that these reports do not constitute a sensitive instrument for, for example, measuring the serviceability of an automatic exchange, but on the other hand

Fig. 2
The distribution of fault reports on the different parts

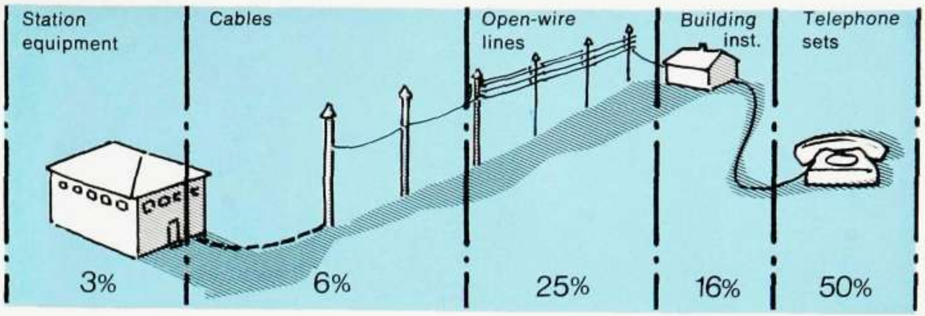


Fig. 3
Diagram of the desired relationship between service and costs

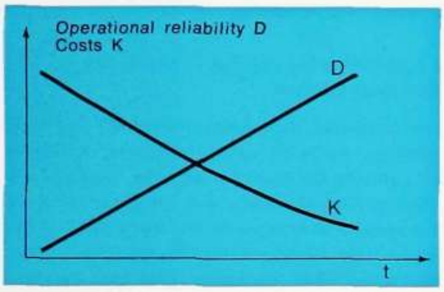


Fig. 4
Preventive maintenance.
Constant operational reliability.
High work contribution

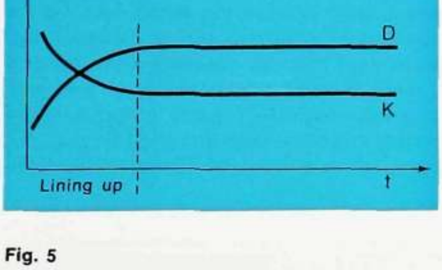


Fig. 5
Corrective maintenance.
Considerably varying operational reliability.
Temporarily high work contribution

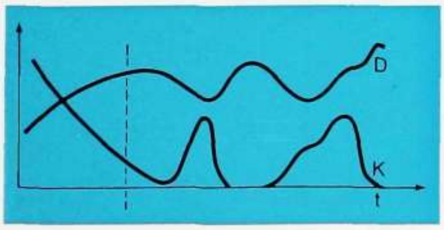
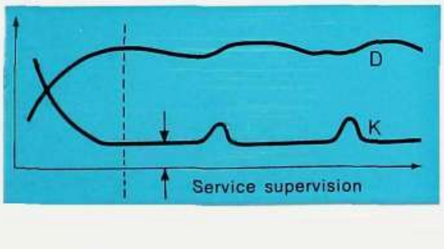


Fig. 6
Corrective maintenance with service supervision.
Slightly varying operational reliability.
Low work contribution



maintenance measure, and keeping a record of these measures gives the administration a fairly good picture of where one is obliged to lay down most money for maintenance.

Even though we will mainly confine ourselves here to problems concerning the maintenance of exchange equipment it can nevertheless be of interest to take a quick look at the complete installation. Fig. 2 shows the distribution of subscriber fault reports on different parts of the telecommunication network of a representative Scandinavian telephone administration.

Each fault report results in action by the administration and thus costs money. Calculations have shown that each fault report costs about 10 SKr when it is just a question of accepting and immediately classifying the report and the maintenance staff do not have to take any action. If measures have to be taken to find and clear the fault it costs about 15 SKr.

Normally about 0.8 faults are reported per subscriber and year and of these about 0.7 faults per subscriber and year are located and cleared. If for the sake of simplicity we take an installation of 12,000 to 13,000 lines, the administration concerned would receive about 10,000 reports anually. This corresponds to an expenditure of about 140,000 SKr, of which sum the exchange is debited 4,200 SKr and the network, building installations and telephone sets the remainder in accordance with the percentage distribution given in fig. 2.

The figures obtained from an investigation of this sort are quite interesting. The fault reports attributed to the exchange amount to only 3 %. It is true that one can point out that a large number of the exchange faults are of the type that do not affect the same subscriber repeatedly and hence do not occasion fault reports, but despite this the figure provides grounds for reflection.

Maintenance costs and service requirements

Whenever there is a discussion about combating costs, sooner or later the question of quality is bound to arise. In our case the question will be: Is it possible to reduce the maintenance costs and at the same time maintain or even improve the service? The answer to this question is yes and must be yes as long as technical progress continues. The ideal relationship between costs and s rvice, which is shown in fig. 3, is doubtlessly a goal for every telephone administration. This relationship has of course an optimum. Where this lies, however, and how it can be achieved is surely a question that no one is prepared to answer today.

There are many paths towards this goal. The traditional attitude to the problem costs-service has always been, and still is in many parts of the world, that a stable operational reliability at a high level should be achieved through a large work contribution (costs). This method is called preventive maintenance, which consists of periodically recurring servicing operations such as cleaning, lubricating, routine testing etc. These operations are carried out consistently and one does not ponder so much over whether the measures taken are really justified at all, but more as to whether certain routines could be dispensed with or simplified or the time intervals between them increased without causing any problems. Preventive maintenance can be represented schematically in accordance with fig. 4.

The opposite to preventive maintenance is corrective maintenance, which means that the operational reliability is increased through temporary work contributions when it is considered that the subscribers begin to complain too loudly. This methodology, fig. 5, is characterized by considerably varying operational reliability and uneconomic changes in work contributions.

As has been mentioned earlier, preventive maintenance has many advocates and is to a certain extent justifiable for certain systems with mechanically operating components, which require periodic servicing such as cleaning and lubricating. Take for example LM Ericsson's 500-line selector. This is a robust and durable selector with a pronounced high operational reliability. It must, however, be serviced once every second or third year depending on such environmental conditions as humidity, dust concentration etc.

However, with the new systems, which are built up of maintenance-free components such as crossbar switches and relays, it must be poor economy to carry out expensive testing of 1,000 switching elements in order to establish that there is a fault in only one of the units. On the other hand it is obviously good economy to test only the unit in the group that is faulty and to eliminate the remaining tests.

Rationalization paths to a cheaper maintenance

We have now got on to the subject of a maintenance methodology which might perhaps be called corrective maintenance with service supervision. This is characterized by a slightly varying operational reliability and a small work contribution, see fig. 6. The maintenance methodology is based on statistics from service supervision, on automatic indications from centralographs and counters, on indications from congestion meters and the results of traffic measurements. The statistics constitute the standard of value for the service that the telephone exchange gives the subscribers, and at the same time they provide information as to when certain types of faults exceed a permitted value and hence when corrective measures must be undertaken. In addition to the statistics, certain information is obtained concerning the function of the exchange from alarm display panels and through fault reports from subscribers and telephone operators.

A maximum return, both as regards low maintenance costs and high operational reliability, is influenced by the following factors:

- diagrammatical and mechanical design of the system
- equipments for service supervision and fault location
- processing of the operational statistics
- external conditions
- qualifications of the staff.

All of these factors will be dealt with later on in this paper and in discussions during the course of the conference, but to sum up I will just touch upon them here for a few minutes.

Diagrammatical and mechanical design of the system

It has already been pointed out here that as regards design the systems manufactured by LM Ericsson satisfy the requirements that can reasonably be set for operational reliability.

Equipments for service supervision and fault location

We consider that equipments for fault recording, such as centralographs, counters etc. should be used for service supervision. Operational statistics will be obtained from the results of complete test connections between test numbers corresponding to normal subscriber numbers. The test connections may of course be set up manually but with automatic equipment more reliable and quicker results are obtained at lower cost. LM Ericsson have designed an automatic traffic route tester for this purpose. Later on we propose to demonstrate this equipment. It is the intention that the traffic route tester shall provide the basic data for the operational statistics direct. Suitable test equipment must be available when there is a need to carry out fault location and fault clearing. Register testers, group selector testers etc. have been designed for this purpose. These will also be demonstrated later.

Fig. 7

**Opening of the 1956 conference.
The conference dealt mainly with maintenance of automatic telephone exchanges**

Processing of the operational statistics

If a maintenance methodology based on statistics is to give the intended result and be a true standard of value for the condition of an automatic exchange, the statistics must be analyzed in a scientifically impeccable and sensible way. Suitable test programs must be prepared and the required number of test connections decided so that the result obtained is sufficiently accurate. Regard must be paid to any cases of congestion for both loss and delay systems. All these problems will be dealt with later.

External conditions

By external conditions is meant the design of the exchange premises, the humidity in the exchange building, the dust concentration and the temperature. These are factors which we in LM Ericsson are not always able to influence to any great extent, but which are particularly important for good maintenance economy and high operational reliability. Very interesting problems arise round these questions about premises, air conditioning etc. which cry out for a solution. It is our hope that the collected experience represented here will enable us to shed some light on these obscure points in the forthcoming discussions.

Qualifications of the staff

When the talk about the staff at automatic exchanges we leave the technical field and consequently we are no longer on firm ground. The human factor comes into the picture in a very marked way, and the picture not only varies from country to country but also at the same place from one time to another.

We are concerned not only with the behavioural pattern of the individual but we must also come to grips with the administrations' social views on staff problems and the solicitude of the trade unions for the employment security of their members. With the rational maintenance methodology outlined earlier the staff requirement can be reduced considerably. In actual fact we consider that it is wrong to have staff in the exchange except on those occasions when they have a specific job to do. The aim is that the staff who work at the exchange should be well qualified. The work should be systematized and not, as sometimes happens, be carried out on the principle of "drifting round the racks". A telephone administration can find itself in the paradoxial situation that the difficulty of removing surplus exchange staff is the greatest stumbling block on the way to good maintenance economy.

A sensible measure that can be taken in such a situation is to transfer the surplus staff temporarily to some other type of work so that later, in connection with extensions to the exchanges, they can be used to satisfy the consequent need for additional maintenance staff.

If the staff at a telephone exchange is too large, the problem arises of keeping them occupied. This problem is solved through unnecessary activity, which almost always finds expression in a patholog'cal need to adjust relays. A surprisingly large number of the corrective measures shown in fault reports we receive from instalations in various parts of the world, consist of changes to the adjustment of contact spring sets. I find it very difficult to believe that our relays are worthy of this marked attention.

It is particularly important that the staff who are to carry out the maintenance at the exchanges are given a sound and comprehensive training. The training must be both practical and theoretical. This is a state of affairs which is by no means foreign for telephone administrations. Thus it is with great interest that we from LM Ericsson look forward to an exchange of experience in this field later on during this conference.

New operational methods

What has been said earlier in this paper regarding ways and means of achieving a sound maintenance economy must be considered as recommendations from a producer of telephone equipment. LM Ericsson do not have much experience from their own telephone operations in the sense intended here, the ideas put forward being mainly the results of the impetuses we have obtained through cooperation with our customers, not least in the Scandinavian countries.

We are well aware that the need for rationalization applies not only in production but also within the operational field. Hence, as I have mentioned before, we are extremely interested in getting our products adapted to the requirements of a rational operation. We know the components in our telephone exchanges very well and therefore consider we have a certain right and even duty to put forward our views and wishes to our customers regarding the care and attention of these components.

To summarize, our views and wishes can be presented in accordance with the following:

Preventive maintenance is abolished for crossbar switch exchanges and considerably simplified for exchanges with 500-line selectors, and is replaced completely or in part with automatized service supervision to the greatest possible extent. Results of the service supervision alone determine when intervention in the equipment is to be carried out. The rapid development in the field of automatic telephony means that preventive maintenance is set aside more and more. In, for example, the semi-automatic primary centre group and trunk traffic network, automatic supervision of lines and other equipment must become more and more necessary the greater the extent of this type of traffic becomes. In the coming electronic systems information from the equipment itself will provide the basis for all fault clearing.

Some wishes in the present phase may be given in the form of the following three rules:

- each routine testing, in which no fault is encountered, is unnecessary
- each form of service that cannot be shown to improve the operational reliability or increase the life is valueless
- do not interfere with the equipment unnecessarily.

With these rules as the guiding principles, and with regard paid to the factors discussed earlier, the work contribution for the maintenance of a lined up and correctly dimensioned crossbar switch exchange should not exceed 0.3 hours per line and year for an operational reliability such that the fault rate does not exceed 0.1 per cent. For 500-line selector exchanges the corresponding work contribution should not exceed 0.6 hours. At these exchanges the motor driven 500-line selector and its transmission system require a periodically recurring service, but on the other hand this service can be carried out by relatively cheap labour.

After this "manifesto" it is now time to consider what has happened since then.

Conferences 1957—1971

In 1957 an English version of the 1956 conference was held and in 1958 a Spanish version. Since then the conferences have been held every fourth year in Swedish, followed by an English version the year after and a Spanish version the year after that. Fig. 8 is a tabulation of the number of administrations and delegates who have taken part in the conferences that have been held hitherto.

The guiding principles for controlled corrective maintenance, which were drawn up in 1956, have constituted the

Year	Nordic		English		Spanish	
	Administrations. No.	Delegates No.	Administrations. No.	Delegates No.	Administrations. No.	Delegates No.
1956	13	29				
1957			13	28		
1958					15	30
1960	16	39				
1961			21	43		
1962					16	36
1965	18	46				
1966			22	55		
1967					17	47
1969	17	55				
1970			37	78		
1971					26	73
1973	18	60				
1974			35	84		
Sum total	82	229	128	288	74	186

Total administration visits 1956—1974: 284

Total number of delegates 1956—1974: 703

Fig. 8
Tabulation of the number of administrations and delegates at the maintenance conferences 1956—1974

framework of the programs for the succeeding conferences. The principles have of course undergone further development in intimate collaboration with LM Ericsson's administration customers.

It is extremely interesting to go through the programs for the different conferences.

The conference of 1956 was confined almost entirely to questions concerning the maintenance of automatic telephone exchanges. It then emerged that the majority of the faults encountered by subscribers were caused by faults outside the telephone exchange equipment (97 per cent in the network and telephone sets, as shown in fig. 2). Consequently in the next series of conferences, held in 1960—1962, a large part of the program was devoted to maintenance of the network and transmission equipment. For example, in the program for these conferences we find such headlines as:

Network maintenance methodology
Maintenance of the Swedish long distance cable network
Maintenance of telephone sets
Maintenance of transmission equipment

Several new features were introduced in the third series of maintenance conferences held during the years 1965—1967. Integrated maintenance with centralized service supervision not only of local traffic but also of national and international traffic was the subject of very intense discussions. Interesting information was provided by the Swedish Telecommunications Administration concerning the supervision of the quality of service in the telecommunication network through the establishment of comprehensive test traffic using traffic route testers. During this series of conferences the question of maintenance and operation of SPC (Stored Program Control) exchanges was taken up for the first time. In other words electronics had come to stay even at LM Ericsson's maintenance conferences.

Experience from earlier conferences had shown that many delegates were interested in taking part in detailed discussions devoted to operation and maintenance problems within their own special fields. Consequently at the 1965 conference, and at each conference since then, one day of the conference week has been allocated to group discussions with the following division:

Fig. 9
The 1974 English speaking conference assembled for a plenary session

Maintenance of automatic telephone exchanges

Maintenance of networks and telephone sets

Maintenance of PABX equipment

Maintenance of transmission equipment

This form of conference work proved to be very successfui as it provided the opportunity for freer discussions than had been possible at plenary sessions. Among other things the delegates were given the opportunity of proposing in advance a certain subject that could be of interest for such discussions. The other delegates then had time to prepare for the discussions. This form of discussion was particularly profitable within the field of maintenance of PABX equipment.

A subjet that gave rise to interesting viewpoints and discussions during the conferences held in 1969—1971 was the possibilities for subscribers of connecting up fully automatic calls even outside the boundaries of their own country and the resultant problems that arise for the telephone administrations of maintaining an efficient service supervision. New aspects of maintenance problems emerged as a result of these discussions. Operation and maintenance questions were obviously not confined solely to the technical field but also embraced the fields of administration and organization.

"Centralized supervision of conventional systems" was a main headline that covered a great many valuable presentations of the experience of different telephone administrations. It was clear from these presentations that there had been many structural changes within the administrations during the preceding years. Boundaries that had earlier been clearly defined between the different technical fields were being erased slowly but surely. Thus, for example, a transmission man could be compelled to think about problems connected with automatic switching equipment and so on. This would have been unthinkable ten years earlier.

Conferences 1973 and 1974

The Swedish and English versions of the fifth series of conferences were held during 1973—1974 and the Spanish version is planned to take place during the last week in May 1975.

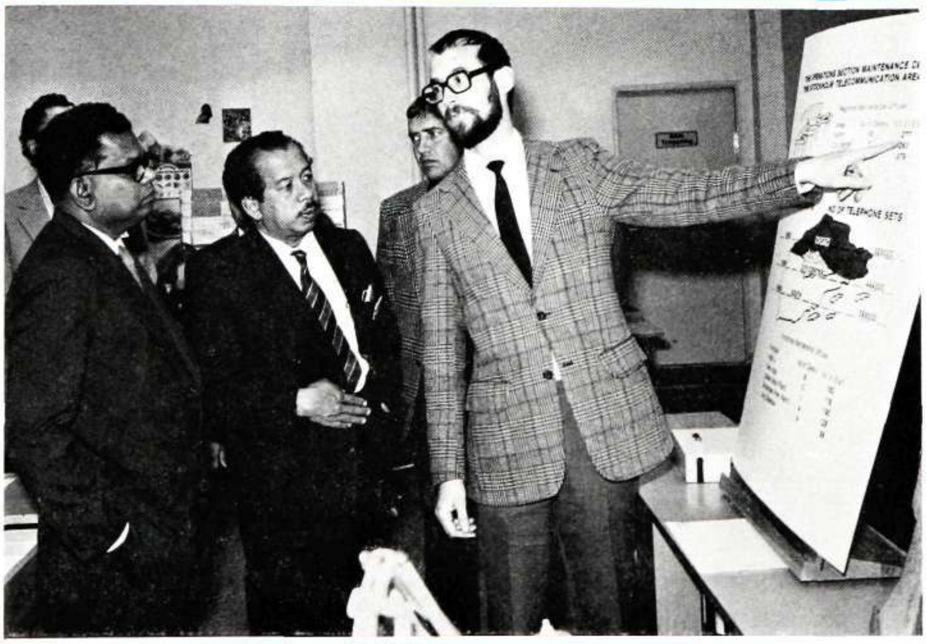


Fig. 10

Conference delegates visit the Swedish Telecommunications Administration's maintenance section

If the programs for 1956 and 1974 are compared one naturally finds considerable differences.

SPC technique now plays a prominent role.

Great interest has been shown in the subject of cable maintenance.

"Human factors — problems in operation and maintenance" is a newcomer among the headlines.

"How do telecommunication administrations master abnormal situations in the telecommunication network?"

In a paper entitled "Productivity — Results pay — Cooperation — Service (PRS)" Mr. T. Larsson from the Swedish Telecommunications Administration gave an extremely interesting account of his administration's efforts to create the prerequisites for providing an even better customer/subscriber service through, for example, collaboration between different work functions.

However, the corner stones from the 1956 program still remain. The maintenance and service policy that was presented then and which found favour in the eyes of the delegates is unchanged. Reports from various administrations indicate how this philosophy has been accepted in full or at least in part. The Swedish and Dutch telecommunication administrations are planning, for example, a considerable expansion of a traffic route tester network with the intention of supervising almost all routes, both local and trunk.

The latest program also includes environmental questions and these are just as important today as they were in 1956. Dirty relay and selector contacts still cause functional faults and reduce the life of the equipment.

New aspects concerning the design of telephone exchange buildings and how they should be equipped have emerged as a result of the changes in exchange engineering and these have been compiled in a *Manual for Telephone Buildings*. In this respect SPC systems have other requirements than conventional crossbar switch systems had in 1956, but the fundamental requirement for isolation and cleanliness still applies.

Training is a headline which is always included in the programs. At the 1974 conference LM Ericsson provided information about the resources they had available for training the staff of their customers. Just as a supplier need to train his staff within all the relevant

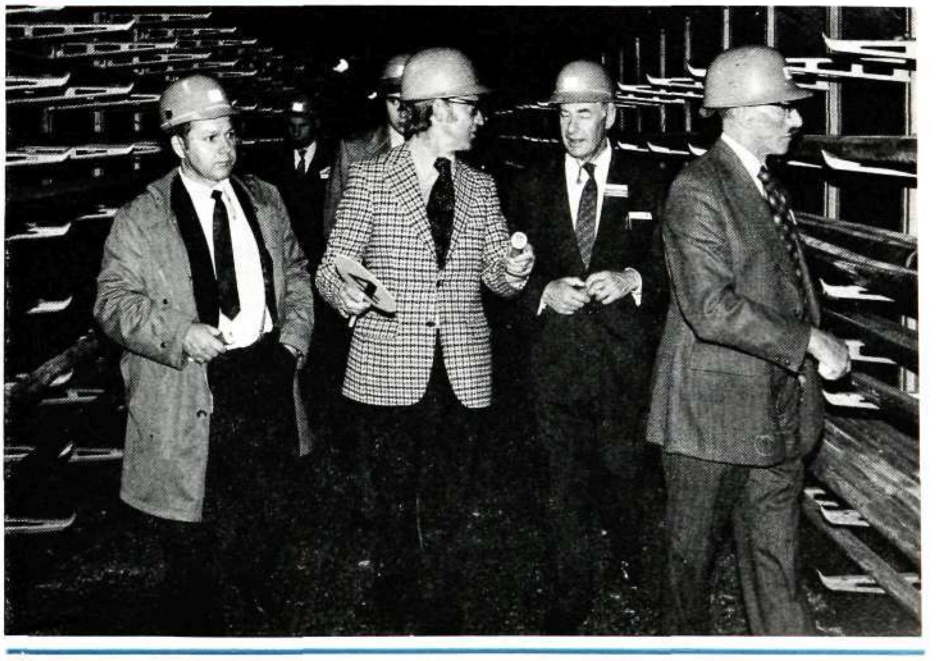


Fig. 11
A visit to Stockholm's "underworld"

fields, a telecommunication administration needs competent staff to manage the complete installation.

At all the conferences few questions have aroused such interest as those dealing with training. It is therefore gratifying that LM Ericsson are able to present suitable programs for different forms of training and can provide the required teachers and material irrespective of whether the course is held in the centre of Stockholm or in the country of the customer in question.

At the maintenance conferences is has been constantly pointed out that apart from the theoretical training the operating staff must receive a thorough practical training. When LM Ericsson carry out the installation work the customer's staff are always given the opportunity of taking part in the assembly and testing. Experience has unequivocally demonstrated that this is a good method.

Delegates to the conferences are all agreed that these occasions for exchange of experience within the field of training, which have been made possible by the maintenance conferences, have been extremely valuable. It is doubtful whether there are many fields in which the supplier and the customer have so many common interests.

Study visits

The maintenance conferences have not been restricted only to addresses and discussions. During the conference week, one day or part of a day has been allotted to a study visit to the Swedish Telecommunications Administration. We have then had the opportunity of studying that administration's development of methods and aids for subscriber service (maintenance section), see fig. 10. The extraordinarily high ambitions that the Swedish Telecommunications Administration have in these respects, and the splendid results they have achieved, for example in reducing the fault clearing times, has greatly impressed colleagues from other administrations.

During recent years delegates have been given the opportunity of visiting Stockholm's "underworld", or in other words the Telecommunications Administration's cable tunnels deep down below Stockholm, see fig. 11.

The conferences for delegates from countries outside Scandinavia have usually been extended by one week, when visits have been made to one of the neighbouring countries. On several occasions the journey has been made to Denmark to visit the Danish administrations. Many are certain to remember the beautiful days of early summer on the plains of Jutland when representatives of JTAS showed how easy and free of trouble it was to plough in telephone cables in the Danish soil. After Jutland trips have been made to Funen, where FTK as exemplary hosts have shown their installations. This second conference week has then been concluded in Copenhagen with KTAS as hosts.

A number of times the journey has been made eastwards to our friends in Finland where visits to the installations of the telephone administrations have been combined with sauna baths and walks in the beautiful Finnish countryside.

In 1971 the delegates from the Latin American countries had the opportunity of making a study visit to the Dutch telephone administration during the second week of the conference. The Rotterdam district was visited, where among other things the delegates were able to obtain first-hand knowledge of the operational experience gained from the SPC transit exchange delivered by LM Ericsson, which was the first in the world of its kind to be put into service. The visit to Rotterdam was extremely interesting in many ways. Delegates were given the opportunity of sharing the experience gained by the administration from the use of traffic route testers for service supervision. The Rotterdam district has been something of a pioneer as regards the use of traffic route testers.[1, 2] Other districts in Holland have been able to exploit the experience gained in the Rotterdam district.

Summary

Up to and including 1974 LM Ericsson have delivered automatic telephone equipment corresponding to 25.3 million subscriber lines. (Excluding North America this constitutes 8 per cent of all the telephone equipment in the world.) Of this amount, equipment for 3.5 million lines was put into service during 1974.

LM Ericsson have no experience of their own of operating a telephone service. It is our customers who must tell us if our products are satisfactory from a maintenance point of view. It is almost a vital necessity for us that this feedback functions.

The maintenance conferences have been and are of very great value to LM Ericsson as regards coming into contact with those employed by our customers who deal with service and maintenance questions every day. During the conferences these persons have told us about the troubles they have had with a certain unit — a component may be unstable, a contact spring set will not give the correct contact pressure etc.

All this may appear to be a matter of insignificant details, but it is extremely important that these details are put right both in production and in delivered equipment.

We have reason to believe that our customers have also found the maintenance conferences useful. Statements made during the course of the conferences and many friendly letters of thanks after two hectic conference weeks indicate a positiv attitude. LM Ericsson also attach great value to the fact that more and more people wish to attend the conferences even though in some cases it means travelling half the way round the world.

To ventilate problems concerning service and maintenance, both technical and administrative, is a part of the conference. To learn to know each other, to become personally acquainted with each other and to become good friends is another important result of being together. It contributes to a great extent to the maintaining of good relations between administrations even after the end of the conference weeks.

There are many problems in arranging a conference of this type. For example, one is not always successful in finding the right balance when allocating the times for reading the paper submitted and for discussions. It is not possible to know in advance how loquacious the delegates are. This is especially difficult at the Spanish speaking conferences where there are simultaneous translations into English and Spanish.

We have tried several ways of satisfying the desire for longer discussion time. We have, for example, sent out the papers in advance to all delegates and during the conference presented a summary of the subject and thereafter allocated quite a long time to discussions and questions, for which purpose a panel of experts has been available. The result was not what had been hoped for, mainly because the delegates had not had the opportunity of preparing sufficiently before the conference.

After 14 conferences we have found that the best approach is to present a paper in full and then allocate a reasonable time to discussion with possibly time for a final discussion on the last day of the conference.

LM Ericsson intend to continue holding maintenance conferences in the future. We consider that we cannot do without the benefits we derive from them. When the new generation of equipment is introduced by telephone administrations in all parts of the world it will be even more necessary to maintain an intimate contact in matters concerning service and maintenance.

The demands of telephone administrations and subscribers for suitable equipment with low maintenance costs must always constitute a lodestar for LM Ericsson as designers and manufacturers.

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Power Supply System with Booster Converters – Viewpoints after 10 Years in Operation

Tadeus Wolpert and Dag Björk

In 1964 LM Ericsson introduced a new power supply system for telecommunication equipment. The system contained a new type of unit, the booster converter. Up to 1974 the booster converter system had been used in over 1500 telecommunication plants of various types, from small unmanned radio link stations to very large telephone exchanges with a central position in the national and international network. LM Ericsson's AKE 13 type of stored program controlled exchanges have also been equipped with this power supply system. In this article a comparison is made between the booster converter system and other power supply systems, seen against the background of 10 years' operational experience. Only a summarized description of the booster converter system is given, however, as it has already been described in detail earlier in Ericsson Review.[1-4]

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Compared with other power supply systems the booster converter system offers a number of advantages. For example, an exchange voltage which is held within close limits in all operational cases, fully automatic operation and the possibility of unlimited extension. Moreover 10 years' experience has shown that the introduction of booster converters has resulted in

— better total economy

— greater flexibility for meeting the various operational requirements

— higher reliability.

The system has also proved to be particularly suitable for supplying the power for electronic telecommunication systems.

System description

FUNCTION

Booster converter system BZD is used to supply telecommunication plants with d.c. at a nominal voltage of normally 48 V. The output voltage of the system is uninterruptible, stabilized and has a low noise level. Fig. 1 shows the main parts of the system, comprising rectifiers (R), storage batteries (B), booster converters (C) and the distribution field (D). The BZD 101 system also includes equipment for automatic battery charging (OC) and automatic parallel operation of the rectifiers.

Normally the system is fed from the mains supply, but if there is a mains failure or rectifier failure all feeding takes place from the storage batteries.

When feeding from the mains, the rectifiers maintain a constant d.c. voltage across the batteries and at the same time deliver the required current to the telecommunication plant. The batteries receive only sufficient current to maintain the floating voltage and the booster converters are not operative.

When there is a mains failure the storage batteries supply current and hence their voltage falls. The booster converters then start automatically and deliver a booster voltage which increases as the battery voltage decreases. The converters thereby attempt to hold the distribution voltage constant until the battery is discharged, see fig. 2.

When the mains voltage is restored, the rectifiers are connected in and charge the batteries in parallel with the feeding of the plant. When the bat-

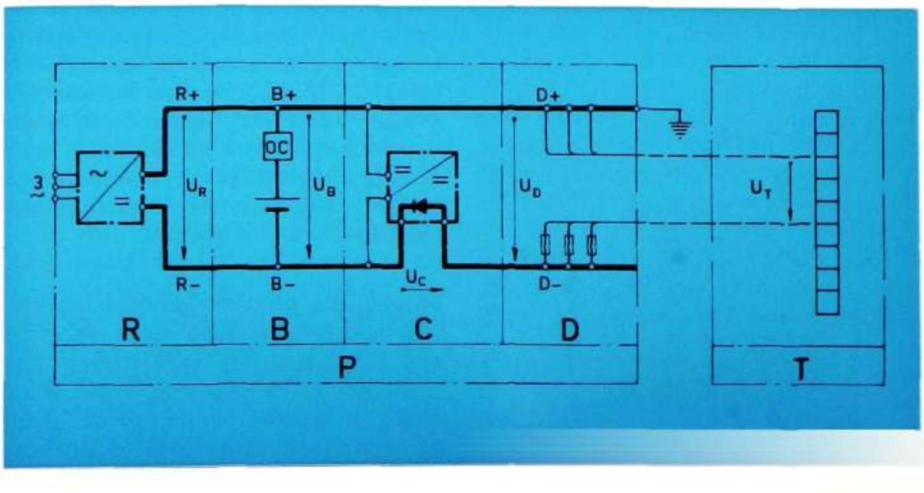

Fig. 1
Power supply system BZD with booster converters

P	Power supply plant
T	Telecommunication plant
R	Rectifier
B	Batteries
C	Booster converter
D	Distribution rack
OC	Automatic battery charging
U_R	Rectifier voltage
U_B	Battery voltage
U_C	Converter voltage
U_D	Distribution voltage
U_T	Telecommunication plant voltage (exchange voltage)


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teries reach their normal voltage level the booster converters stop operating. In order to be able to fully recharge the batteries during operation the automatic battery charging equipment is connected in and increases the voltage of the rectifiers. When the batteries are fully charged the battery voltage is again reduced to normal level.

When working on peak load there must be at least one rectifier and one converter in reserve, among other things in order to be able to recharge the batteries.

MECHANICAL DESIGN

The system consists of modules with the components mounted on gratings which provide efficient cooling and flexible positioning of the components. The modular units are mounted in floor racks 600 or 800 mm wide, 2200 mm in height and 800 mm deep. All the units can be fitted from the front. Each module is a functional unit which is sufficiently robust to withstand transport. The modules are tested individually in the factory and are tested together on the installation site.

Fig. 3 shows a rack with six modules and fig. 4 a power supply plant.

MAIN PARTS OF THE SYSTEM

Rectifiers

The rectifiers, fig. 5, provide a constant d.c. voltage with a regulation accuracy of ± 0.5 %. Current limiting takes place when the rated current is exceeded, the output current being held constant at approximately 110 % while the voltage falls. Voltage and current regulation is provided by phase angle control of the thyristors in the main circuit.

The rectifiers can be set up with a control switch for automatic operation, manual operation or charging. In all positions the rectifiers operate with current and voltage regulation.

For automatic operation, which is the normal operational mode for the rectifier, the rectifier is connected in automatic parallel operation with the remaining rectifiers, so that, for example, the load is distributed between the rectifiers in accordance with a given pattern. The voltage level is adapted to the floating level of the batteries and is increased automatically when battery charging is required.

With manual operation the rectifier is connected in manually and works independently of the other rectifiers. The

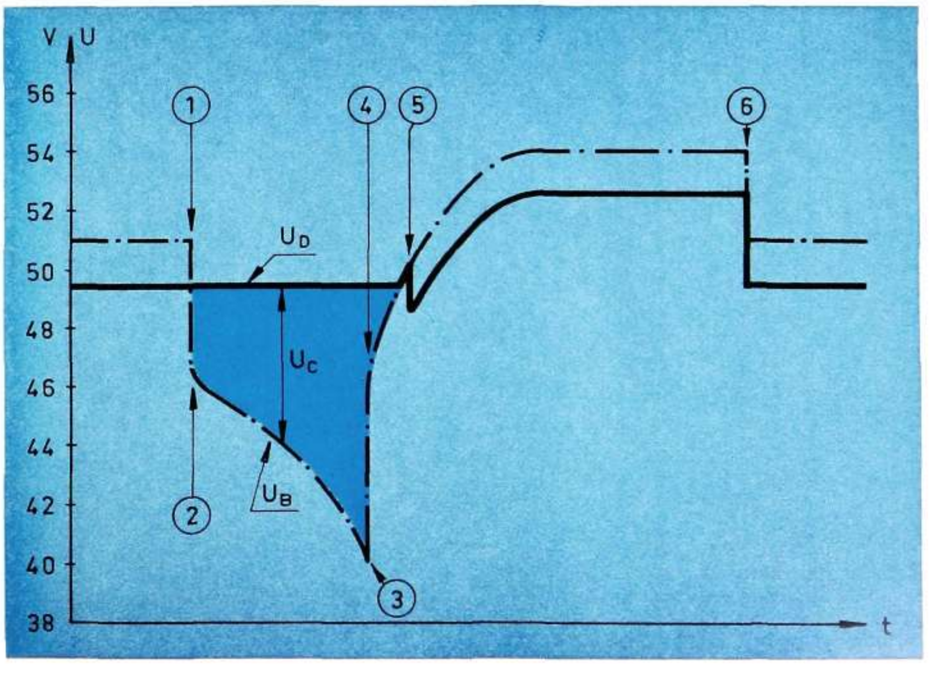


Fig. 2

Converter system 48 V with 23 battery cells. The sequence for the distribution and battery voltages during the time of a mains failure and the recharging of the battery

U_D	Distribution voltage (with heavy load)	———
U_B	Battery voltage	—·—
U_C	Converter output voltage	
1	Mains failure (lengthy)	
2	Converters start	
3	Battery discharged	
4	Mains voltage recovers	
5	The converters stop. Recharging of the battery starts	
6	Charging ceases	

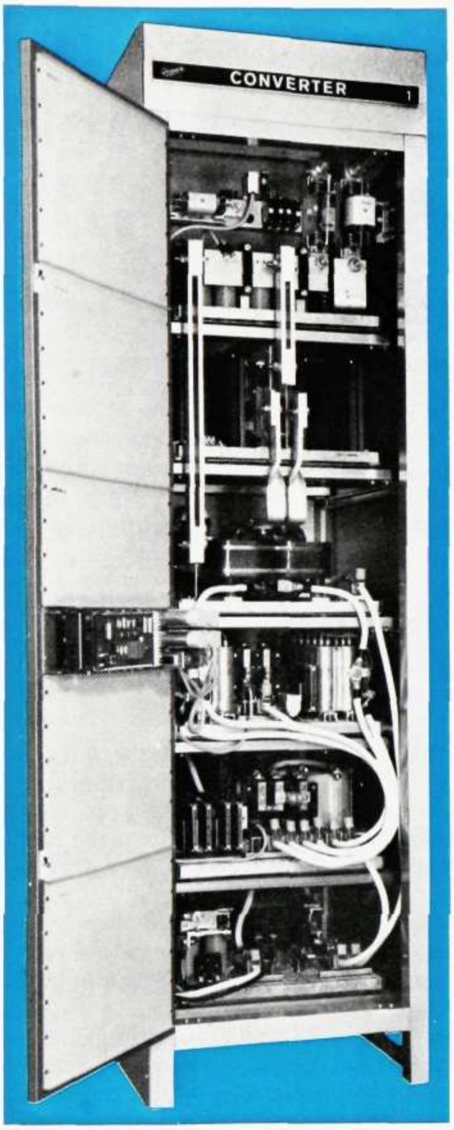


Fig. 3
Booster converter 630 A 48 V/0—9 V, type BMR 207

current and voltage levels are set up manually. Automatic parallel operation and automatic battery charging are then not functioning.

When charging, the rectifiers function in the same way as in the case of manual operation, but the regulation level is higher. The voltage level should normally be sufficient to give the batteries a stirring or equalizing charge without the maximum level of the distribution voltage (56 V) being exceeded.

Booster converter

The booster converters are d.c. converters consisting of thyristor inverters and rectifiers. They are fed from the battery and supply a voltage which regulates over a range of 0—9 V insulated from the battery circuit. Voltage and current regulation is obtained through pulse width modulation in the thyristor inverter.

All the converters are connected in parallel with each other and the current distribution between them is indeterminate. Overload is prevented through individual current limiting at the rated current in each converter.

Batteries

The batteries are normally of the stationary lead storage type with tubular positive plates in sealed single cells. In order that the batteries shall be as efficient as possible and have a long life they are always kept fully charged in accordance with the floating principle. Thus a constant voltage is applied across the batteries equivalent to about 2.2 V per cell (a total of 51 V for 23 cells), and the amount of current taken up by the batteries is equivalent to the self discharge.

Automatic parallel operation

The equipment for automatic parallel operation ensures that the total load is divided up between the rectifiers in a very rational way. One rectifier functions as pilot rectifier and is constant-voltage regulated. In this way it determines the voltage across the battery and follows the load variations.

The other rectifiers receive in or out-stepping pulses depending on whether the load increases or decreases. The rectifiers work in four steps with constant current in each step, i.e. 25 %, 50 %, 75 % and 100 % of the rated current of each rectifier. When the load

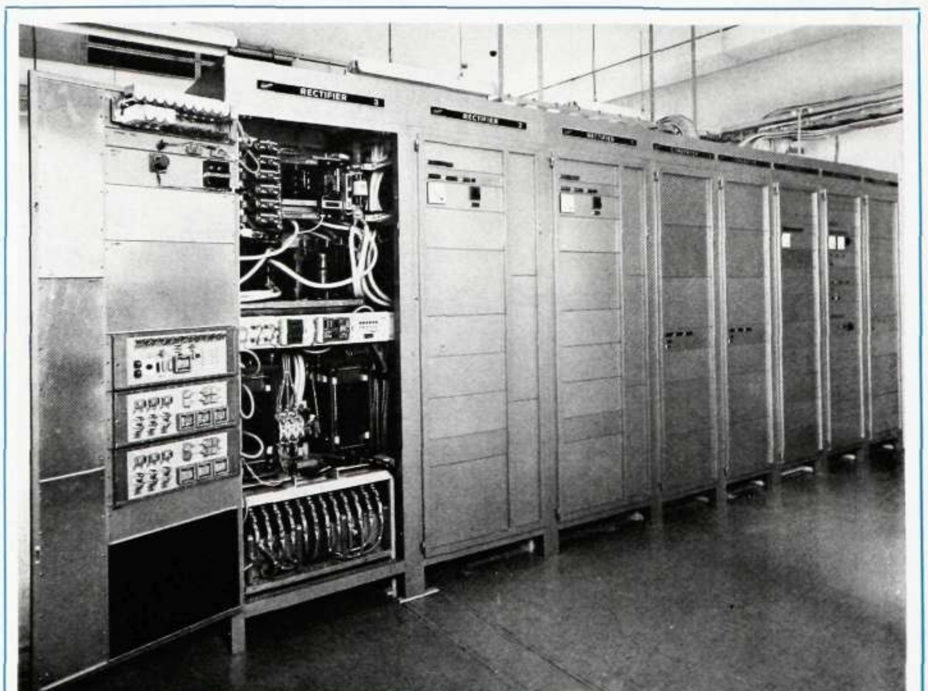


Fig. 4
A power plant according to the converter system. The picture shows a section of the plant in the stored-program-controlled exchange, type AKE 13, in Fredhäll, Stockholm

increases, steps 1, 2 and 3 of the next rectifier in turn are successively connected in and then the corresponding steps in the next rectifier and so on. The fourth and final step is not connected in until all rectifiers are loaded to 75 % of their rated value. When the load decreases, the rectifiers are stepped out in the reverse order.

The advantages of this load distribution are as follows. For the majority of the time the rectifiers in circuit are working on 75 % load where the efficiency is high and the thermal stresses are low, thereby contributing to increased life. As the number of working rectifiers varies with the actual load, the no-load losses are eliminated. This results in an energy saving of about 5 %.[1]

Automatic battery charging

This equipment supervises the state of charge of the batteries and ensures that they are always kept fully charged. When the batteries are completely or partly discharged, for example after a mains failure, a signal is sent to the pilot rectifier. This increases the voltage level so that the batteries can be recharged completely (2.35 V/cell, a total of 54 V for 23 cells) within a reasonable time. When the batteries are fully charged, the battery voltage returns to the normal value, 51 V. Charging takes place in parallel with the feeding of the telecommunication plant.

Control, protection and supervisory functions

Apart from the control functions in connection with automatic parallel operation and automatic battery charging the following control functions are also included in the converter systems:

- automatic and manual start and stop of the booster converter
- manual start and stop of battery charging
- automatically controlled loading of the rectifiers when changing over to feeding from a standby power plant.

The most important protection and supervisory functions are as follows:

- if the pilot rectifier develops a fault its function is automatically taken over by the next rectifier

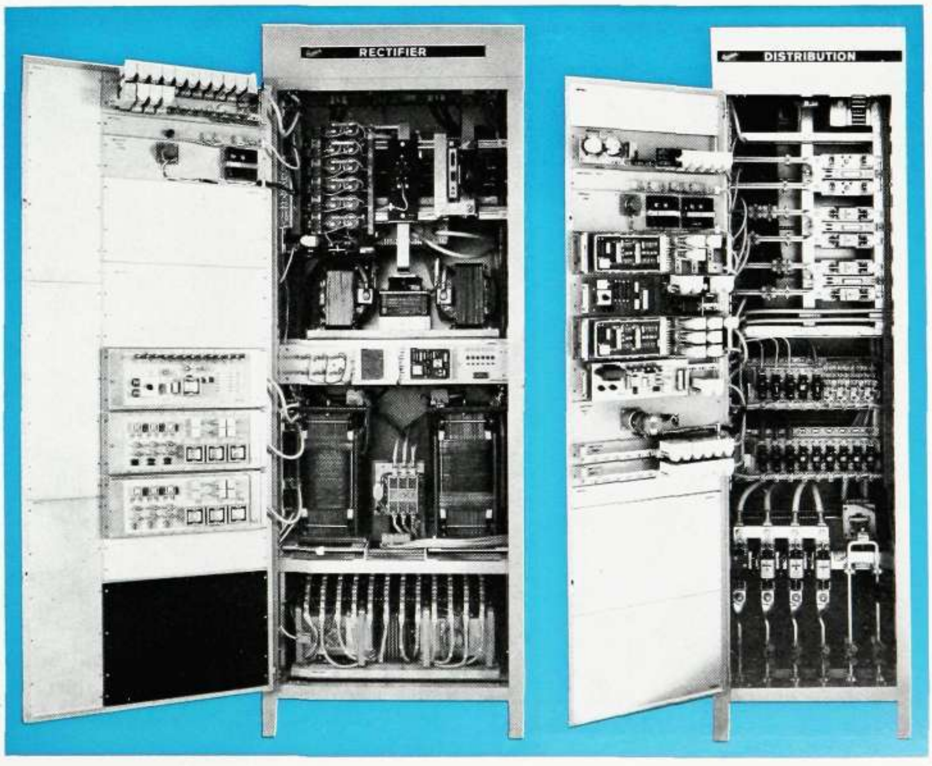


Fig. 5
Thyristor rectifier 630 A 48 V, type BMT 183

Fig. 6
Distribution and battery rack with central central equipment, type BMG 211

Fig. 7

Voltage of a battery cell during discharge with current discharge rates of 1, 3, 5 and 10 hours.

With a lowest permissible cell voltage of 1.96 V/cell and a current discharge rate of 10 hours, only 45 % of the available capacity of the battery can be used during discharge. With higher discharge currents the percentage will be even less

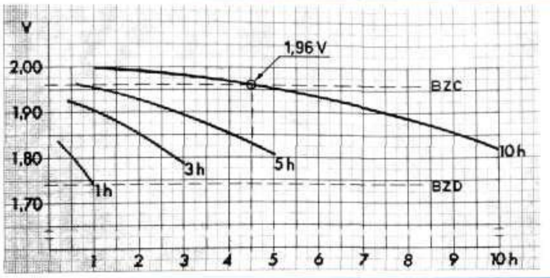
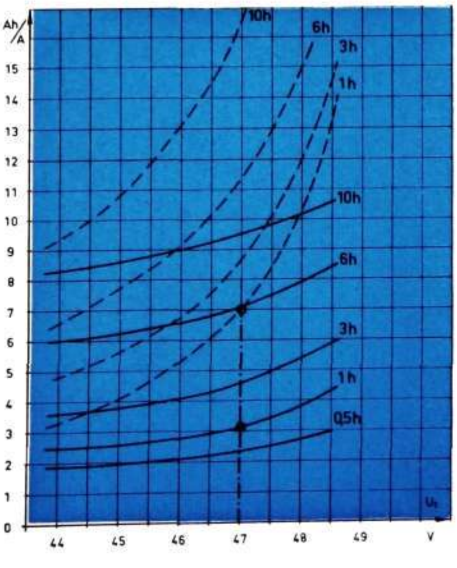


Fig. 8

Required nominal battery capacity (Ah_{10}) with different standby times and different values for the lowest permissible exchange voltage U_T

——— Converter system BZD
— — — Cell switch system BZC

With U_T = 47 V, standby time 1 hour and a distribution current of 1000 A, the cell switch system requires 7000 Ah and a converter system only 3100 Ah



— any rectifier or converter that develops a fault is disconnected and gives an alarm

— an alarm is given if the distribution voltage is low, and with too high voltage the faulty units are also disconnected

— if there is a break, faulty phase or unacceptable reduction of the voltage on the mains supply, the rectifiers are disconnected, the converters start up and a mains alarm is given

— depending on the degree of urgency the alarms are divided up into three categories, A1, A2 and A3, and can either be taken to a central point or be given internally.

The distribution rack, which also contains the central control equipment, is shown in fig. 6.

System characteristics

In the following a comparison is made between the converter system and the most common alternative to this, namely a cell switch system BZC[1] with 23 main cells and 2 end cells. The cell switch system is still used to a great extent in many places throughout the world.

BATTERY CAPACITY REQUIRED

A storage battery must be dimensioned so that

— the capacity is sufficient to give the required current during the whole standby period

— the voltage during this period should not fall below the lowest value specified for the telecommunication equipment.

With regard to reliability and maintenance aspects the lowest voltage value specified for telecommunication equipment is normally 47 V at the rack fuses (U_T). In the cell switch system this corresponds to a minimum battery voltage of 49 V. Hence with 25 cells (1.96 V/cell) only a part of the capacity of a battery can be utilized, as may be seen from fig. 7.

In the converter system the battery voltage is allowed to go down to 40 V (1.74 V/cell with 23 cells) because the converters can supply an additional voltage of up to 9 V. This makes it possible to utilize the full capacity of the battery.

The size of battery needed, taking into consideration standby time and the lowest permissible exchange voltage, is shown in fig. 8. The diagram indicates that the battery capacity required is very much less with the converter system.

EXCHANGE VOLTAGE AND POWER CONSUMPTION

With normal operation the battery voltage is kept at 51 V, so that the exchange voltage on full load is approximately 49.5 V in the cell switch system and approximately 48 V in the converter system. The voltage is lower in the converter system because the inactive converters introduce an extra voltage drop. Hence in this system the exchange voltage is held around the nominal value, which apart from other advantages reduces the power consumption by 2 %.[3]

FLEXIBILITY

In a cell switch system the distribution voltage can only be affected by the rectifier voltage regulation. However, this does not function when there is a mains failure. In the converter system there is also converter voltage regulation, and this is available all the time.

As a result of this difference the converter system has a very much greater flexibility and capability of satisfying varying operational demands, as is illustrated in the following example.

Constant distribution voltage

If constant distribution voltage is required in all operational modes the cell switch system cannot be used.

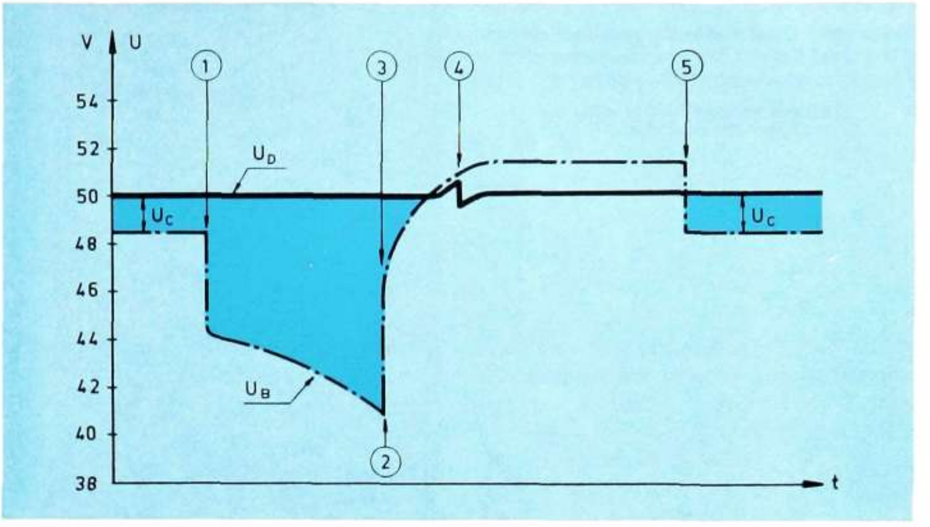
The converter system maintains the voltage constant except in the case of automatic battery charging, when the voltage is increased by 3 V. The system

Fig. 9

Converter system 48 V with constant distribution voltage, 22 battery cells

Sequence for the distribution and battery voltages during the time of a mains failure and the recharging of the battery

U_D	Distribution voltage (with heavy load)	———
U_B	Battery voltage	—·—
U_C	Converter output voltage	
1	Mains failure (lengthy)	
2	Battery discharged	
3	Mains voltage recovers and recharging of the battery starts automatically	
4	The converters stop	
5	Charging ceases and the converters start	



always gives a constant output voltage. In order to do this the number of battery cells is reduced and the converters are made to operate continuously in order to provide the necessary additional voltage. If, for example, 22 cells are used with a battery voltage of 48.4 V (2.2 V/cell), the converters raise the distribution voltage to 50 V. For automatic charging the battery voltage is increased to 51.5 V (2.34 V/cell). The converters then go to the idle condition and hence the distribution voltage falls to approximately 50 V, see fig. 9.

Sectionalized plants

With large installations it is often desirable to be able to divide up the power plant into two or more independent units, what is known as sectionalizing, which has the following advantages.

a) Any operational disturbances will have a limited effect, which is particularly important in electronic exchanges (see also the separate chapter dealing with this).

b) If the different sections of the power plant are mounted near the equipment they supply, the distribution cables can be shorter, and hence smaller diameter conductors can be used.

c) The power plant busbars will have a smaller cross-sectional area.

d) When extending, other available space than the original power room may be utilized.

In a telecommunication plant the voltage must be practically the same everywhere. When sectionalizing is

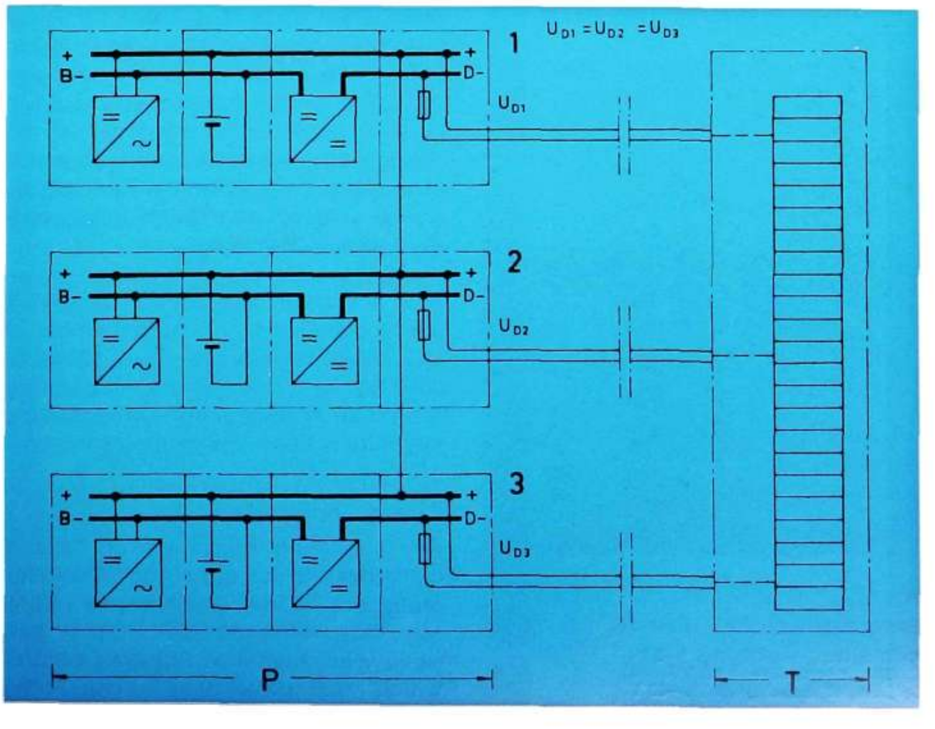


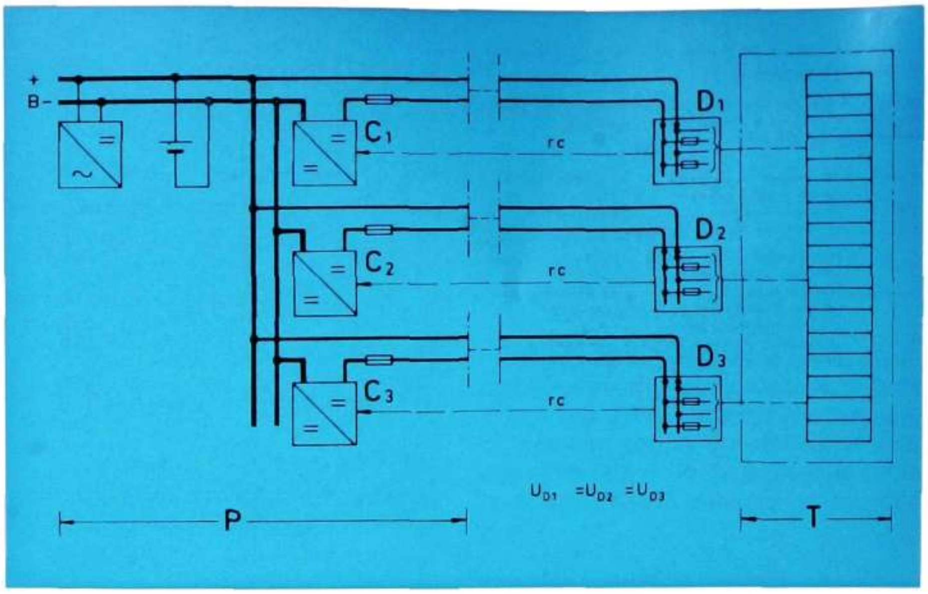
Fig. 10

Sectionalized power plant (P) according to the converter system for the power supply of a large telecommunication plant (T)

Fig. 11

Power plant according to the converter system with a great distance between the power plant (P) and the telecommunication plant (T)

rc Remote sensing for regulating the voltage of the converters



used this requirement can be met by a converter system, fig. 10, but not by a cell switch system. If the mains fails, the battery voltage in the different sections will vary depending on the load. In the converter system the distribution voltage is nevertheless kept to the same value in the different sections through the voltage regulation of the converters. The advantages of sectionalizing can thus only be attained with a converter system.

Remote regulation of the distribution voltage

Only a small voltage drop is allowed in the distribution network. Thus if there is a great distance between the power and telecommunication plants the cross-sectional areas of the cables will be unreasonably large. In a converter system this can be avoided by placing the distribution racks near the telecommunication plant. The converters then operate continuously and regulate the voltage in the distribution racks with the aid of remote sensing, see fig. 11. It is then unnecessary to consider the voltage drop when calculating the size of the long cables from the power room to the telecommunication plant, only the thermal conditions.

With a current consumption of 1000 A and a distance of 100 m the weight of the cable is reduced from 10000 to 3000 kg. As a rule this means a saving even if an increased converter standby capacity is needed in some cases.

Converters for telex

An interesting utilization of booster converters is for supplying power for telex, see fig. 12. Apart from — 48 V, telegraph voltages of + 60 V and — 60 V are then also required, both of which must have the same value. The + 60 V voltage is generated in its entirety by a direct converter and — 60 V by a booster converter, which adds the required voltage to —48 V. The booster converter is thus three times smaller than the direct converter for the same output power. The whole of the power supply requires only one battery (48 V). A conventional solution with three batteries will not satisfy the requirement of voltage equality between + 60 V and — 60 V when there is a mains failure.

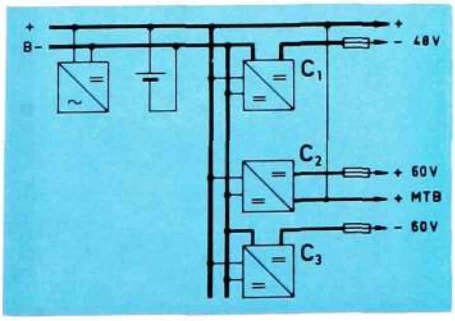


Fig. 12

Power supply system BZT for telex

C_1 Booster converter 48 V/0—9 V
C_2 Direct converter 48 V/60 V
C_3 Booster converter 48 V/0—20 V

ECONOMY

Acquisition costs

Compared with the cell switch system, the converter system has the additional cost of booster converters. On the other hand the cell switch system requires, apart from the cell switch, larger batteries with charging equipment, switches in the battery circuits, more expensive rectifiers and larger cables.

For a medium sized plant, 2400 A 48 V, the costs for a cell switch system will be 27 % higher than for a corresponding converter system, see table 1.

The acquisition costs with different voltage values U_T and different standby times are shown in fig. 13. As can be seen from table 1 and fig. 13 the battery costs are decisive when comparing the two systems. For the purpose of the calculations a sealed type of battery with tubular positive plates has been chosen, which has a low price on the international market.

Moreover, for large plants intended to be extended in stages, the cell switch system demands a larger initial investment, because from the outset the cell switch must be dimensioned for the

Equipment included	Acquisition costs %	
	Converter system BZD	Cell switch system BZC
Rectifiers BMT 183	37.4 %	41.3 %
Converters BMR 207	26.8 %	—
Cell switch with accessories	—	9.9 %
Distribution and battery rack	4.5 %	3.7 %
Battery cable	4.9 %	7.3 %
Batteries	26.4 %	64.8 %
Total	100.0 %	127.0 %

Table 1

Acquisition costs for a power supply plant, 2400 A 48 V, with battery standby of 1 h. Lowest permissible exchange voltage 47 V

The total acquisition costs for the converter system are set to 100 %

Annual costs	Converter system BZD	Cell switch system BZC
Energy	8.0 %	8.2 %
Depreciation	1.9 %	4.4 %
Interest on acquisition capital	5.0 %	6.4 %
Total	14.9 %	19.0 %

Table 2

Annual costs for a plant, 2400 A 48 V, in accordance with table 1

Relative values. The acquisition costs for the converter system are set to 100 %

Assumptions:

Energy costs: mean power: 1/3 max. power efficiency 88 %

Depreciation: life: batteries 15 years other equipment 40 years

Interest: 10 %; average interest during the whole depreciation time 5 %

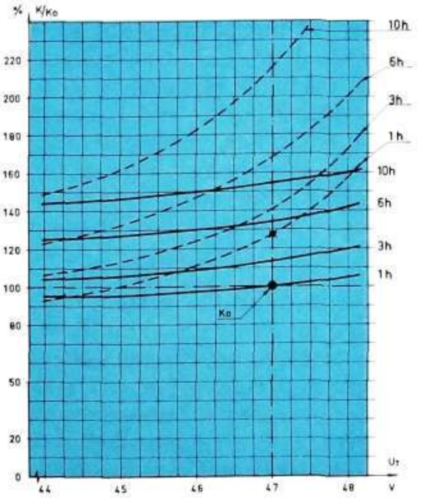


Fig. 13

Acquisition costs for power supply system with different standby times and different values *for the lowest permissible exchange voltage U_T*

K_0 Acquisition costs for converter system BZD with $U_T = 47$ V and standby time 1 h has been taken as 100 %

In an equivalent cell switch system BZC the acquisition cost will be 27 % higher $K/K_0 = 127$ %)

——— Converter system BZD
— — Cell switch system BZC

Annual costs

Annual costs (operating and capital costs) for the same plant as in table 1 are given in table 2. With the assumptions used in table 2 the annual costs for a cell switch system are about 27 % higher than for a converter system. The lower maintenance costs of the converter system have not been taken into consideration when making the calculations.

RELIABILITY

In order to be able to compare the reliability of the two systems a calculation method for maintained systems has been used which is based on an engineering approach to probabilistic reliability[6]. A medium sized plant for 2400 A 48 V has been considered. The converter system has five rectifiers and five booster converters, one of each of which serves as standby. The cell switch system has five rectifiers and one cell switch.

The structure of the converter system permits redundance, i.e. standby for each functional unit, which in itself gives a considerably higher reliability than in the case of the cell switch system, since the latter system cannot be duplicated. Furthermore, in large plants the converter system can be sectionalized but not the cell switch system. Sectionalizing limits the effect of unit faults and reduces the probability of system failure.

The calculations, which for reasons of space are not included here, have resulted in a mean time between system failures of 2220 years for the converter system and 109 years for the cell switch system.

The probability of system failure during 40 years of operation is thus 0.002 for the converter system and 0.30 for the cell switch system.

EXTENSION POSSIBILITIES

Due to the converter system principle with parallel connection of new units, the system may be successively extended until the desired final capacity is attained. The different units may be connected in arbitrary order and hence the distribution current can be divided up in a suitable way. When the load capability of the busbars has been fully utilized a new section may be added, which, as has been pointed out earlier, has several advantages.

As the cell switch cannot be connected in parallel, the final capacity of the cell switch system is limited by the load capability of the cell switch. Moreover the concentration of the distribution current through one single point, the cell switch, makes it difficult to design the distribution outputs in a rational way. Any increase in sections, each with its own cell switch, would lead to a plant with unacceptable voltage differences.

OPERATION AND MAINTENANCE

The operation of a converter system is fully automatic, whereas a cell switch system often requires manual intervention during recharging of the batteries after a mains failure.

A converter system is built up of electronic components, so that maintenance work is reduced to a minimum. Maintenance is limited to periodic checks of the batteries, normally once every quarter, and units, once a year, and any necessary repairs.

The repair frequency has been calculated on the basis of the fault rates. For a medium sized plant, 2400 A 48 V, the expected fault rate was calculated to be about 0.7 faults per year. Operational statistics for seven years show a fault rate of about 0.5 faults per year and plant, which agrees quite well with the calculation. Hence converter systems may be used to advantage in unmanned stations, which is substantiated by, for example, a large number of unmanned radio link stations, all of which show positive operational results.

Converter systems in electronic telephone exchanges

Electronic telephone exchanges make more stringent demands on power plant than electromechanical exchanges. The converter system is particularly suitable for electronic exchanges and satisfies the new demands without difficulty. Since this subject has been dealt with earlier[5] only the most important characteristics will be discussed here.

Electronic equipment is usually supplied with power from a number of small d.c. converters placed in the telecommunication equipment, which convert — 48 V to the required electronic voltages (5 V, 8 V, 12 V etc.). Owing to the fact that the exchange voltage — 48 V is kept within such close limits these converters can be made small and hence economic.

The sectionalizing principle offers increased reliability. For example, the synchronized duplicated processors and switching equipment in AKE 13 are provided with power from three separate 48 V sections, with a common standby. Consequently a fault in the power plant does not affect both processors within the synchronized duplicated pair. Hence in such cases operation can continue without interruption.

When feeding fast electronic circuits there must be no stepwise voltage changes. This has been eliminated in the converter system, but occurs in the cell switch system when the cell switch operates.

Reference plants

Some of the more interesting of the roughly 1500 converter plants delivered hitherto are mentioned below.

110 plants for unmanned radio link stations in Mexico, 100 A 48 V, taken into service in 1965.

A 10000 A 48 V plant for the local, national and international exchange Victoria in Mexico City, taken into service in 1968.

16 sectionalized plants for AKE 13 in Denmark, Finland, Mexico, Norway and Sweden, 2000—8000 A, 48 V. Some in service and others being delivered.

Constant voltage plant with permanently operating converters, 6000 A 48 V, Cidade Interurbano in São Paulo, taken into service in 1974.

Telex plant ± 60 V, 400 A, Cidade Interurbano in São Paulo, taken into service in 1974.

Sectionalized plant (seven sections) 25000 A, 48 V equipped with a central master voltage control, for a national and international transit exchange in Barcelona. Delivery in progress.

Conclusion

For ten years LM Ericsson's booster converter system has been used successfully for the power supply of telecommunication plants, which make stringent and varying demands on the power plants.

Through the structural design of the system and the possibility of sectionalizing to suit any particular application, a high reliability is obtained and also the possibility of unlimited extension. Operation is fully automatic and unmanned plants have worked for ten years with good results. The system is economic both as regards the acquisition and operational costs.

The flexibility of the system makes it possible to satisfy the various requirements of telecommunication plants, for example high voltage stability, and also to meet the special demands made by electronic telecommunication systems. The indications are that the converter system will also be able to meet the requirements of future telecommunication systems.

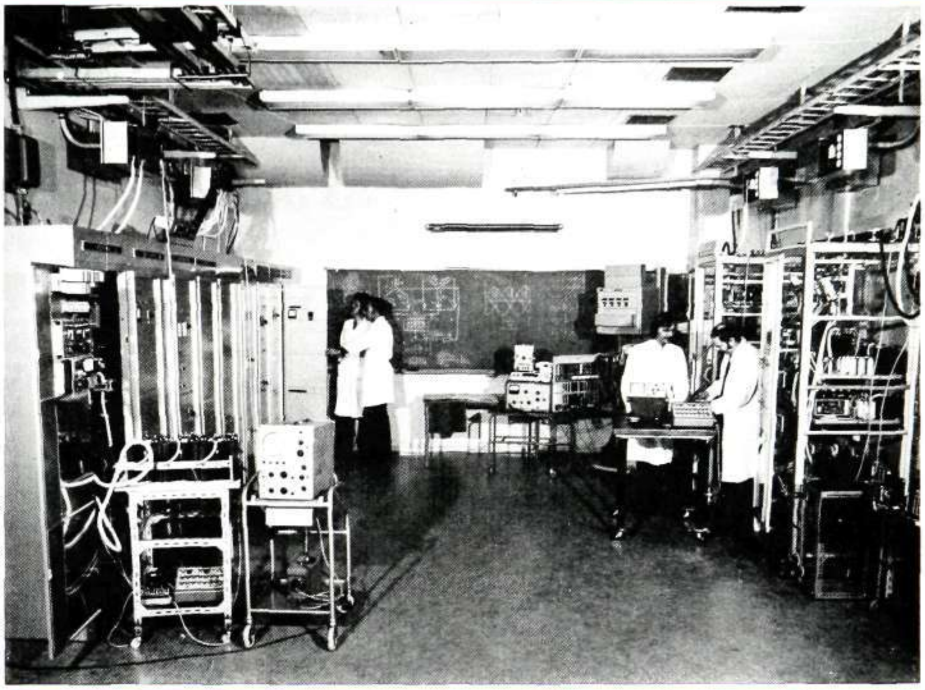


Fig. 14
Power supply laboratory. Test room for large power supply systems

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Telecommunication Equipment for Power Station Operation

Christian Semb Magnus and Terje Olsen

Carrier technology has already been utilized for more than 55 years for transmitting information with power lines as the transmission medium. In Scandinavia LM Ericsson and A/S Elektrisk Bureau have supplied their own types of carrier equipment for power lines (CPL) since the end of the 1930s. In 1968 the entire responsibility for CPL equipment within the Ericsson Group was transferred to A/S Elektrisk Bureau, who since then have developed a completely new CPL system based on the Group's M4 construction practice. This construction practice is also used for all other transmission equipment produced by the Group. In addition a number of other new equipments have been developed for use in connection with the transmission of information for power stations. The article first describes the technical design of the CPL equipment ZAP 01—2, and then the principle of connecting to the power line using the Line equipment ZGBR 00101. This is followed by a description of the AF terminal equipment ZAT 11 SF. This equipment provides the possibility of utilizing the same division of the AF (audio frequency) band as is used with CPL, for other types of communication.

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Carrier equipment ZAP 01-2 for high voltage lines

Experience from several countries shows that high quality CPL equipment can be used to provide very good circuits for telephony, remote control and also data transmission. ZAP 01-2 is designed in accordance with the technical requirements for such high quality circuits. These are to some extent more stringent than the recommendations of IEC (International Electrotechnical Commission) for equipment in the CPL range.

When developing ZAP 01-2 particular attention has been paid to the following three operational characteristics:

1. Low inherent noise level in the speech channel ($<$ 65 dBm0p)

2. Possibility of effective and flexible utilization of the baseband

3. Low level of spurious emissions.

Reduction of spurious emissions, which in the main consist of intermodulation products, is extremely important. These products fall in the frequency bands adjacent to the band used for transmission, and if they are large they can give rise to noise in these adjacent bands. Elimination of this noise permits a much freer use of the different frequency bands within the available frequency range of 24—488 kHz.

The various manufacturers of CPL equipment utilize different bandwidths in their equipment, for example 2.5, 3.0, 4.0, 5.0 kHz or multiples of these. It is, however, obvious that most systems use a 4 kHz spacing. Within the Ericsson Group the 4 kHz spacing has always been used in CPL equipment in the same way as for normal multichannel carrier equipment, where this is the CCITT standard. This means that CPL equipment is particularly suitable for the transmission of signals from modern data modems, as these are developed for use with telephone channels in the general switched telephone network.

AUDIO-FREQUENCY SIDE

There are two types of signals that one normally wishes to transmit in connection with power plant operation, namely analog and digital.

Nowadays more and more information is transmitted in the form of digital signals. This applies for:

measurements
messages
orders
control signals

For most forms of communication the information speed requirements for these signals are satisfied by the use of voice-frequency telegraph channels for 50, 100, 200 (or 600) bauds in addition to the speech channel.

During recent years, however, the need for higher information speeds has become very evident. By utilizing the frequency band normally occupied by a speech channel, standard data modems with transmission rates of 1200 and 2400 bits/s or even higher may be used to satisfy this need.

Normally it is only speech that is transmitted in the form of analog signals. It is desirable that speech should also be transmitted digitally, but with the bandwidth available this is not practically or economically possible at

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Available baseband and utilization

A frequency band with a bandwidth of 4 kHz (baseband) is to be transmitted in each direction.

A normal frequency division is shown in fig. 1, but other divisions are also used. The frequency band 300—2400 Hz is used for the speech channel. This is connected to external equipment, for example an automatic exchange, on a 2-wire or 4-wire basis.

In the band above 2400 Hz there is space for eleven 50-baud voice-frequency telegraph channels or a corresponding number of 100-baud or 200-baud channels. The voice-frequency telegraph channels are in accordance with CCITT recommendations, but they also have frequency variants outside the frequency range recommended by CCITT. Alternatively one 600-baud plus three 50-baud voice-frequency telegraph channels may be transmitted if the frequency band for the speech channel is reduced to 2200 Hz.

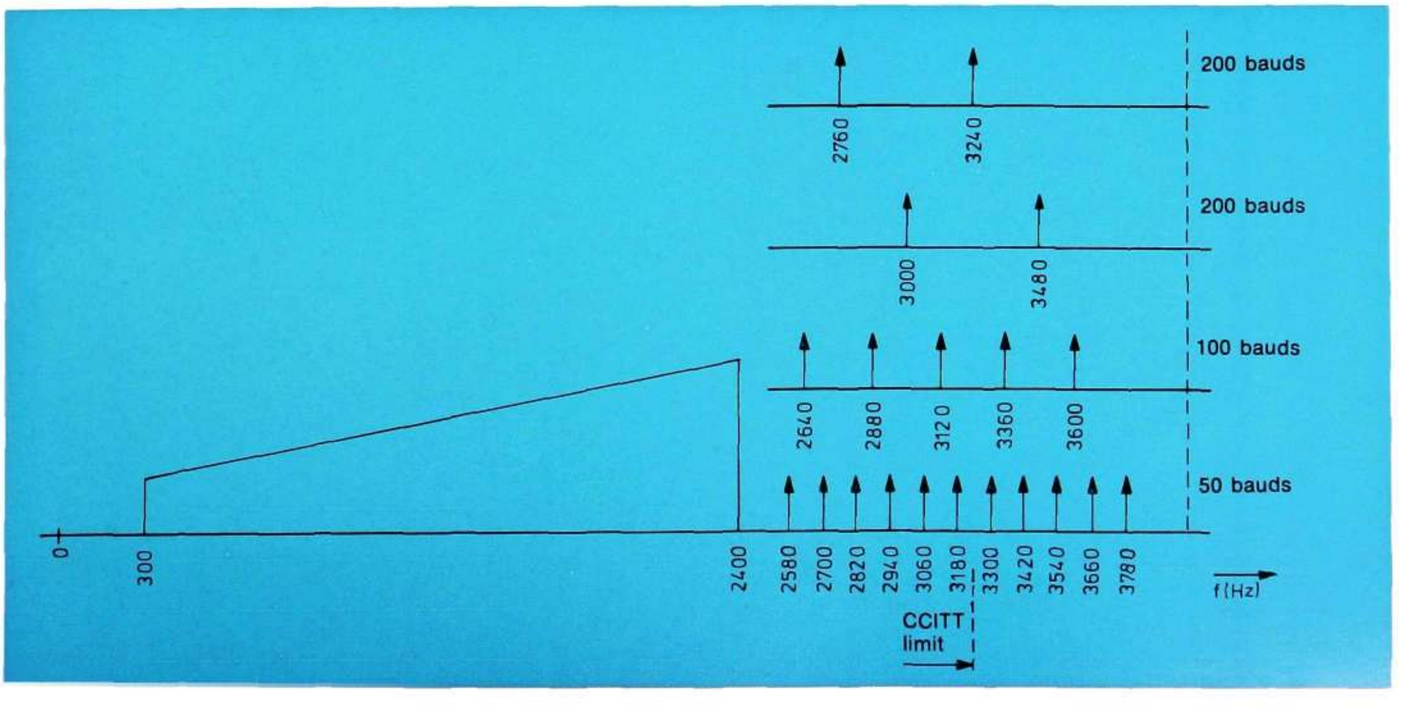
The voice-frequency telegraph channels are used for various services: transmission of control signals, transmission of simple measured values, transmission of signals from cyclic systems for data collection, transmission of relay protection signals (for protection of the high voltage power line), and the signalling for the speech channel.

When a data modem for 1200 bits/s (ZAT 1200) or 2400 bits/s (ZAT 2400) is used, the speech channel filter with a cut-off frequency of 2400 Hz is replaced by a filter with a cut-off frequency of 2700 Hz. This latter filter is specially designed for data transmission and has, for example, a small amount of group delay distortion in relation to the speech filter. The circuit is normally used for the transmission of either speech *or* data. Hence the filter with a cut-off frequency of 2700 Hz is not designed in accordance with CCITT recommendation H34 as it is used only for data transmission. In such cases a maximum of eight 50-baud (or equivalent) voice-frequency telegraph channels can be accommodated.

Basic design of the AF equipment

The AF part of CPL equipment ZAP 01-2 is shown in the block diagram of fig. 2. Basically it is a 4-wire equipment in which the send side is connected

Fig. 1
Utilization of the baseband 0—4000 Hz.
The speech band is allocated 300—2400 Hz.
Alternative possibilities for 50, 100 and 200-baud voice-frequency telegraph channels are shown.
The arrows show the mid-frequencies



to one pair and the receive side to the other.

On the send side the level of the speech signals is adjusted with a strappable attenuator. The signals are then limited in the following limiter amplifier L. Limiting takes place at approximately + 2.0 dBm0.

The speech frequency band is then limited in the speech channel filter to 300—2400 Hz, and in the equalizer E that follows the frequency response can be adjusted to compensate for the attenuation-frequency characteristic of the power line over the frequency band.

The speech signals and the signals from all the voice-frequency telegraph transmitters T are then combined in the combining amplifier C before being sent in to the translating equipment for modulating up to the wanted frequency band.

On the receive side the AF signals from the translating equipment are distributed to the respective voice-frequency telegraph receivers R via a branching amplifier B. The voice-frequency telegraph signals go direct to the receivers, but the speech signals go to the local side via an equalizer E, a speech filter F and an AF amplifier A.

Speech channel

On the local side the speech channel can be adapted for 4-wire or 2-wire exchanges by suitable selection of terminating units. For older exchanges 4-wire through connection is used, but the exchange's local subscribers are connected on a 2-wire basis, the changeover from 2-wire to 4-wire connection taking place in the terminating unit instead of in the exchange as in the case of modern exchanges.

The input and output levels can be adjusted within wide limits with attenuators provided in the terminating unit. A normal 50-baud voice-frequency telegraph channel is used for signalling. A telephone unit can be fitted in the terminal (not shown in fig. 2), so that a speaker circuit can be set up between the terminals.

If data signals are transmitted instead of speech, the data modem is connected to the same terminating points as the speech (usually 4-wire).

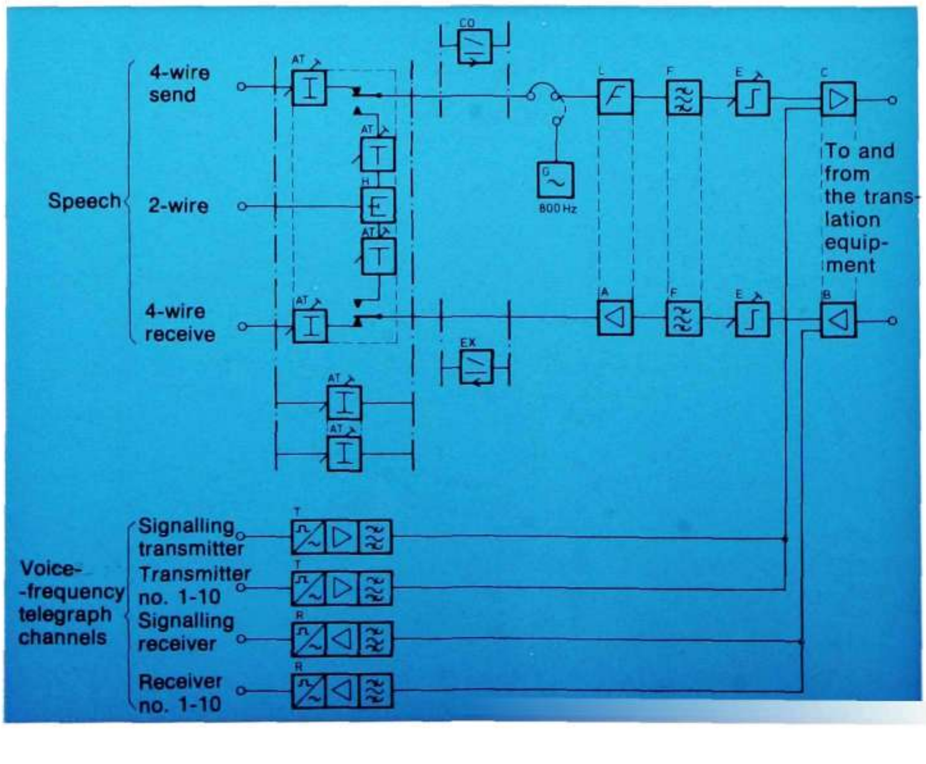


Fig. 2

Block diagram for the AF part of the CPL system ZAP 01-2

A	Amplifier
AT	Attenuator
B	Branching amplifier
C	Combining amplifier
CO	Compressor
E	Attenuation equalizer
EX	Expander
F	Filter
G	Generator
H	Hybrid
L	Limiter
R	Voice-frequency telegraph receiver
T	Voice-frequency telegraph transmitter

Voice-frequency telegraph channels

The voice-frequency telegraph channels are normal frequency shift channels designed in accordance with CCITT recommendations. The telegraph transmitters can be keyed with single current or double current or with voltage-free relay contacts. The signals from the voice-frequency telegraph receiver are taken out in the form of single current or double current signals via an electronic relay connection. For 50-baud channels an electromechanical output may also be used.

The input stage of each telegraph transmitter and the output stage of each receiver are insulated from the remainder of the system so that independent external voltages may be applied at these stages. A d.c. converter giving + 15 V and — 15 V can if necessary be connected in to provide the operating voltage for the electronic relays. These voltages are completely isolated from the remainder of the voltages in the system.

Each voice-frequency telegraph receiver has alarm circuits which provide an alarm when the received level falls below a certain limit.

TRANSLATING SIDE

The modulation plan used in the CPL system is shown in fig. 3. The AF band 0—4 kHz is used to modulate a 20 kHz carrier. Only the upper sideband 20—24 kHz is used, and this is filtered out with very steep flanks. After filtering the resultant band is translated to its final position in the frequency range 24—488 kHz with the aid of a suitable translating frequency f_t. The corresponding demodulation takes place on the receive side.

The frequency band that can be utilized for transmission over power lines is limited by the following considerations:

At low frequencies the limit is set by the interference from the coupling capacitors used. The practical limit lies in the region of 20—40 kHz. The upper frequency limit is determined by the line attenuation, which increases steeply with frequency. The practical limit lies between 450 and 500 kHz.

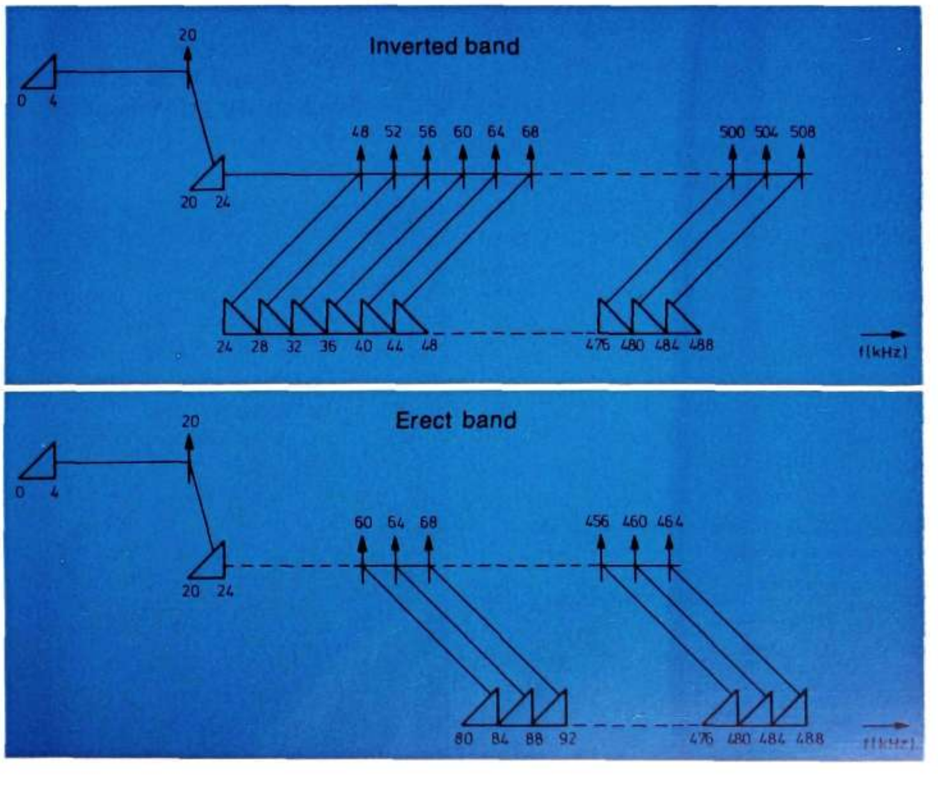


Fig. 3
Modulation plan

Basic design of the translating equipment

The translation equipment is shown in the block diagram of fig. 4.

In the transmit direction modulator M1 translates the incoming AF band to the intermediate frequency (IF) band 20—24 kHz. The carrier frequency 20 kHz is suppressed partly in M1 and partly in the IF filter F2. If 20 kHz is used as the pilot tone it is inserted via the IF filter F3.

The IF band is translated up in modulator M2 to the final frequency band with the aid of carrier f_t. There are four main versions of the following filter F4, and these can easily be adjusted with the aid of sets of capacitors to give the 116 filter versions. Filter F4 suppresses the unwanted sideband and the carrier. The output band is then amplified in preamplifier PRA and a power amplifier PA before being taken via a send filter F5, a line hybrid H and a cable to the line equipment for connecting to the high voltage power line. There are three main versions of the send filter and the line hybrid which can be adjusted with sets of capacitors to give 116 versions to cover the frequency range 24—488 kHz.

The line hybrid, which connects together the send and receive sides towards the line, is unsymmetrical in order to give as little attenuation as possible on the send side ($\approx$ 0.5 dB).

The receive frequency band, which can be the adjacent band to the send frequency band, is taken from the power line via the line equipment, cable, line hybrid H and an attenuator AT to filter F6 on the receive side.

Demodulator D1 translates the receive frequency band to the IF band 20—24 kHz. All frequencies outside this band are suppressed in the filters F7 and F8, and the level regulator LR between the two filters holds the output level almost constant for all input levels within a certain level range.

Demodulator D2 translates the IF band to the original AF band 0—4 kHz. The demodulator is followed by a filter F9 which attenuates unwanted frequencies above 4 kHz.

The three modulation frequencies are provided by a frequency synthesizer S. With the aid of an associated crystal oscillator in the 5 MHz range all the wanted frequencies are generated through division and control from the master oscillator. The intermediate frequency 20 kHz is fixed but the optional frequencies, f_t and f_r, are obtained by strapping. The crystal oscillator is temperature compensated and does not require a crystal oven. The frequency

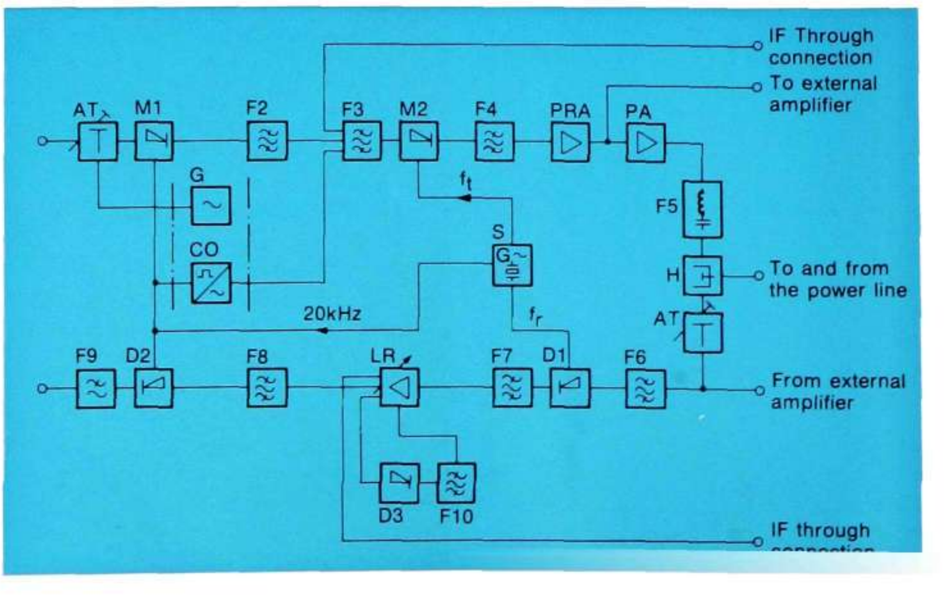


Fig. 4

Block diagram of the translating equipment in the CPL system ZAP 01-2

AT	Attenuator
CO	Converter square-wave/sinusoidal signal
D	Demodulator
F	Filter
G	Oscillator
H	Hybrid
LR	Level regulator
M	Modulator
PA	Power amplifier
PRA	Preamplifier
S	Frequency synthesizer

stability of the generated frequencies over the temperature range is better than $\pm\ 2.5 \cdot 10^{-6}$.

Important parameters for the CPL equipment

Level regulation

Pilot-controlled level regulation is used to hold variations of the received audio-frequency to within $\pm$ 0.5 dB for variations of the incoming level of 30 dB, and within a limit of — 2.5 dB for a further reduction of the incoming level by 10 dB.

Any one of three pilot frequencies may be selected:

1. 2.58 kHz, which takes up the band for a 50-baud voice-frequency telegraph channel in the centre of the base band. This frequency cannot be used with data transmission.
2. 3.78 kHz, which takes up the band for a 50-baud voice-frequency telegraph channel at the top end of the baseband.
3. 20 kHz translating frequency, which is transmitted at a reduced level. This is the carrier frequency for modulator M1 and thus corresponds to 0 Hz in the baseband.

With alternative 3 no part of the baseband is used for the pilot.

Output power

The output signal from the system is amplified in a preamplifier and a power amplifier with an optional output power of 7.5 W, 40 W or 120 W P.E.P. (Peak Envelope Power). With particularly long power lines or with lines having a very high noise level the CPL equipment can be used together with a separate amplifier rack giving almost 500 W P.E.P. The power amplifier operates in class A when moderate signal input levels are applied and goes gradually over to class B at higher levels. This has the advantage that the intermodulation products from signal components in the equipment's own transmission band are suppressed, at nominal level settings, by about 20 dB more than if the power amplifier operated continuously in class B for all applied signal levels.

Intermodulation requirements

The level difference between the send and receive bands can be as much as 30—40 dB, even 50 dB if the line attenuation is high. This makes great demands on the attenuation of the intermodulation products and distortion on the send side, particularly in the power amplifier. With normal operation of the CPL equipment, unwanted frequency components (spurious emissions) will be attenuated with relation to the P.E.P. level (max. operating level for the amplifier) by more than 85 dB.

Stringent demands are also placed on the intermodulation attenuation in the receiver input stage. This applies particularly in the case of demodulator D1 in fig. 4, which must be able to operate satisfactorily when the level of the receive frequency band is low, at the same time that the equipment transmission band is only attenuated by the balance of the hybrid towards the line. In extreme cases there is a risk that the level of the transmit band into demodulator D1 will be 10—20 dB higher than the level of the receive frequency band.

Relay protection

In the arrangement with protection of the power line the CPL equipment can be equipped with two relay protection channels. A relay protection channel consists of a voice-frequency telegraph channel together with a control unit. The speed of the telegraph channel can be 50, 100 or 200 bauds, but in view of the transit time requirements (15—30 ms) it is usual to use 100-baud or 200-baud channels. The control unit operates as an intermediate connection between the external relay protection equipment and the voice-frequency telegraph channel, and at the same time provides the possibility of testing the functions of the relay protection channel.

SPECIAL USES

Through-connection at IF

In some cases the distance to be covered by a CPL circuit is so great that it must be divided up into two circuits

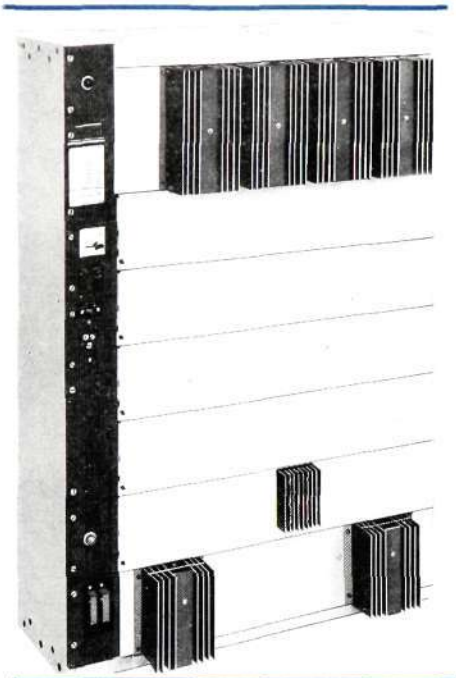


Fig. 6
CPL terminal

connected in series. This is usually because the attenuation of the high voltage line is so great that the signal/noise ratio will be poor if a direct circuit is used.

If there is no interest in taking out signals at the intermediate station, the whole of the AF part can be looped in each of the two equipments at the intermediate station. Likewise the first modulator and the second demodulator, M1 and D2 in fig. 4, can be looped and through connection can take place in the frequency band 20—24 kHz.

Separated AF and translating equipments

The place at which information is transmitted and received, for example the control room in a power station, is often at some distance from the place where the power line terminates. In such cases the translating equipment can be installed at the power line. The relay protection channels that are included in the protection unit for the power line will also be terminated there. The AF equipment (speech channel, voice-frequency telegraph channels) are installed at the place where the information is transmitted and received. The AF and translating equipments are then connected via two cable pairs. The AF equipment may be mounted in a CPL rack or the AF terminal equipment ZAT 11 SF may be used.

The practical arrangement with such a division is shown in fig. 5. The relay protection shelf is prepared for this arrangement. It has been assumed in the figure that the ordinary voice-frequency telegraph channels can also be terminated in the CPL shelf if desired.

Parallel connection

In many cases two or more CPL equipments transmit over the same power line. In order to be able to use the same line equipment in such cases, the different terminal equipments must be connected in parallel.

The send filter, which is fitted in the line hybrid, is a simple filter with little attenuation outside the passband to which it is tuned. Hence the impedance outside the passband increases slowly. It is therefore specified that there must normally be 16 kHz between the mid-frequencies of the transmitted bands in order that the individual equipments shall not attenuate each other by more than 1 dB. The mid-frequencies can be placed closer together but this will result in an additional attenuation of between 1 and 3 dB.

Extra line hybrids must be used if the transmit bands are to be close to each other. These must be symmetrical and thus will attenuate the band 3.0—3.5 dB. Adjacent bands are rarely connected in parallel because the additional attenuation is so large.

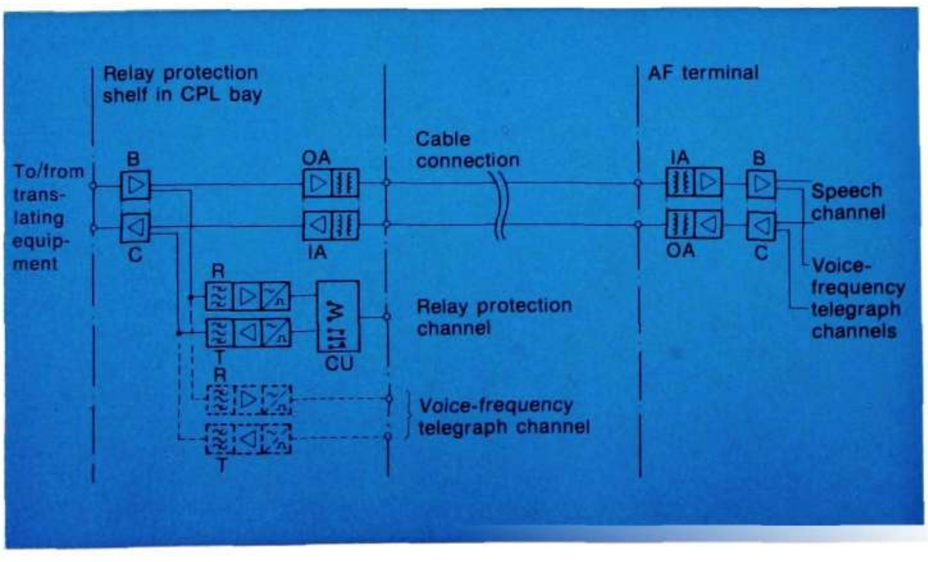


Fig. 5
System solution with the AF equipment and translating equipment at different localities

B Branching amplifier
C Combining amplifier
CU Control unit
IA Input amplifier
OA Output amplifier
R Voice-frequency telegraph receiver
T Voice-frequency telegraph transmitter

POWER SUPPLIES

Various types of voltage sources may be used for providing the equipment with power.

The equipment can be fed either from 110 V, 127 V or 220 V a.c. or from a 24 V or 48 V d.c. source. However, when 120 W power amplifiers are used, only a.c. and 48 V d.c. may be used.

The voltage used in the rack is normally 24 V but the power amplifiers are driven either from 24 V, 48 V or 100 V, depending on the power they provide.

MECHANICAL DESIGN

ZAP 01-2 is built in accordance with the M4 construction practice. A fixed bay with a height of 23 modules is used. The bay is equipped with the necessary shelves for each individual system solution. A photograph of the bay is shown in fig. 6. Its height with feet is 1057 mm and without feet 1022 mm.

The power amplifier is fitted at the top of the bay. The bay in fig. 6 is equipped with a 40 W amplifier.

The units in the translating equipment are mounted in the shelf directly under the power amplifier, while the AF units are placed in the second shelf under the amplifier. The third shelf is the voice-frequency telegraph channel shelf which is used when there are a large number of telegraph channels. The fourth shelf contains the relay protection channels with the control unit and signal blocking. All the d.c. converters are mounted in the fifth shelf. The rectifiers required when the bay gets its power from an a.c. source are mounted at the bottom of the bay as can be seen from fig. 6. The mains switch with the mains lamp above it can be seen at the bottom left-hand side of the bay. The alarm lamp for the main alarm is mounted at the top and under this there is a data label. In the middle of the left-hand side of the bay can be seen a measuring instrument with a switch for checking the output level, the pilot input level, the 24 V supply voltage and the supply voltage for the power amplifier.

The bay cabling between the shelves is laid in the right-hand side of the bay seen from the front, while the cables into the bay are taken in on the left-hand side behind the mains switch.

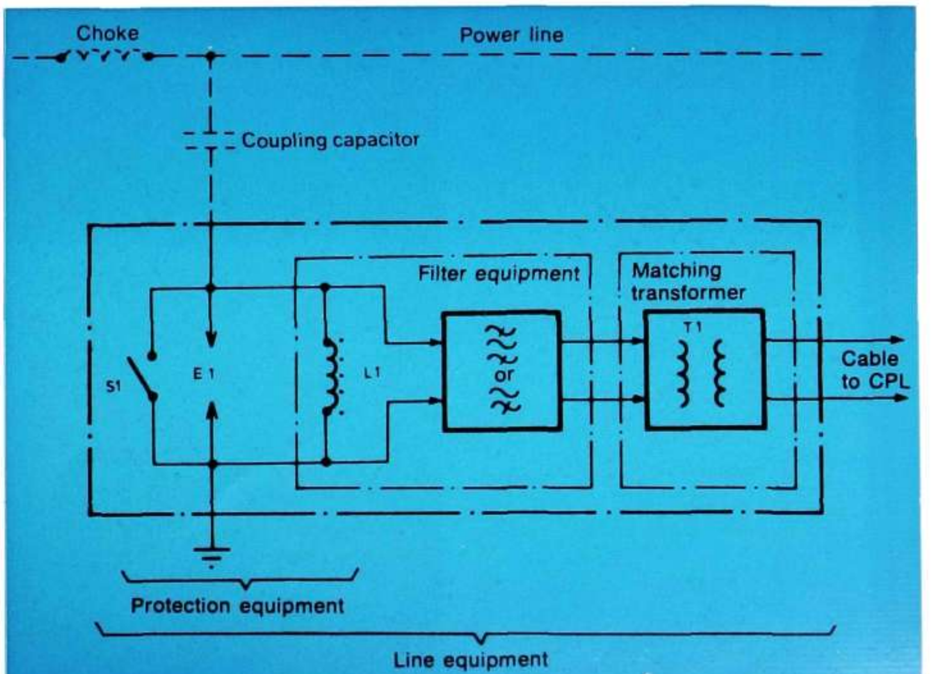


Fig. 7
[illegible] connection to the power line

The large cooling flanges ensure a very moderate temperature even in the 120 W amplifier, the converters and the rectifiers.

CONNECTION OF THE CPL EQUIPMENT TO THE POWER LINE

In order to be able to connect a CPL equipment to a power line and to ensure that a clearly defined transmission path is achieved, an arrangement is used consisting of chokes, coupling capacitors and line equipment.

The connection can be made to one phase or between phases. Fig. 7 shows a one-phase connection and also how the line equipment is built up, while fig. 8 shows the principle for a connection between phases. In the latter case a combining transformer is also included in one of the line equipments.

The chokes and coupling capacitors must of course be power engineering equipment as they are subjected to the voltage and current on the power line.

The line equipment is a transmission engineering equipment. A new unit has been developed that covers almost all the connection alternatives used. It has been given the designation ZBGR 00101.

Line equipment ZGBR 00101

The line equipment contains a protection part, a filter part and a matching transformer.

Protection equipment

The function of the protection equipment is to prevent voltage transients from the power line, caused by switching in and out in the power plant, atmospheric discharges or line failures, from getting through to the CPL equipment and causing injury to the staff or damage to the equipment.

With normal operation there is a fixed connection through the line equipment via coil L1, see fig. 7. Voltage transients above 1000 V will discharge through spark gap E1. When working on the line equipment the coupling capacitor is connected to earth with the knife-blade earthing switch S1.

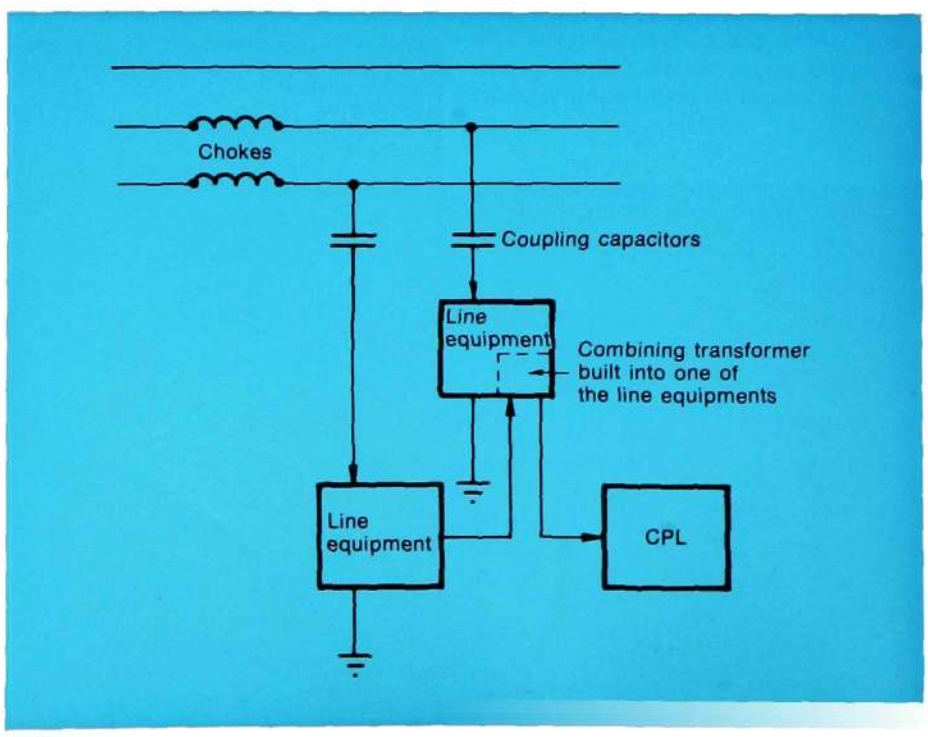


Fig. 8
Connection to the power line between phases

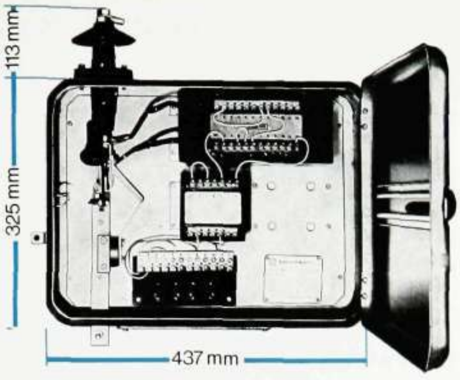


Fig. 12
Line equipment ZGBR 00101 with the door open

Matching transformer

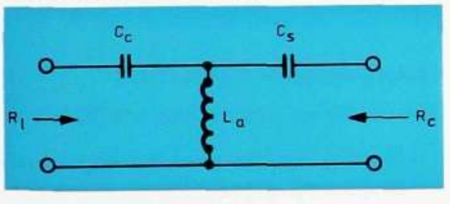
The matching transformer can match the line equipment to cable impedances of 50, 75, 125 and 140 ohms, and to line impedances of 230, 300, 390 and 510 ohms. The transformer also provides protection for the CPL equipment against overvoltages from the power line. The breakdown voltage between the primary and secondary sides is greater than 10 kV.

Filter equipment

The filter part of the line equipment, together with the connected equipment (high-voltage line, coupling capacitor and cable to the CPL equipment) can provide a pass band for the frequencies that are to be transmitted over the line. Three different filter configurations are used for this purpose.

The simplest filter configuration is a high-pass filter as shown in fig. 9, where C_c is the capacity of the coupling capacitor in the power plant. This capacity value will vary from one power plant to another. The line impedance R_l depends on the design of the high voltage line and R_c is the value of the cable impedance transformed in the matching transformer. L_a and C_s are included in the filter part of the line equipment and their values are determined from nomograms, such that the wanted filter effect is achieved. The example shown is for a line impedance of 300 ohms and a cable impedance of 125 ohms.

Fig. 9
Configuration and examples of the *characteristics for the high-pass filter*



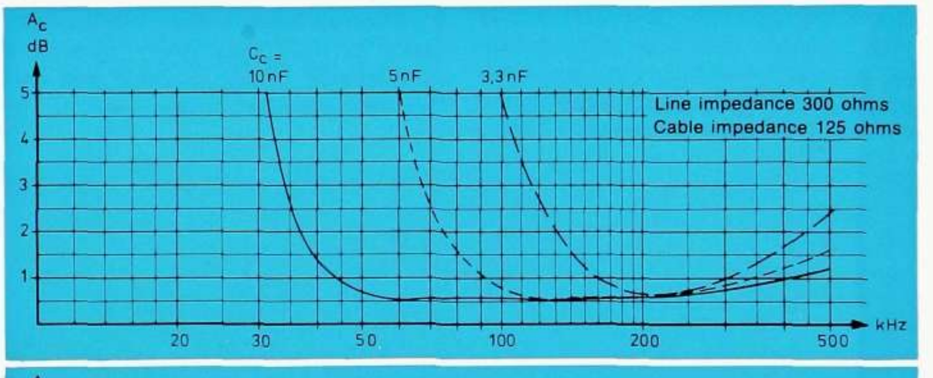
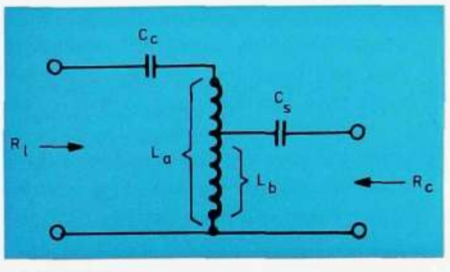


Fig. 10
Configuration and examples of the characteristics for the modified high-pass filter



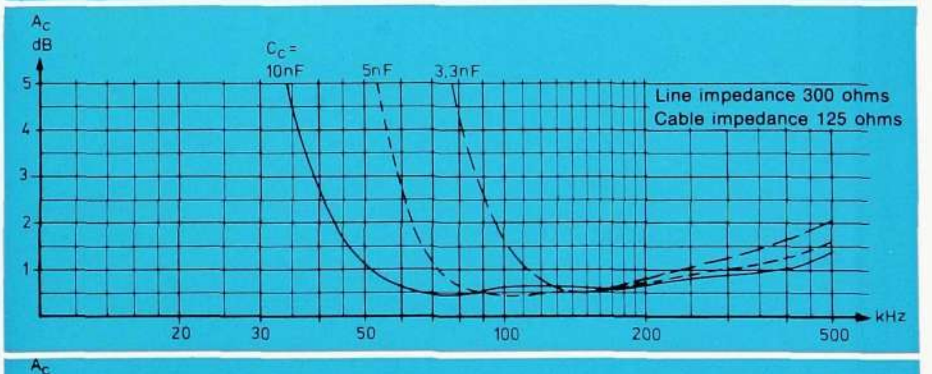
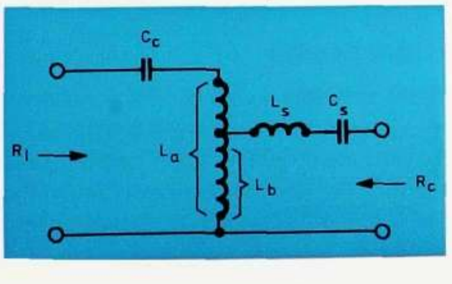
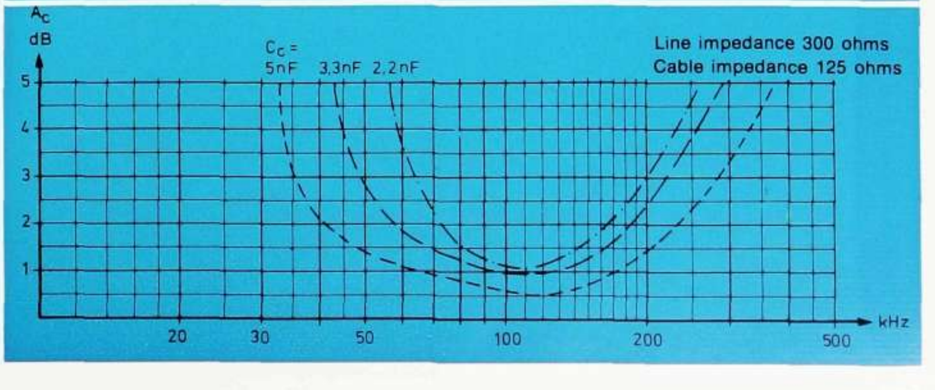


Fig. 11
Configuration and examples of the characteristics for the band-pass filter

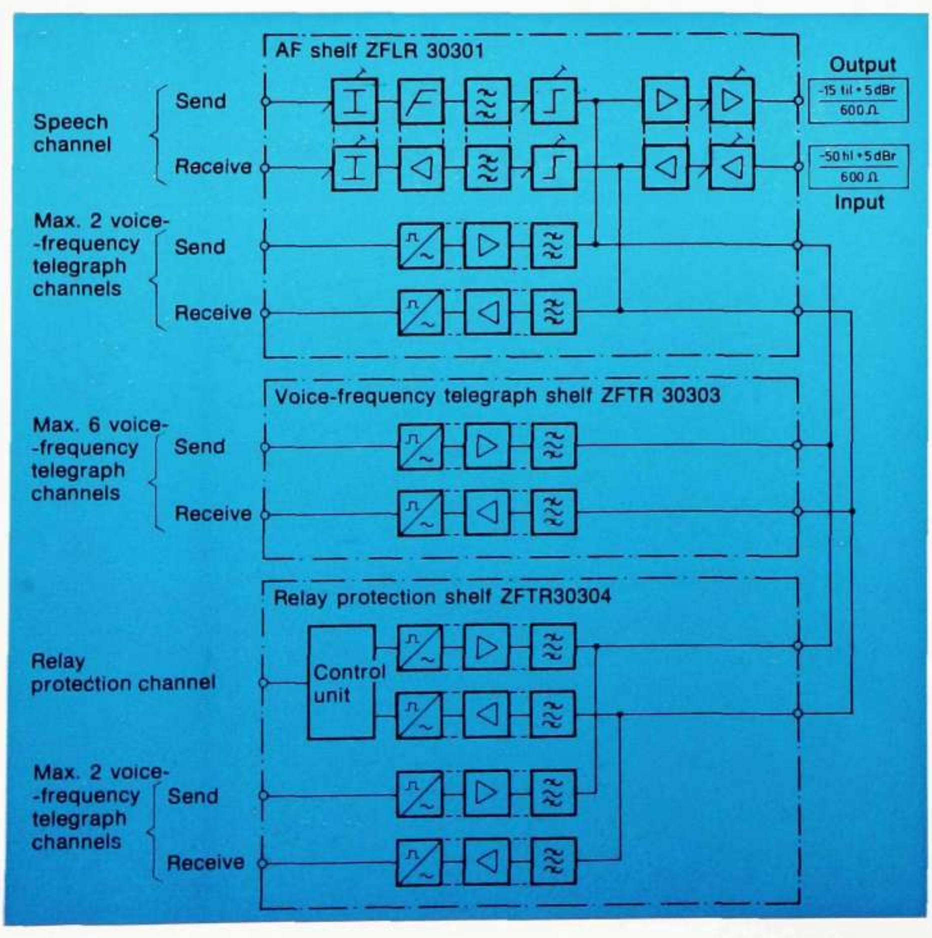




From fig. 9 it can be seen that with low values of coupling capacitor C_c the lower cut-off frequency will be rather high. If the value of the coupling capacitor is low and it is desired to transmit a low frequency band, the filter can be connected as a modified high-pass filter. The circuit diagram for such a filter is shown in fig. 10. The values for L_a, L_b and C_s are determined from nomograms. Fig. 10 shows some examples of filter characteristics using the same values of line impedance and cable impedance as in fig. 9.

The lowest cut-off frequency is obtained with the filter coupled as a transformed band-pass filter. The circuit diagram for this and examples of filter characteristics are shown in fig. 11. From the figure it can be seen that the band-pass filter transmits a relatively narrow band. Hence this configuration is used only when there is a combination of low C_c value and narrow frequency band.

Fig. 13
Block diagram of an AF terminal ZAT 11 SF consisting of three types of shelves



Mechanical design

The line equipment is mounted in a housing of stainless steel plate, in which all other items are also of non-corrosive materials. A photograph of the line equipment is shown in fig. 12. All the electrical components, capacitors, coils and transformers, are moulded in three blocks. This provides excellent protection in all weather conditions.

AF terminal equipment ZAT 11 SF for other transmission media

The desire to be able to use the same division of the AF band for transmission over other transmission media than power lines has led to the development of ZAT 11 SF.

The units used are the same as are included in the AF part of the CPL equipment, but the shelves are arranged for mounting in a 19" rack or bay. The block diagram for a terminal is then, in principle, as was shown in fig. 2.

TRANSMISSION FACILITIES

The following alternatives are possible:

1. Signals may be transmitted as low-frequency signals over a low-frequency circuit, which can be either cable or open-wire line.

2. Signals may be transmitted over a radio link. The data for the radio link will limit the number of channels that can be used in this case.

3. Signals may be transmitted over a normal carrier circuit. The carrier equipment will then usually limit the upper end of the AF band to 3400 Hz, so that it will not be possible to use the voice-frequency telegraph channels with frequencies above this.

BASIC DESIGN

Shelf versions

Three different shelves are specified:

1. AF shelf ZFLR 30301 with space for the speech channel units and 2 voice-frequency telegraph chan-nels

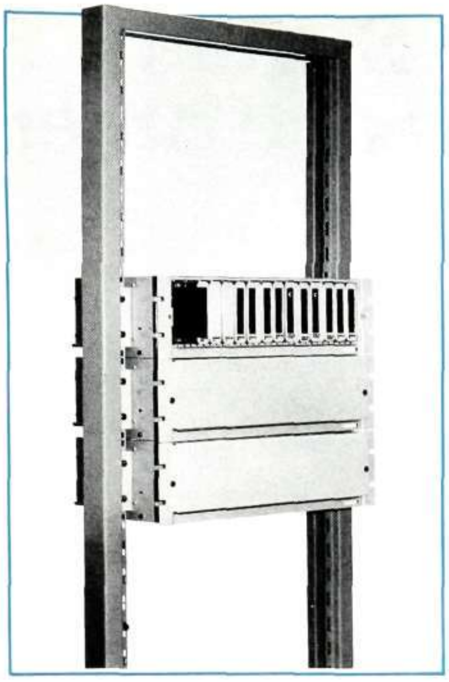


Fig. 14
AF terminal consisting of three shelves mounted in a rack

2. Voice-frequency telegraph channel shelf ZFTR 30303 with space for 6 voice-frequency telegraph channels.

3. Relay protection shelf ZFTR 30304 with space for 1 relay protection channel and 2 ordinary voice-frequency telegraph channels.

All the shelves have space provided for power units, combining/branching amplifiers and output/input units towards the line, but in any one terminal these units are provided in only one shelf. Depending on the requirements a terminal may be built up of a single shelf or any desired combination of an arbitrary number of the three types of shelves. A number of shelves are connected together to form a terminal with the aid of cables that are plugged in at the rear of the shelves. The station cabling is also connected at the back of the equipment.

Fig. 13 shows a block diagram for a terminal consisting of one of each of the three types of shelves.

Units

The speech channel, voice-frequency telegraph channels and relay protection channels have the same units as in the ZAP 01-2 and the same system solutions are possible.

An amplifier unit, with separate amplifiers for the send and receive directions, may be included in the input and output units. The output level can be varied over a wide range with a maximum output level of + 5 dBr. The input amplifier is able to accept all signal levels that are obtained in practice. Both amplifiers are provided with simple equalizer networks to compensate for any attenuation/frequency distortion that may be introduced in the top part of the frequency band by the transmission medium. If a higher output level than — 15 to — 12 dBr is not required, and the receive level is not below — 30 dBr, the amplifier unit may be replaced by a simple matching unit.

The equipment can be driven from a 24 V or 48 V d.c. source.

Mechanical design

The shelves and units are built in accordance with the M4 construction practice. The width of the shelves is adapted for mounting in 19" racks or bays. The shelves are secured with brackets which can be fixed to four different positions on the shelves. This makes it easy to adapt the shelves to other equipment mounted in the same framework or rack.

A terminal consisting of three shelves mounted in a rack is shown in fig. 14. The shelf with the front cover removed is an AF shelf.

Technical data

AF PART OF ZAP 01-2 OR ZAT 11 SF

Capacity	With a bandwidth of 4 kHz:	A duplex speech channel 300—2400 Hz and a maximum of eleven 50-baud voice-frequency telegraph channels in each direction, or a correspondingly smaller number of 100 or 200-baud channels,
		or:
		A duplex speech channel 300—2200 Hz, one 600-baud plus three 50-baud voice-frequency telegraph channels (or equivalent),
		or:
		A data channel 300—2700 Hz and a maximum of eight 50-baud voice-frequency telegraph channels or the corresponding number at other speeds.
Impedance	Input/Output	600 Ω
Attenuation/frequency	300—400 Hz and 2300—2400 Hz:	— 0.8 dB to + 3 dB
distortion in the speech	400—600 Hz and 2000—2300 Hz:	— 0.8 dB to + 1.7 dB
channel relative 800 Hz	600 Hz to 2000 Hz:	— 0.8 dB to + 0.8 dB
Psophometric noise in the speech channel		< — 65 dBm0p

TRANSLATING PART OF ZAP 01-2

Channel bandwidth		4 kHz
Transmitted band (4 kHz)		Within the range 24—488 kHz
Power amplifier		7.5 W P.E.P.
		40 W P.E.P.
		120 W P.E.P.
Carrier frequency stability	between 0° and 45° C	Better than ± 2.5 · 10^{-6}
Level regulation	Relative line level	Relative AF level
	+ 10 dBm0 to — 20 dBm0:	+ 0.5 dBm0 to — 0.5 dBm0
	— 20 dBm0 to — 30 dBm0:	0 dBm0 to — 2.5 dBm0

LINE EQUIPMENT ZGBR 00101

		The equipment may be used with coupling capacitors between 2.2 and 20 nf
Impedance towards the power line		230 Ω, 300 Ω, 390 Ω, 510 Ω
Impedance towards the cable side		50 Ω, 75 Ω, 125 Ω, 140 Ω
Breakdown voltage towards the cable side		> 10 kV
Spark gap	Flash-over voltage:	1000 V approx.
	Current capacity:	> 10 kA in 1 second

AKNR 50 – A Telephone System for Power Line Networks and other Special Networks

Harald Hovland

In Norway the first telephone calls over power lines were made as long ago as 1922 and a system for automatic telephony over the power line network of Oslo Lysverker was described in Ericsson Review in 1936.[1] The telephone equipment was supplied by A/S Elektrisk Bureau in Oslo, an associated company of LM Ericsson. During the Second World War the same company designed a special "Power station exchange" which today is used for telephone communication in the Norwegian power line network.
As a result of the need for communications and the developments in the technical field, in 1970 A/S Elektrisk Bureau started the development of a new telephone system intended for power line networks and other special telephone networks.
Previously LM Ericsson have supplied types AMB 20 and ARD 316 exchanges for communication in power distribution networks, but in 1970 it was decided that A/S Elektrisk Bureau should take over the responsibility within the Ericsson Group for the supply of all telephone exchanges and transmission equipment marketed for telecommunications in power line networks.

UDC 621.315.052.63:
621.395.44
LME 8427

The AKNR project

As the HF exchanges developed earlier by A/S Elektrisk Bureau for the Norwegian power station network eventually proved to have too limited a capacity, it was decided in 1970 to develop a new exchange equipment with a larger capacity and more services, and which could be supplied together with the carrier equipment for power lines newly developed by A/S Elektrisk Bureau.

Together with LM Ericsson the company were at that time in the process of developing a new public telephone system, which had been designated AKK 50. The experience gained from this project as regards the system technology, circuit engineering and method of construction was used as a basis for the development of the AKNR 50 system.

The project was commenced during the autumn of 1970 and the design phase during the spring of 1971. A prototype network with three exchanges was installed in the Oslo area during the summer of 1974.

Summary of three requirements

Meetings with customers, and studies of the demands and requirements of suppliers of electric power in various parts of the world has resulted in the following technical requirements:

- 4-wire through connection
- alternative route selection
- possibility of connecting up circuits anywhere in the network
- rapid and reliable signalling (MFC)
- 2-wire and 4-wire subscriber lines
- possibility of setting up conference circuits
- linked numbering scheme with up to 4 digits
- possibility of barring subscribers from getting into the network or parts of it
- two-party line equipment
- PBX line selection
- push-button dialling
- possibility of dialling through the network

Fig. 1 shows a typical network for power station circuits. The network shown in the figure consists of a number of sub-networks with exchanges of different manufacture. These can be connected together via manual exchanges. Two circles at a point indicate that a PABX is connected to the network at that point. The numbers give the number of available speech circuits. There are usually only 1—2 circuits between two points. The circuits may consist of carrier channels in the range 44—450 kHz, over cable or radio links.

As the telephone is an important communication medium in the power station operation network and is of great importance in an emergency, it is essential to be able to get through even if the circuits are engaged. Hence alternative route selection and the possibility of connecting up and taking over a circuit are very necessary services.

AKNR is a system that has been devel-

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works but it has characteristics that are also important in other closed networks, for example military networks and networks for "oil communications".

Capacity and trunking diagram

Two versions of the AKNR system have been designed, AKNR 512 and AKNR 515.

AKNR 512 is the smaller exchange of the two. It has a maximum capacity of 20 subscriber lines, 2 registers and 2 code receivers. The number of SNRs (connection circuits) is limited by the switching capacity and the number of FDRs (relay sets). Three examples are given below of the maximum requirements for three different traffic needs:

20 subscriber lines, 6 FDR, 4 SNR
15 subscriber lines, 10 FDR, 5 SNR
10 subscriber lines, 13 FDR, 2 SNR

The trunking diagram for the exchange is shown in fig. 2. The switching stage consists of up to two 6-point code switches and thus gives the stage a maximum capacity of 30 multiple positions and 20 vertical units. The register and code receiver are connected to SNR/FDR via a 12-point code switch.

The connecting circuit SNR is used for outgoing and terminating traffic and is connected to the relay set FDR. For local calls the two vertical units of the

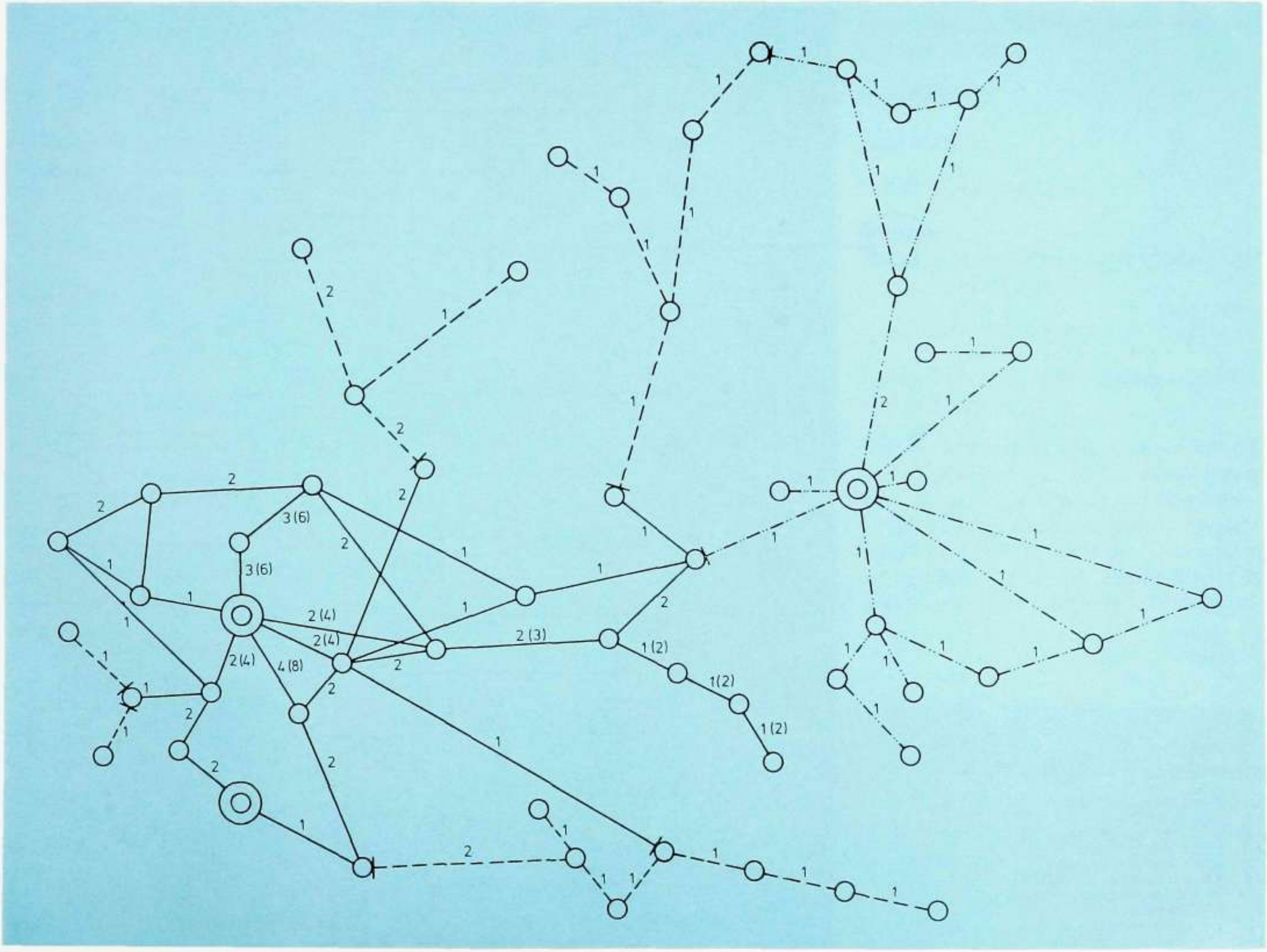
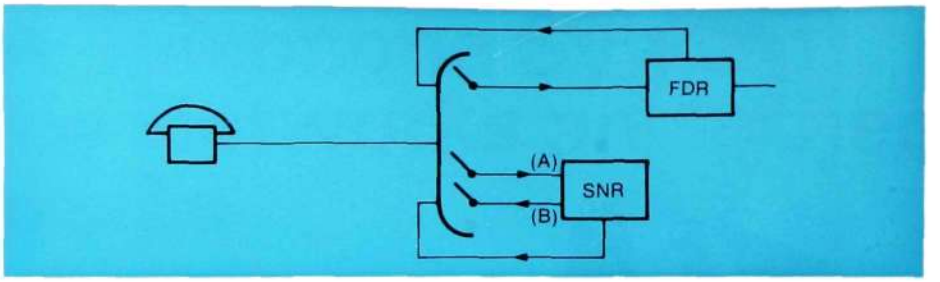


Fig. 1
Typical telephone network for power stations

- ○ **Power station exchange**
- ◎ **Regional centre**
- **Interface point**
- ——— **New system**
- — — — **Existing system 1**
- — · · — **Existing system 2**

Fig. 2
Trunking diagram for an exchange with a 6-point code switch

FDR Two-way relay set
SNR Connecting circuit



SNR are connected to the A and B subscriber respectively.

Fig. 4 shows a transit circuit. In this case the vertical unit of the outgoing FDR is connected to the multiple position of the incoming FDR.

Functionally AKNR 515 is the analog of AKNR 512, but the number of switches has been increased so that there is a maximum capacity of 60 subscribers, 50 FDR and 10 SNR.

Signalling

The line signals are transmitted outside the speech band over a separate signalling channel in each direction. Thus a continuous signalling system is obtained. Seizure and clearing consist of shifting the tone in the signalling channel. When a channel is occupied, short and long signals (50 and 150 ms) having a particular meaning are sent.

The register signalling takes place in the speech band using compelled multi-frequency code signalling (MFC). The same frequencies are used and, in the main, the same signals as in exchanges in the public telephone network. However, the two lowest frequencies, 540 and 660 Hz, are not used, because measurements made in older power distribution networks indicate that these frequencies are attenuated much more than the higher frequencies. End-to-end signalling is used.

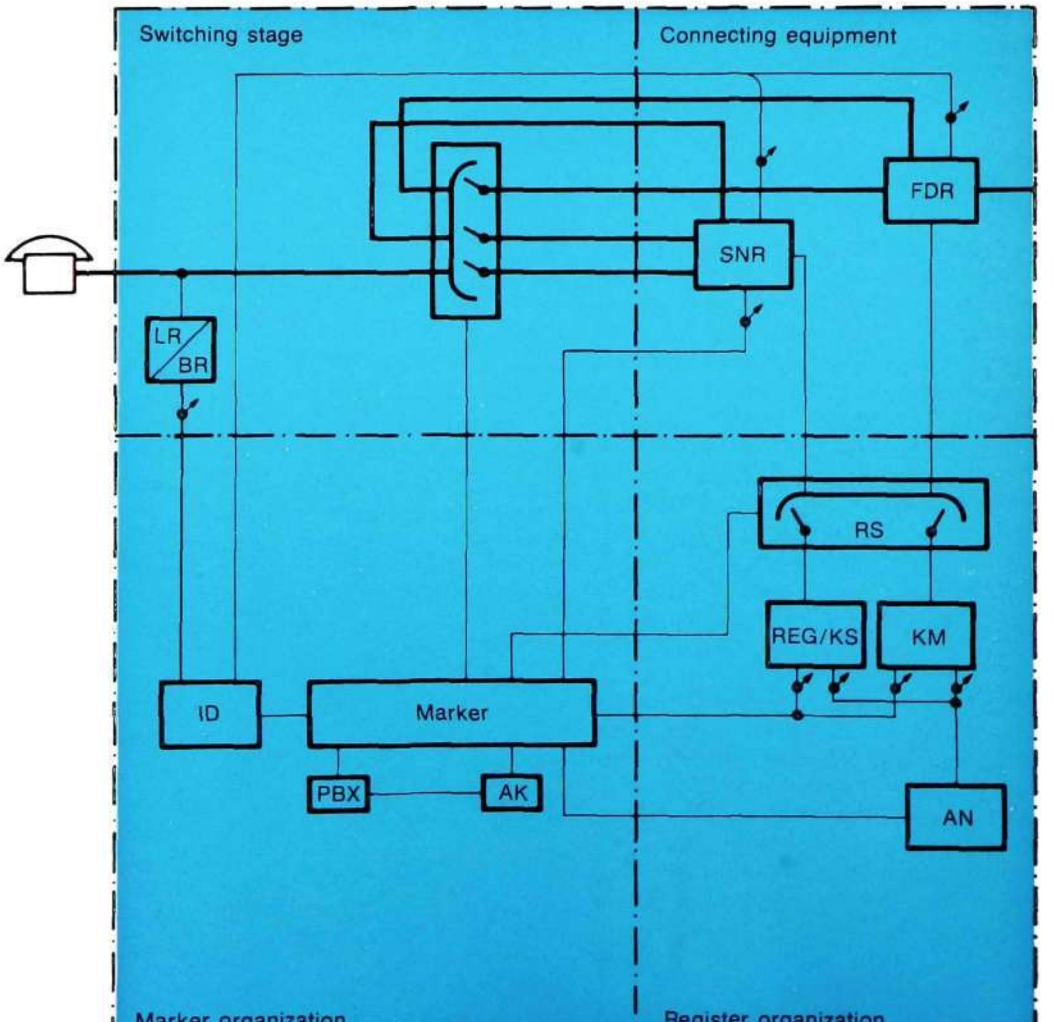


Fig. 3
Block diagram of AKNR 50

LR/BR Line/cut-off relays
ID Identifier
PBX PBX equipment
AK Class analyzer
AN Central analyzer
REG/KS Register/code sender
KM Code receiver
RS Register finder
FDR Two-way relay set
SNR Connecting circuit

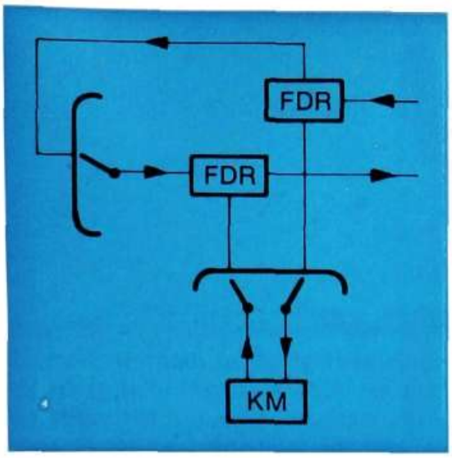


Fig. 4
Transit circuit

FDR Two-way relay set
KM Code receiver

Technical description

A block diagram of the system is shown in fig. 3. The system is marker controlled and has a central analyzer AN which contains programs for number series and for certain services.

AN has a scanner which is controlled by a clock and which continuously scans over the registers and code receivers and over the identifier ID. When the scanner points out a device its contents are analyzed and the device is connected to the marker if it contains sufficient information to cause switching to take place. AN is a parallel analyzer, and the contents of the register/code receiver are transferred to AN via a bus, on which the analyzer result is transferred to the marker and back to the device that is analyzed.

ID has a scanner that scans over the calling contacts of the line relays (LR), over FDRs in cases of incoming calls, and over SNRs that may have received a signal from a subscriber wishing to have a conference circuit established. When ID detects a call the scanner stops and AN connects ID to the marker.

The function of the marker is divided into sub-operations that are controlled by a clock. The register and code receiver also operate in the same way and here it is possible to go back to sub-operations that have been carried out earlier when the input criteria decide this. Thus the code receiver can go back to the sub-operation "calling in of the marker" if a call put out on a channel is not answered. This can result in the selection of another channel, and if this is also unsuccessful the rerouting signal can be sent back so that another route can be selected in the previous exchange (through-connected earlier).

The division into clock-controlled sub-operations has been extremely useful both in the design phase, where the sub-operations were initially defined with the aid of flow diagrams, and in the laboratory and prototype phases where it has simplified the tracing of design and circuit faults.

Special services

The class analyzer AK can give out the following classes:

A classes:
priority subscriber with second priority (limited priority)

restricted for traffic outside own area

restricted for traffic outside own exchange

test number

data modem

4-wire subscriber line.

B classes:
PBX group hunting number (given from AK to the PBX board)

4-wire subscriber line

subscriber line with through-dialling (in-dialling).

Priority subscriber with first priority is not determined by AK, but is included as a strapping facility in the line relay. When a call is received from a priority subscriber the circuits are connected up everywhere in the network where this is necessary because of conges-

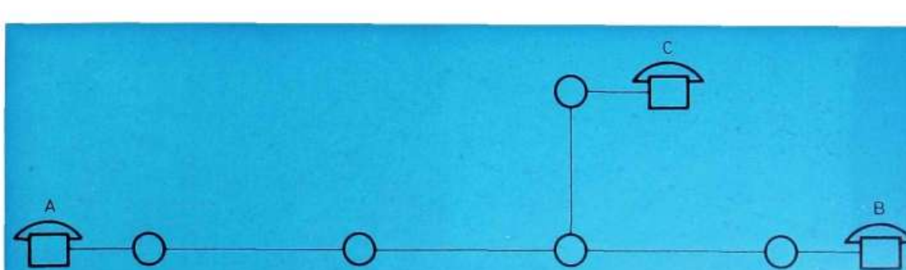


Fig. 5
Conference connection
A calls B and thereafter B makes a conference call to C

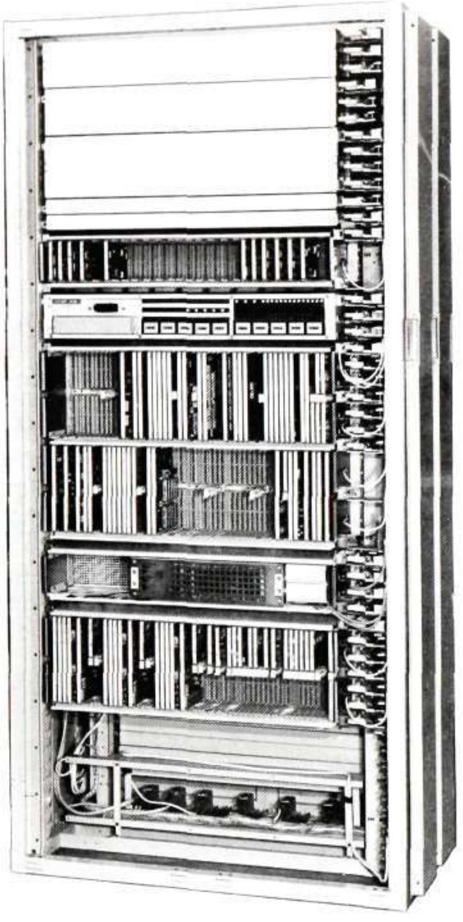


Fig. 6
Exchange of type AKNR 512

tion or engaged conditions. The warning tone is then given both to the calling and the connected subscribers and these are then able to talk to each other. The calling subscriber can now send the breakdown signal and take over the circuit. If the connected call also has priority it cannot be disconnected, and instead the breakdown signal causes another circuit to be connected up. Subscribers who do not belong to the priority class can also obtain priority by dialling a special number, called the emergency number.

The object of the test class is to be able to seize test equipment, and with this facility it is possible to determine which FDR/SNR is to be seized. Thus, by dialling a certain digit it is possible to proceed from point to point in the network and test it from a central place.

Conference calls can be set up anywhere in the network. A conference call is initiated by a subscriber, who is already connected up to another subscriber, sending a signal (dialling pulse) which is detected by his SNR. The identifier finds the SNR that has received the conference call signal, and connects in the marker that connects the SNR to a register. The subscriber who has initiated the conference call then hears the conference dialling tone and is able to dial the number of the person who is to take part in the conference call. This can be a number belonging to the same exchange or any other exchange in the network. Fig. 5 shows a conference connection where A has called B who has made a conference call to C. The call to C follows the same route as is used for the connection from A to B as long as the routes are common.

Push-button dialling may be used in the system, in which case the same type of push-button receivers are used as in public systems. (When making conference calls "hook flash" is used for calling in a register.)

Service supervision and fault location

The exchanges of fig. 6 have equipment for measuring the fault rate. This equipment gives an alarm if the fault rate exceeds a certain limit. It supervises markers, registers and code receivers and faulty devices are blocked in those cases where the equipment is duplicated. If a fault occurs in for example both registers, the blocking is removed. Moreover, the number of calls and faults are recorded on fixed counters.

A number of test jacks are provided from which information may be taken out on to boards containing light emitting diodes. Boards are also available with memories, which can be inserted in the test jacks. When a fault occurs it is entered in the memories, where it is stored with the reason for the fault until the memories are reset to zero manually. Thus it is possible to read out how far the connection has come and which sub-operation has failed.

Components and mechanical design

The design of ANKR 50 is based mainly on DTL and TTL types of integrated circuits. MSI circuits have been used to a great extent for, for example, binary counters, 5-bit memories and drive circuits for miniature relays and other interface circuits. The use of MSI has meant that many functions have been included in one and the same printed circuit board assembly.

6-point and 12-point code switches are used. Switches, printed circuit board shelves and the remaining equipment are connected to the rack cabling via plugs and sockets. 12 V signals are used for information between shelves and these go to the relevant devices via interface circuits.

The cabinet used is an LM Ericsson type BDH and has a height of 2180 mm.

References

1. Riise, C. W.: *Automatic Exchanges Interconnected by Carrier Channels.* Ericsson Rev. *13* (1936): 2, pp. 79—81.

WORLDWIDE NEWS

ELLEMTEL inaugurate new premises

On January 17th, 1975 ELLEMTEL Utvecklings AB, the development company owned jointly by LM Ericsson and the Swedish Telecommunications Administration, officially took into use their new office and laboratory buildings, with a total area of 22,000 square metres, at Älvsjö, Stockholm.

The Swedish Minister of Communications Bengt Norling, the Chairman of the Board of LM Ericsson Dr Marcus Wallenberg, representatives of the Swedish Telecommunications Administration led by Director General Bertil Bjurel and the President of LM Ericsson Björn Lundvall took part in the opening ceremony. The ELLEMTEL staff of almost 400 and its President Erik Eriksen also took part.

The Minister of Communications expressed the opinion that the setting up of a joint development company by the Telecommunications Administration and LM Ericsson will contribute to continued prominent positions for the Swedish Telecommunications Administration, for LM Ericsson as an international telecommunication company and for Sweden as an industrial country.

Dr Wallenberg spoke about the background to the formation of ELLEMTEL and mentioned how engineers from the Administration and LM Ericsson used to compete in attempting to achieve the best technical solutions, at the same time that a comprehensive cooperation existed between them. As an example he took the case of the 500-line selector and the crossbar switch. In conclusion Dr Wallenberg expressed the hope that this desire to compete will remain in ELLEMTEL but that it will be directed against foreign competitors.

In a summary of the activities of ELLEMTEL Erik Eriksen, the company President, said that the largest projects at present were a stored-program-controlled telephone exchange system for local exchanges and transit exchanges for traffic between local networks and a PABX. The telephone exchange system is an important corner stone in the long term plans of the Telecommunications Administration for modernizing the Swedish telecommunication network. For LM Ericsson this constitutes a significant new design, strengthening their competitiveness on the foreign market.

ELLEMTEL has also developed equipment for a trial network for data traffic, which was put into service during 1974 between Stockholm, Gothenburg and Malmö, and which has been of great importance in the preparation of the technical principles for a joint Nordic data network.

This is the fifth year that ELLEMTEL have been operating. The company was formed in 1970 after investigations and negotiations between the Telecommunications Administration and LM Ericsson.

LM Ericsson's Chairman of the Board Dr Marcus Wallenberg signs his name on a commemorative tablet at the inauguration of the new office and laboratory buildings of ELLEMTEL.

Centenarian LM Ericsson to found a telecommunication prize

Next year Telefonaktiebolaget LM Ericsson will be 100 years old. It was in 1876 that Lars Magnus Ericsson, a precision tool maker, laid the foundation of what was to develop into an internationally large-scale enterprise in the field of telecommunications. One of the events in connection with the centenary will be the award of an international prize of 100,000 SKr (approx. US $ 25,000). This is to be called "The LM Ericsson prize for an important contribution in telecommunications technology".

The LM Ericsson prize, the aim of which is to "encourage scientific research and development in telecommunications technology" is to be awarded every third year commencing with the jubilee year. The contribution that is rewarded must have been made or produced results during the preceeding three years.

The contribution to be rewarded will be selected by an independent jury consisting of three members: Dr Håkan Sterky, former Director General of the Swedish Telecommunications Administration, Chairman, appointed by the Swedish Academy of Engineering Sciences, the present Director General Bertil Bjurel, appointed by the Swedish Telecommunications Administration, and Professor Stellan Ekberg, appointed by the Professors in Electrotechnology at the Institutes of Technology in Stockholm and Gothenburg, the technical faculties at Lund University and Linköping University. Dr Christian Jacobæus has been oppointed by the Board of LM Ericsson to be the secretary of the prize committee.

All organizations and private persons active in the field of telecommunications may propose prize winners. Those wishing to obtain further information regarding the prize regulations and nomination forms can write to the prize committee at the following address:

LM Ericsson prize committee
S-126 25 Stockholm
SWEDEN

Proposals must reach the prize jury not later than October 1st, 1975 if they are to be considered for the prize award for 1976.

Satellite equipment for 10 MSKr ordered by ESRO

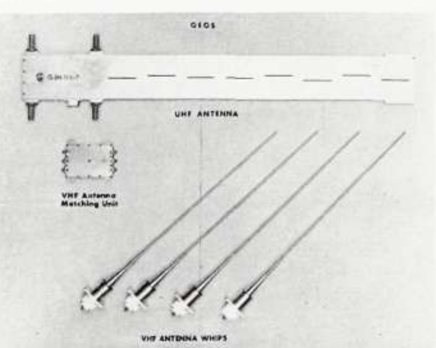
The European Space Research Organization, ESRO, has placed orders with LM Ericsson for satellite equipment for just over 10 million SKr. The orders comprise microwave equipment for the maritime telecommunication satellite MAROTS (Maritime Orbital Test Satellite) and the microwave antenna for receiving and transmitting data from a scientific satellite called ISEE-B (International Sun-Earth Explorer—Daughter Satellite). Both these satellites are expected to be launched during 1977 by the American space organization NASA.

The order for MAROTS consists of a local oscillator system for the satellite transponders. Frequencies of 11 and 14 GHz in the X band are to be used between the satellite and land-based stations, and frequencies in the range 1.5—1.7 GHz in the L band between the satellite and terminals on ships. When in orbit the satellite is to be used for providing telephone, telex and data communication between land-based stations and terminals on ships. The coverage area will be the Atlantic, Persian Gulf and Red Sea and adjoining parts of the Indian Ocean. LM Ericsson are working here in a consortium that has the task of developing and manufacturing the whole of the communication equipment in the satellite. The consortium is led by Marconi, England and the total value of the order amounts to 7.0 million SKr.

The GEOS satellite set up at LM Ericsson's factory at Mölndal for making antenna radiation measurements.

The ISEE-B satellite is to measure space and time variations of the magnetic field and solar wind in the magnetosphere which surrounds the earth. Two satellites are to be launched by an American carrier rocket. One of these satellites, called the mother satellite, is being developed by NASA and the other, the daughter satellite, by ESRO. The two satellites are to be launched simultaneously. When they have come into orbit around the earth, they are to be separated and will then follow each other at a certain distance, up to 10,000 km, in the same high elliptical orbit around the earth.

The microwave antenna, which is to be delivered by LM Ericsson, is dimensioned for receiving command signals to the satellite and for the transmission of data from the scientific equipment in the satellite. The antenna consists of a waveguide with slots and is very similar to the antenna developed by LM Ericsson for the geostationary scientific satellite GEOS, also on contract from ESRO. LM Ericsson are working in the STAR consortium that has the task of developing and manufacturing the whole satellite. The total value of the order amounts to 3.3 million SKr.



Antennas for VHF and microwave (UHF) for the GEOS satellite. The UHF antenna for the ISEE-B satellite is of the same type.

Computer control in the oldest ARF 10 exchange

This picture was taken in connection with the switchover to ANA 30 of the 20-year old ARF local exchange at Århus. In the picture can be seen, from left to right, Messrs. R. Relsted, JTAS, F. Meland, LM Ericsson, and M. Schönau-Hansen, JTAS, in front of a part of the register organization in ANA 30.

In Århus, Denmark the local exchange, with type ARF 10 crossbar switches manufactured by LM Ericsson, which was taken into service in 1953, has been modernized. In connection with this, the stored-program-controlled register organization ANA 30 has been introduced. The original exchange has thus been given a level of service comparable to that of other stored-program-controlled telephone exchange systems. The original exchange was the first ARF 10 exchange to be taken into service anywhere in the world. Since then ARF 10 has become one of the most widely used local exchange systems.

The switchover of the first 10,000 subscriber lines from ARF 10 to ANA 30 took place in December last year. The switchover in Århus of a further 60,000 lines is expected to be completed within a year.

In 1970 JTAS, Denmark decided — the first administration to do so — to introduce LM Ericsson's stored-program-controlled register organization ANA 30 in their existing crossbar exchanges and also for new installations (ARE 11). Operational trials with a modernized exchange comprising 1,000 subscriber lines were carried out at Mundelstrup in 1973. Operational results from Mundelstrup and the other units have been very good.

60 MHz multiplex to Italy

LM Ericsson's subsidiary company in Italy, FATME, have received an order for 60 MHz multiplex equipment from the Italian operating company ASST (Azienda di Stato per i Servizi Telefonici).

The order is the first for 60 MHz equipment from a country outside Scandinavia and comprises two terminal racks and an oscillator rack for the route Bologna—Padua, a route with a large amount of traffic.

Electronic fire alarm system BRANDLARM 80

BRANDLARM 80 is the name given to an electronic fire alarm system introduced by LM Ericsson Telemateriel AB. The system is characterized by its versatility, through the use of a new modular design, a new detector program and the very advanced engineering.

All the important control devices in BRANDLARM 80 are completely electronic. Light emitting diodes, transistors and printed circuit board assemblies have replaced filament lamps, relays and mechanical components. This ensures more reliable function, clearer indicating and greater possibilities of adaptation to different requirements.

All devices for functional control are assembled in the central equipment where the start of a fire or any failure is indicated with both light and sound signals. At the same time an alarm is also sent to the fire fighting organization. The central equipment is based on a mechanical design with uniform modules for the central unit, power unit, orientation plans, alarm transmission equipment and all other units. The equipment is very shallow and can thus be mounted without being let into the wall.

Fire risk varies considerably depending on the nature of the premises and the use to which the premises are put. Four main types of detectors are included in the system for various requirements and environments: smoke detectors, heat detectors, differential detectors (affected by how rapidly the temperature increases) and flame detectors. The detectors are placed strategically and grouped in sections depending on the appearance and position of the premises. The section wires are run in telephone cables and the whole system is driven from 24 V.

Remote display panels are provided for alarming over long distances within a company unit. All information coming into the centre is transmitted to these panels via two-wire circuits. Such display panels can be placed up to 20 km from the central unit and hence they can function at the entrance to a factory area as an indicator board for the fire brigade.

A selection of accessories makes it possible to build up a suitable supervisory system for each individual case, with auxiliary equipment for automatic regulation of fans, release of sprinklers and closing of fire-proof doors.

The central equipment of the electronic alarm system BRANDLARM 80. It contains all devices for functional control and here the start of a fire is indicated with both light and sound signals.

New modems for data transmission

Two new modems for data transmission, ZAT 4800 for synchronous data transmission at 4,800 bits/s and ZAT 300 for transmission at 300 bits/s, are now in production.

Transmitting data at 4,800 bits/s makes great demands on the transmission qualities of the lines, and hence ZAT 4800 has been provided with an efficient equalizer of phase and amplitude distortion.

Thanks to the test facilities provided in the equipment it is possible to determine quickly whether a fault is attributable to the line, the modem or the remainder of the data equipment.

Functions are built into the modem for setting up the equalizer and for testing in a fault situation, and thus no external test instrument is needed.

Modem ZAT 4800 is frequently used on multidrop circuits, i.e. circuits to which a number of terminals are connected in parallel. The terminals are often at great distances from each other.

In modem ZAT 300 the modem and the control equipment are in the same unit. The unit is small and is designed to harmonize with an office environment.

ZAT 300 permits asynchronous data transmission at up to 300 bits/s in full duplex over the general switched telephone network.

A data connection is established as a normal telephone call. The modem is then connected for transmitting data by means of the telephone/data switch on the modem control panel.

ZAT 300 is equipped with an automatic answering function, which means that the terminal may be unmanned for incoming traffic.

Apart from the mains voltage indicator ZAT 300 has two signal lamps, one of which indicates that the line signal is received and the other that the modem is connected to the line and ready for operation.

Agreement with SJ — new interlockings

The Swedish State Railways, SJ, have concluded an agreement with LM Ericsson regarding the development of a new type of interlocking system based on computer technology. The agreement also includes the supply of equipment for an initial plant to be installed in Gothenburg, and which is expected to be taken into service at the beginning of 1977. LM Ericsson's UAC 1610 computers are to be used. The total value of the order amounts to 13 MSKr.

In SJ's present modern interlocking systems the safety requirements are met with permanently connected logic and specially designed safety relays. In the new system the stringent safety requirements can be met with the aid of a single process computer. The fundamental principle of the system implies that through two different programs the computer carries out condition calculations for, for example, working the points. The individual calculation results are checked and transferred to equipment situated near the devices in the station yard. It is at this stage in the process that the result comparison is made from the viewpoint of safety. The answer decides whether the order sent out may be carried out.

This method, with a computer and duplicated programs, and the new principles for information processing is very likely unique. Interlocking systems based on computers provide economic advantages compared with conventional techniques, particularly for large stations. Moreover, there are greater possibilities of simplifying the work of the train dispatchers by automating certain functions, thereby increasing the traffic capacity at the stations.

Apart from the computer-based safety part, the agreement also includes the development of a separate computer-based visual display system which is to replace the traditional track diagram.

With this new interlocking system SJ and LM Ericsson continue the collaboration in the signalling field that has earlier resulted in, for example, modulator designed relay interlocking systems, remote control systems based on relays and the computer-based centralized traffic control office which has been in service at Stockholm central station since 1971.

Telephone set with modem ZAT 300 for data transmission.

Nils Palmgren In Memorian

Nils Palmgren, one of the great pioneers in Swedish automatic telephony, died on January 30th, 1975 at the age of 87.

When he was only twenty years old Nils Palmgren made his first discovery in the field of telephony. He was then on the staff of AB Autotelefon Betulander. With G. A. Betulander as co-inventor, in 1912 he was granted Swedish patent 35814, which related to, among other things, "interconnections", the grouping system that was later to be called the link system. Since then link systems have been used on a very large scale, first in the crossbar systems and now in the electronic systems. The patent also included a description of the marker principle, which has become a matter of course in modern telephony.

The other great contribution was made at the end of the 1910s with the invention, again together with G. A. Betulander, of the modern crossbar switch, a selector design which has been more extensively used than any other apart from the Strowger selector.

One can say that Palmgren and Betulander were long before their time with these inventions. It was not until after the Second World War that technology in general had caught up and it was possible to exploit these inventions on an industrial scale. The Swedish telephone industry was then able to take up the designs of Palmgren and Betulander and on the basis of these build up their present prominent position. It was given to Nils Palmgren to live to see his designs applied in most countries in the world almost half a century after their conception.

When AB Autotelefon Betulander was taken over by LM Ericsson in 1920, Nils Palmgren, as a member of the technical staff, was entrusted with a long succession of tasks in telephone exchange technology. He contributed actively to the development of circuits for the 500-line selector system. From 1938 until his retirement he was employed in the telephone exchange laboratory, most of the time as the Head. He was there able to make important contributions to the design work on all LM Ericsson's automatic systems.

Friends and colleagues of Nils Palmgren respected him for his sound knowledge and his inventiveness. He had a modest and unassuming personality which made it easy for his colleagues to work with him. His friends and associates feel a sense of sadness and loss at his death.

Telefonaktiebolaget LM Ericsson have reason to remember Nils Palmgren and his contributions with deep gratitude.

Christian Jacobæus

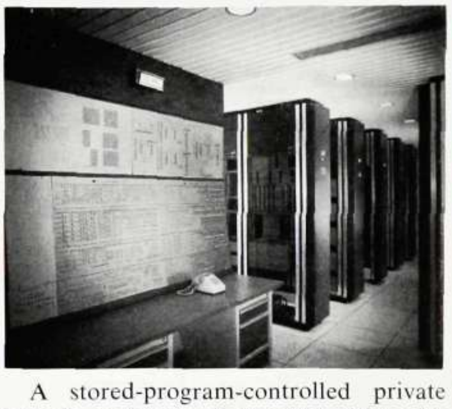
New changeover system for transmission links

LM Ericsson, in collaboration with the Telecommunications Administrations of Sweden and Norway, have developed changeover equipments which make possible automatic changeover of wide-band transmission links such as supergroups, mastergroups, supermastergroups or whole line groups in the frequency range up to 12 MHz, to standby links.

The changeover equipments are included in a larger changeover system which permits independent changeover from faulty links to existing standby capacity in other routes in the long-distance network, for example if a breakdown occurs on a long cable section through damage to the cable etc.

A 5 MSKr order for changeover equipment for a trial network was received in January from the Swedish Telecommunications Administration.

Stored-Program-Controlled Private Branch Exchange in Paris



A stored-program-controlled private branch exchange of type PE 1024 with reed switches, developed by LM Ericsson's French subsidiary company Société Francaise de Téléphones Ericsson, was taken into service in December in the Paris head office of the French bank Crédit Lyonnais.

The installation comprises 7,000 extensions and 700 exchange lines, and is included in an extensive private network for the bank's various offices throughout the country. The exchange is placed in a room with a floor space of only 120 square metres and can be built out to 8,000 extensions.

The stored program control is handled by two processors of type ERIC 32, developed by STE. The processors work in the traffic sharing mode and each has a capacity of about 15 calls per second.

LM Ericsson's new printed board factory at Ingelsta, Norrköping, is now in production. The annual production capacity is about 14,000 square metres of completed boards. The photograph shows, from the left, production lines for through-plating of holes in electrolytic copper baths, etching and gold metallization.

The factory is devoted entirely to the production of high class printed boards with, primarily, conductor widths down to 0.25 mm. The production techniques are adapted to meet the precision and complexity requirements for printed boards made necessary by the increasing production of electronic systems for telecommunications.

The Head of the printed board factory is Mr. Arne Spångberg, formerly Production Manager at LM Ericsson Pty Ltd in Melbourne.

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6. Other associated company
7. *Technical office*

TELEFONAKTIEBOLAGET LM ERICSSON

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THE MOLLISON INTERNATIONAL SWITCHING CENTRE
LONG DISTANCE TRAFFIC IN MEXICO
INSTALLATION OF 12 MHz SYSTEM
MULTIPLEX AND RADIO-RELAY EQUIPMENT
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Test consoles for measurements of the national and international circuits in the Mollison Switching Centre, London

The Mollison International Switching Centre

Rowland W. Button and Manfred Buchmayer

In April 1972 the United Kingdom Post Office awarded LM Ericsson the Contract for a large International Switching Centre (ISC) in London.
The Mollison International Switching Centre is one part of the Stag Lane International Telephone Service Centre multitask project to establish one of the largest switching centres for international telephone traffic in the world.
What made the Mollison project a special one to LM Ericsson was that with its 25,000 ARM 20 crossbar positions, a switching capacity of 8,000 Erlangs and a call handling capacity of well over 100,000 calls an hour, it is the largest single international exchange project LM Ericsson had ever undertaken.
Because the ARM 20 system with well over 600,000 lines in service by the end of 1973 is so well known, the system design will not be gone into in any great detail in this article. Instead, attention will be paid to the management of the project, the special facilities offered and to the integration of Mollison ISC into the UK national and international networks.

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The Mollison order

In September 1971, LM Ericsson, together with other manufacturers of telecommunication equipment, was invited by the United Kingdom Post Office to submit a tender for the design, manufacture and installation of an international 4-wire switching centre in London. Two switching units had to be provided, one for outgoing international traffic and one for incoming international traffic. The initial and final capacities of each of the units were specified to be 1,500 and 4,000 Erlangs respectively. Each of the units were to be equipped with an international maintenance centre. The Post Office planning strategy required the units to cater primarily for international subscriber-dialled traffic originating and terminating in the United Kingdom. On April 27, 1972, the contract, which later on came to be known as the Mollison Contract, was awarded to LM Ericsson.

The contract is divided into three phases. The contractual handover date for Phase I with a traffic capacity of 3,000 Erlangs was December 27, 1974. Phase II with a traffic capacity of 2,000 Erlangs and Phase III with one of 3,000 Erlangs should be ready for service on December 27, 1975 and December 27, 1976 respectively.

As mentioned above, the order comprised manufacture, design, delivery and installation of a 4-wire ARM 20 international switching centre with an initial capacity of 3,000 Erlangs and a contracted final capacity of 8,000 Erlangs. Within this framework two switching units had to be provided, one for outgoing international traffic and one for incoming international traffic. Each unit had to be served by an international maintenance centre comprising an International Transmission Maintenance Centre (ITMC) and an International Switching Maintenance Centre (ISMC). The equipment to be supplied had to be complete, i.e. to be supplied as a working entity including power plant and rack lighting.

Automatic transmission measuring equipment, service observation equipment, international accounting equipment using computer techniques and maintenance equipment were included in the order.

Three national line signalling systems, AC11, DC3 and LD4, were specified. The two first line signalling systems mentioned are associated with the Multi-Frequency inter-register signalling system MF2.

The third is a combined line and register signalling system with loop disconnect pulsing. These signalling systems are described in more detail under Register signalling and signalling systems.

Three international signalling systems were also specified, CCITT 4, CCITT 5 and CCITT R2.

A training package for PO engineering and maintenance staff, and provision of a complete training exchange were included in the order.

The international and national network configuration of Mollison ISC

Mollison ISC position and importance in the international network

Before phase I of the Mollison ISC was brought into service in October 1974, the Faraday and Wood Street ISCs had to carry all international traffic to and from the United Kingdom.

The total design capacity of these two CT1 "full facility" ISCs was then about 4,400 Erlangs. The term "full facility" is

ROWLAND W. BUTTON
Head of Network Control Division,
External Telecommunications Executive,
Post Office Telecommunications
Headquarters

MANFRED BUCHMAYER
Telephone Exchange Division,
Telefonaktiebolaget LM Ericsson

applied to any ISC offering all internationally agreed facilities.

By the end of 1974, International Subscriber Dialling (ISD) facilities were planned to be available for subscribers in 45 centres in the United Kingdom. At the same time approximately 65% of all international calls originating in the United Kingdom were directly dialled by the subscribers. By the end of 1979 ISD facilities will be available from most United Kingdom group switching centres (primary centres) generating international traffic of more than 0.25 Erlangs.

With the rapid increase of ISD, the traffic not requiring operator assistance is taking a bigger and bigger share of the total international telephone traffic. As a consequence there is a trend towards diverting the ISD traffic to big switching units handling automatic international traffic only. The Mollison ISC is such a unit and therefore operator assistance and transit facilities are not provided. It is termed a "limited facility" unit. Operators of distant administrations may dial through the unit provided no United Kingdom operator intervention is required.

The introduction of the Mollison ISC will affect the network functions of the Wood Street and Faraday ISCs. Much of the growth of ISD traffic will be diverted to the Mollison ISC and only traffic for which full facilities are essential will be connected to the UK ISCs offering such facilities.

The United Kingdom network

At present the United Kingdom national network is evolving from a 2-wire switched network based on fully interconnected zone-centres with subservient group-centres to a network based upon Group Switching Centres (GSC) interconnected via one or two links on a two-wire switched basis and backed by a 4-wire switched transit network for certain multilink traffic.

These changes follow from the introduction of Subscriber Trunk Dialling (STD) which also prepared the way for ISD by giving subscribers dialling access to distant centres via the trunk network. Each local exchange is connected to its GSC which is basically a two-wire switching unit. The GSC is linked to at least one secondary centre called a District Switching Centre

Fig. 1
The Mollison International Switching Centre equipped with crossbar switching system

(DSC) which is a 4-wire switching unit. In turn the DSC is connected to its Main Switching Centre (MSC), which has basically the same system design as the DSC, but is also fully connected to all other MSCs. The transmission standards are given in fig. 2. The Mollison ISC connexion to the basic network is shown in fig. 3.

The incoming and outgoing units

The network configurations of the incoming and outgoing units of the Mollison ISC are completely independent of each other. There are no bothway circuits of any description. No interconnection exists between the incoming and outgoing unit. The networks can therefore be described separately but there are a few facts common to both units which, in order to fully explain the network logic, will now be stated.

— Access on the international side has been limited to major traffic streams only. Initially this means access to European countries and four "intercontinental" destination countries. The European countries are France, Germany, Spain, Sweden, Norway, the Netherlands, Denmark, Italy, Belgium and Switzerland. There is also access to and from the USA, Canada, South Africa and Australia.

— As already stated there are no international assistance operator facilities provided. The units are primarily designed for calls directly dialled by subscribers or operators.

— No international automatic transit facilities are provided.

For the *incoming unit* the planned objective is to give access to all UK numbering groups. There are about 700 of these.

For the traffic terminal in London there are three basic modes of access. These are:

— via direct circuits using LD4 to exchanges within the central sector of London

— via sector switching centres serving the outer sectors of London. These routes employ AC11/MF2 as a general rule but DC3/MF2 is a possibility

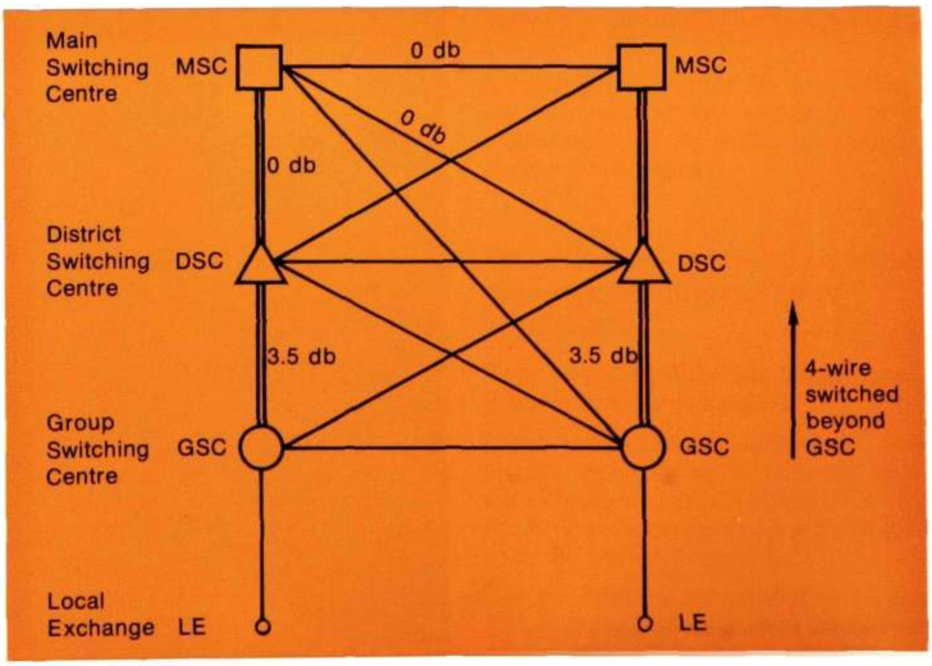


Fig. 2
UK transit network
Basic routes
Auxiliary routes

— via a trunk tandem exchange to which is connected all London exchanges. This will tend to be the second choice route and employs LD4 signalling techniques.

For the traffic terminal in the provinces, routes using AC11/MF2 are always specified and this policy permits direct routes (where traffic level justifies) to the group switching centres (primary centres) serving numbering groups. These routes may be high usage or fully provided. Alternatively, calls may be routed to terminal exchanges via the national transit network which comprises district (secondary) and main (tertiary) switching centres.

The international network will initially consist of CCITT 5 and CCITT 4 routes but already agreements have been reached to incorporate CCITT R2 into the circuit provisioning plans as well as augmenting the international network. Considerable re-configuration of the existing UK Post Office international network is also planned. Distant administrations have to "parcel" their traffic into the appropriate categories to ensure that the correct traffic facility is available at the incoming ISC in the UK. The planned network configuration for the incoming unit Phase I is given in fig. 4.

The *outgoing unit* is handling international subscriber-dialled traffic from the UK destined for countries with which the UK has major traffic streams (the same countries as listed for the incoming unit) originated in London and the provinces. The provision of outgoing ISD facilities at almost all of the UK group switching centres is planned. London and other major centres are already equipped and equipment provision programs for many cities and towns are in hand. All ISD traffic follows the same route as subscriber dialled national trunk traffic (STD) until the GSC is reached. At this point the destination country code is identified, the appropriate UK ISC selected and the process for call charging initiated.

ISD traffic originating in London will therefore be routed via London central switching units or via London sector switching centres. As with the incoming unit routes from central London units use LD4 signalling or sometimes DC3/MF2, routes from the outer sector switching centres in London use AC11/MF2.

ISD traffic from the provinces is routed via AC11/MF2 direct from GSCs or via the national transit network with the national transit network being the final choice in all cases. It may be useful to state that access to the major traffic streams is not confined to Mollison ISC and the trunking arrangements permit access to other UK ISCs for this class of traffic.

The network configuration for the outgoing unit is shown in fig. 5.

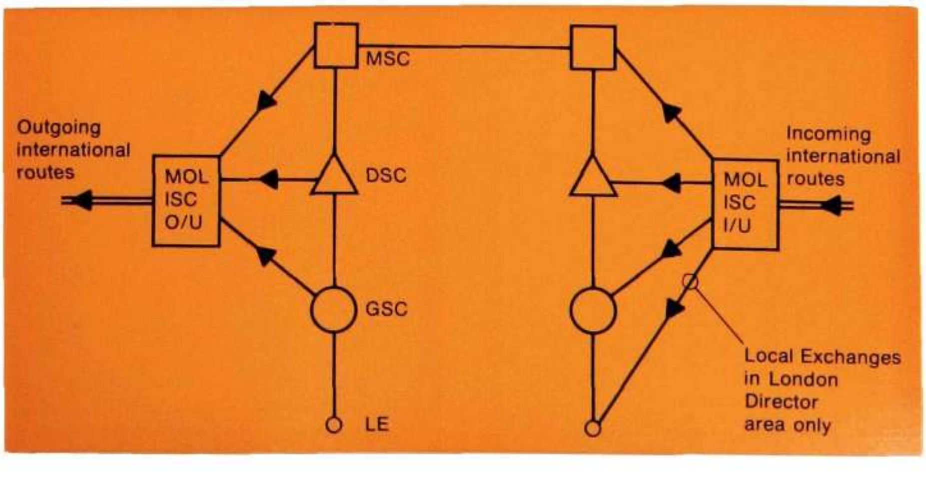


Fig. 3
Mollison ISC connexions to basic network

Linkup of Stag Lane ITSC with the national and international network

Stag Lane is located some 16 Km from central London. Since approx. 70% of all telephone traffic to and from the UK is terminated or originated within central London it is thus out of centre of the traffic density. To connect calls to and from London a large number of PCM systems are used to minimize cable needs.

To connect calls to and from the provinces HF systems are employed.

To interconnect the ISCs at Stag Lane with coast and earth stations, dedicated HF hypergroups are assigned for international services. The Stag Lane repeater station will be capable of providing terminations for about 17,000 international circuits which include all the international telephone circuits at Stag Lane plus in addition leased circuits and circuits for other special requirements. The ultimate line capacity for all purposes is expected to be provided by 70 hypergroups carried by 24 ×12 MHz line systems on 5 coaxial outlet cables and 550 24-channel PCM systems.

The LM Ericsson management of the project

Twelve departments in three LM Ericsson divisions, several United Kingdom subcontractors and Thorn-Ericsson, the LM Ericsson associated company in the United Kingdom, are involved in this project. A project manager with the overall technical and financial responsibility for the project was appointed. For each department a co-ordinator was appointed.

In the course of a project the management effort of the project leading team shifts between different areas. Whereas in the beginning most efforts have to be put into the design of the equipment specific for the project, the emphasis shifts at a later stage to monitor production, deliveries and installation activities.

To keep control of the project it was essential to establish one single communication channel between the project management at LM Ericsson and the counterpart at the Post Office. It was therefore agreed that all communication had to be channelled through those two project managers.

All meetings between representatives of the Post Office and LM Ericsson, even meetings of a purely technical nature, were attended by the Post Office and LM Ericsson project managers or their deputies since technical decisions cannot be made without considering the consequences on the time schedule and cost involved.

During the whole project the cooperation between all parties involved in both the Post Office and LM Ericsson has been excellent.

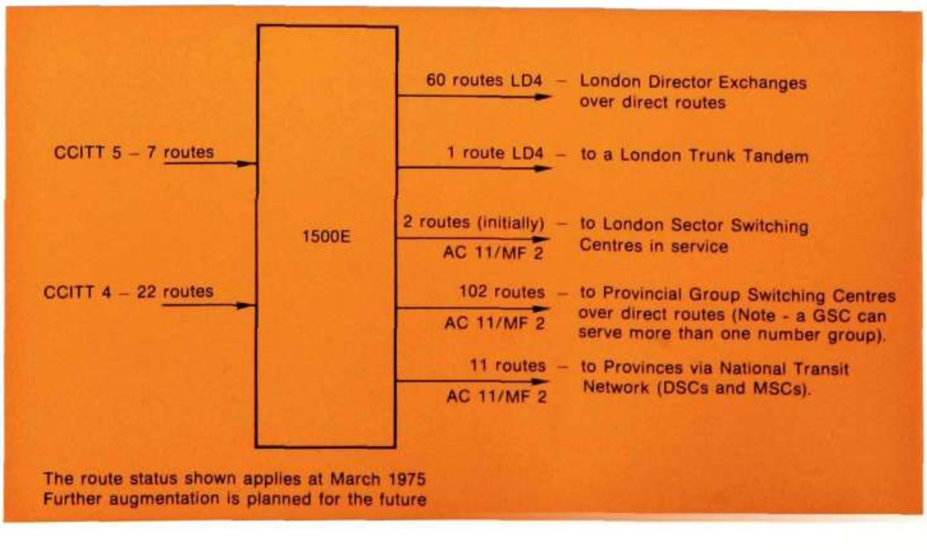


Fig. 4
Incoming unit phase 1. Outline network configuration

Not counting the project coordinators in the different LM Ericsson-departments, there were at the most 10 people involved in the project management team during the project.

Project schedule

A major project can be divided into several partly overlapping phases, each one of them important for acheiving overall success, but some more critical and vital than others:

— collection of information for design;
— design of floor plan lay-out;
— design of equipment specific for the project;
— verification of design;
— manufacture of equipment;
— production of installation documentation;
— installation and testing;
— final acceptance test.

Collection of information for design

For Mollison a very detailed specification of requirements of about 500 pages, which accompanied the Post Office tender specification, was the starting point upon which the design could be based. However, during the initial stages of the project numerous discussions were necessary between representatives of the Post Office and LM Ericsson to define details of the design. Due to the excellent assistance given by the Post Office engineering staff, the goal to have all detailed design specifications ready four months after order was achieved well ahead of schedule.

Design of floor plan lay-out

The final capacity and the phase in which the exchanges were to be extended from the initial capacity were known from the beginning of the project. This almost unique opportunity made it possible to give much consideration to minimizing the disturbances in traffic when extending the exchange and at the same time to optimize the floor lay-out from the maintenance point of view.

It was agreed between the Post Office and LM Ericsson that as far as possible all suites belonging to phase I should be fully installed to reduce extension work which would have to be done in a suite carrying traffic.

The equipment installed for phase I was confined to areas which in practice could be screened off, so as to prevent installation staff during installation of phase II and III interfering with equipment already in service.

To prevent congestion in the cable troughings, computer calculations of the main cable runways were made before the floor lay-out was presented to the Post Office for approval. At the same time calculations were made to define the average transmission loss and its distribution in the exchange.

Verification of design

The success of any project but particularly a project of the size of Mollison depends very much on designs being correct and that no, or very few,

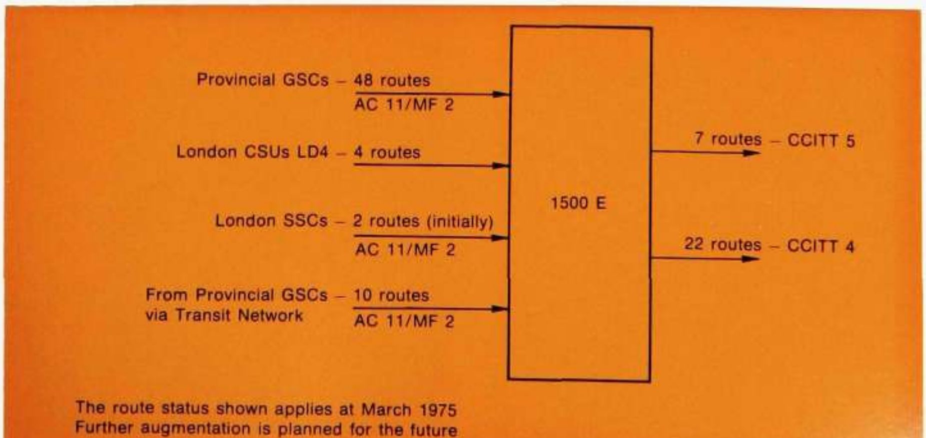


Fig. 5
Outgoing unit phase 1. Outline network configuration

modifications are carried out on the site. Therefore it was decided at a very early stage that a specially-assembled test model should be built to test the compatibility of the new designs with the UK network. It was not considered necessary to make similar compatibility tests with the international network since the design of the equipment for the international signalling systems employed was well known to LM Ericsson and proven in other markets. The model exchange consisted of five racks and contained factory-manufactured prototypes of all equipment necessary to interwork with the UK national network. The trunking diagram for the model exchange is shown in fig. 7.

Prior to and parallel with the compatibility tests at the model exchange in London, extensive laboratory tests and desk tests as well as subsystem tests were carried out at the LM Ericsson laboratories in Stockholm. Post Office engineers were actively involved particularly in the desk and the compatibility tests.

It should be noted that for the design test in the model exchange in London, only the quantity of equipment needed for the test model was at first ordered from the factory. This equipment was manufactured and factory-tested on line in LM Ericsson's production units in accordance with normal production routines.

The production of the equipment to be installed at Mollison was not ordered from the factory until the results of all tests were available and any necessary modifications had been made to the design and the production documentation.

Even though compatibility tests in a model exchange are by no means a guarantee that no faults in design will be detected later on, it is certainly an assurance for the project management that the design has been debugged to the largest possible extent and that the production documentation is correct.

The end result in the Mollison project was excellent. The modifications that had to be carried out on site before the equipment went into service were negligible.

Manufacture of equipment

Because of LM Ericsson equipment practice, in which practically all relay sets are fitted with plug-in units, the equipment can be manufactured in three phases:

Fig. 6
Intermediate distribution frame

1. iron and cable
2. racks
3. relay sets.

Iron, cable and racks are less dependent on the detailed project design and therefore to a large extent manufacturing can be carried out well in advance of the relay sets. The relay sets on the other hand are not needed on site until the start of the testing activities.

Production of installation documentation

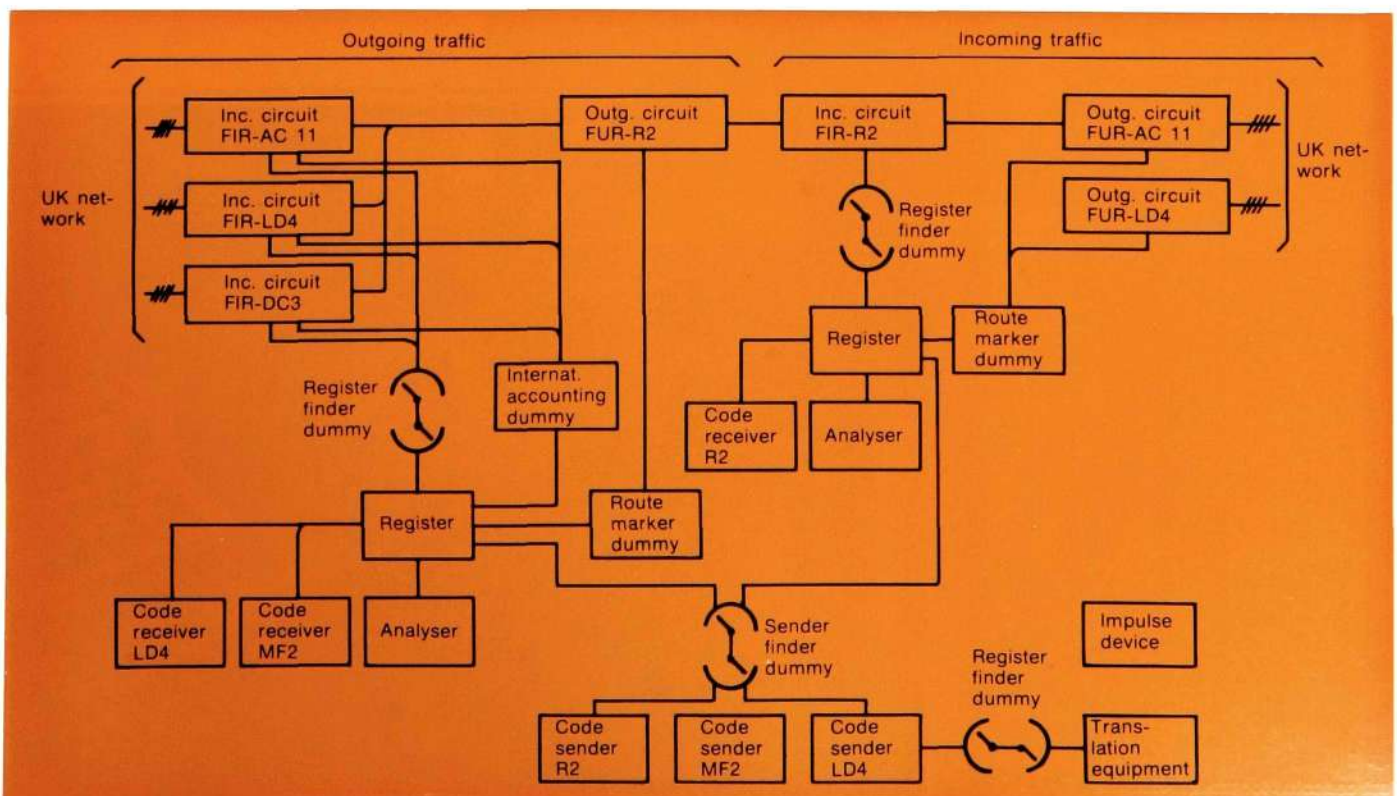
For this project more than 30,000 pages of installation documents were produced, two-thirds of which were produced with the aid of computers. Cable running list for 110,400 cables were automatically printed out. The cable length was calculated to be 2,875 km. Interconnection and grading documentation for approximately 4,300 racks was made up.

To minimize disturbances when extending the exchange, the group selector links were dimensioned from the beginning for ultimate traffic. No rearrangement will be necessary when extending the exchange. Register and code sender groups were graded for the contracted maximum size but equipped for the initial capacity only. This means of course that in the initial phase the grading design is not optimal and to compensate more equipment has to be provided initially. This slight disadvantage is more than offset by the reduction in disturbance of traffic flow during extension, an important factor very relevant to international networks.

Installation and testing

Most of the installation staff was locally employed for this contract. All the locally-employed staff had to be trained, as Mollison was the first public crossbar telephone exchange of LM Ericsson design installed in the UK. Each member of the installation staff had to go through a two-week intensive course at the locally-established training school before he or she was employed in actual installation work. This was necessary to achieve the high standard of installation set by LM Ericsson.

Fig. 7
Trunking diagram. Test model for Mollison project



The locally-employed testers were trained partly at the LM Ericsson international training centre in Stockholm and partly on site in London.

Final acceptance test

Procedures for the final acceptance test were agreed upon well in advance between representatives from the Post Office and LM Ericsson.

During the installation and testing of the exchange PO staff was continuously monitoring all the LM Ericsson activities.

Additionally the PO staff assigned to maintenance duties were actively involved in the functional testing of the exchange and thereby more able to familiarize themselves with equipment and documentation.

Prior to the start of the final acceptance test the PO staff had been satisfied that all the functional and compatibility tests had been carried out in accordance with LM Ericsson test instructions.

The final acceptance test, which was carried out jointly with the PO, has therefore to be seen as a final confirmation of the switching performance of the exchange.

During the final acceptance test for phase I about 270,000 calls were made through the switch blocks.

Technical characteristics of the Mollison ISC

The ARM 20 system, the register organization ANA 12 as well as the LM Ericsson design of the IMC have been described in previous LM Ericsson publications[1–7]. Therefore these designs will not be gone into in any great detail in this chapter.

THE SWITCHING SYSTEM

The switching systems for the two exchange units (incoming and outgoing) are completely separated. For simplified diagrams see fig. 9.

Both are of the ARM 20 crossbar type. The incoming unit has a 5-wire switching matrix whereas the outgoing unit has a 10-wire switching matrix.

Full availability exists from all 8,000 inlets to all 8,000 outlets within a unit.

Fig. 8
Test consoles for measurements of the national and international circuits

The control and supervision of switching through the exchange is vested in the route markers and markers which are called upon by a register as soon as sufficient digital information concerning the routing of the call has been received and stored. The register subsystem employed at Mollison is of the ANA 12 type.

Several different register signalling methods in the transmission and in the reception paths can be used from one and the same register.

The flexibility of the ANA 12 register subsystem is such that in Mollison only one type of register is used, i.e. the hardware is the same independent of whether the register is in the register group for signalling system CCITT No. 4 or any other register group. Only the "programming" of the registers as well as the code senders and receivers connected to it differ, depending on in which group it is employed.

REGISTER SIGNALLING AND SIGNALLING SYSTEMS

Five register signalling systems are used to meet the interface requirements of the exchange. Of these, three are international, CCITT No. 4, 5 and R2, and two national, LD4 and MF2.

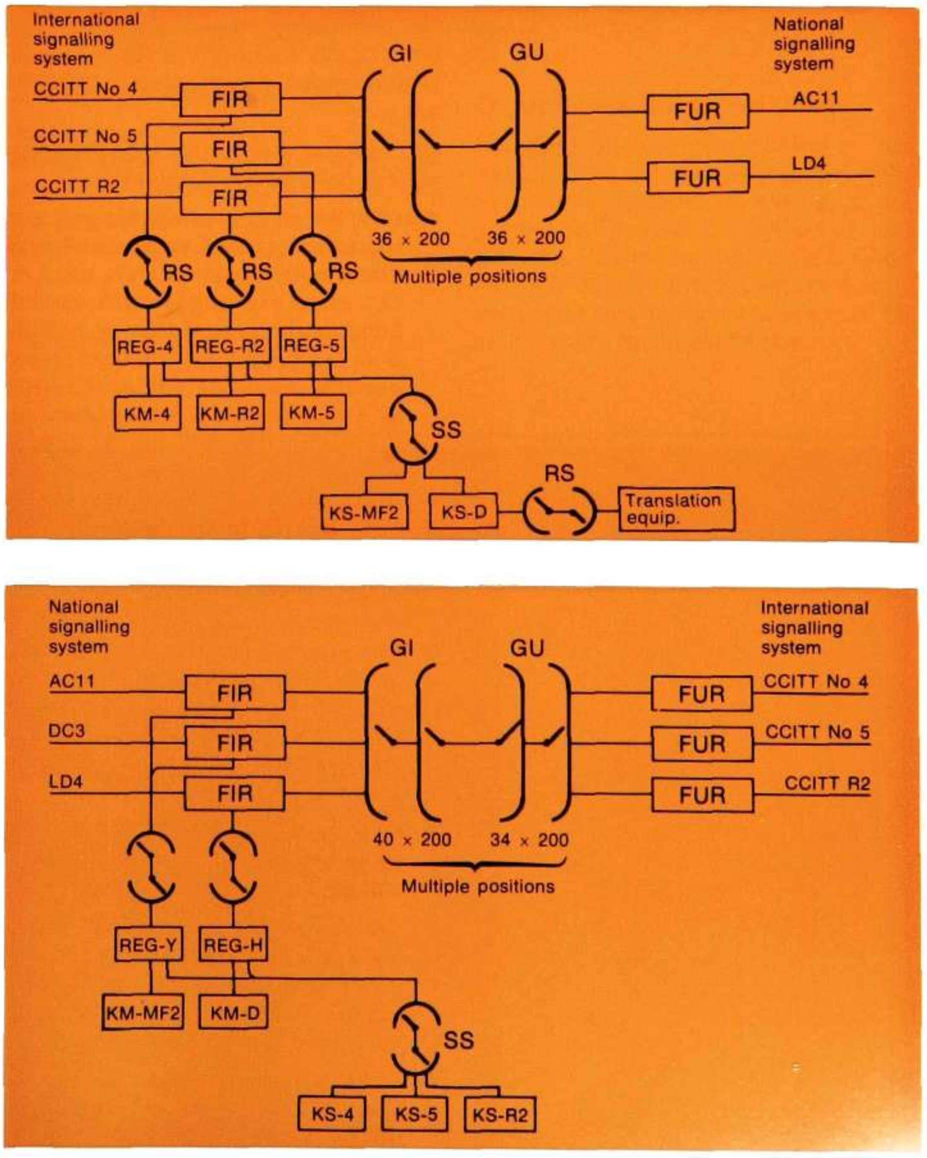


Fig. 9
Incoming unit (top) and outgoing unit. Simplified trunking diagrams

Each incoming and outgoing circuits is terminated on a line relay set (FIR or FUR) adapted to the particular signalling system used on the route. The incoming line relay sets are via register finders (RS) connected to a register group (REG) serving one or more signalling systems.

As shown in the trunking diagram in fig. 9 each register can connect itself to to the appropriate code sender (KS) for signalling on the forward transmission path.

The *international routes* to and from Mollison ISC can be divided into those serving European countries (continental) and those serving other parts of the world (intercontinental).

On continental routes signalling systems CCITT 4 and CCITT R2 and on intercontinental routes system CCITT 5 are used.

On *national routes* the following signalling systems are employed:

- LD4, which is a combined line and register signalling system with loop disconnect signalling. It is used on circuits to exchanges within central London and to and from trunk tandem exchanges serving the London director area. The circuit is seized by a loop phantom arrangement on the 4-wire line and digital signals are received by the register or sent to the line in loop disconnect pulses at the rate of ten per second.
- DC3 is a 4-wire phantom line signalling system used from London Group Switching Centres (GSC). It has a limited number of signals and is designed for use with the MF2 register signalling system. When used, it will be as an alternative to LD4, serving the London director area.
- MF2 is a multifrequency register signalling system. In this system signals are sent in 2 out of 6.

  On seizure of the register, backward guard is sent until a forward guard is received, and then there follows a compelled sequence of backward and forward signals.
- AC11 is a line signalling system used to and from the provincial transit network. The system uses 1-VF 2280 Hz line signals but digital and interregister signals are sent in the MF2 code.

The International Maintenance Centre (IMC)

The Mollison IMC consists of an International Transmission Maintenance Centre (ITMC) and an International Switching Maintenance Centre (ISMC).

International Transmission Maintenance Centre (ITMC)

The main function of the ITMC consists of circuit testing and fault reporting. The following equipment has been provided for the ITMC:

Supervision Consoles

On the supervision consoles an indication is given when a fault occurs on a circuit and the type of fault is identified.

Test Jack Frames (TJF)

All circuits are connected via the TJF to the line relay sets in the exchange. Circuits are easily accessible for maintenance purposes.

Access Selector (AS)

The AS, which has been specially designed for this project, gives automatic access from the test consoles in the ITMC to all line relay sets in the exchange. Three different access points can be selected for each circuit, i.e. line access, circuit access and parallel access. The AS is also accessible from the automatic transmission measuring equipment (ATME 2).

The access selector is mainly used for:

— transmission measurement from test consoles
— functional tests of echo suppressors
— monitoring of circuits
— checking whether the line relay set is occupied or blocked
— recording of line signals
— blocking of circuits.

Test Consoles (TC)

Each of the 24 test consoles is provided with two control panels and two instrument panels. They are used for manual and semi-automatic measurements and tests of the national and international circuits connected to the exchange. Testing can also be performed with the aid of an automatic exchange tester connected to the test consoles. For automatic line access the access selector is used. A number of PABX circuits, omnibus circuits and international service circuits are connected to each test console.

International Switching Maintenance Centre (ISMC)

All common control equipment and the switch blocks are supervised in the ISMC. The following equipment has been provided for the ISMC:

Central Alarm Equipment (CLU)

The CLU signals visibly and audibly abnormal conditions in the exchange which are differentiated in three levels. Blocking of devices and circuits are signalled as supervisory alarms.

Service Alarm (DL)

The service quality of all common control equipment e.g. markers, group markers, registers and code senders is automatically supervised by the service alarm equipment. The supervision is carried out by comparing the number of occupations with the number of forced releases in each group of device. If the present permitted fault level is exceeded, alarm is given in the supervisory console of the ISMC.

Route Alarm (VL)

Each route is supervised and an alarm is given if the number of blocked circuits within the route surpasses a preset level. The alarm is signalled to CLU. Alarm is furthermore given in the observation console where it is also indicated which route has generated the alarm.

Centralograph Equipment (CPH)

Faults in the common control of the switch block are recorded on the CPH equipment. Details of the fault are printed out indicating the type of fault and the equipment connected when the fault occurred. The CPH printout is then used by the maintenance staff for fault tracing in the exchange.

Fig. 10
Installation work

AUXILIARY EQUIPMENT PROVIDED FOR THE PROJECT

Traffic Measuring Equipment

One electronic traffic measuring device of type MET2 has been provided for each unit. For a more detailed description of MET2, see the article in Ericsson Review No. 3, 1972[8].

Service Observation Equipment (SOE)

The service observation equipment which is connected to the incoming line relay sets is intended for supervision of live traffic. In the SOE register and line signals appearing during the setting up of a call are recorded. This information is displayed on the panel in the SOE. In the SOE the address digits are analysed so that, if desired, traffic to certain countries only can be supervised. The SOE is considered to be a very useful tool for statistical purposes.

POWER SUPPLIES

The exchange power plant provided for Mollison is of the LM Ericsson system BZB with an installed capacity of 8,800 A and a normal operating voltage of 48 V DC. Separate plants built up of the following main equipment units are provided for the outgoing and incoming units respectively.

- thyristor rectifiers
- control rack cabinet
- distribution rack cabinet
- battery rack cabinets.

The batteries are built up of high performance enclosed planté cells.

Cables are used to distribute the power from the power room to the switching equipment on the apparatus floor. For a more detailed description of the power supply system see Ericsson Review No. 4, 1968[9].

The computer part of the international accounting equipment is provided with an LM Ericsson no-break power supply consisting of solid-state single and three-phase inverters that are fed from the 48 V DC exchange power plant. The single-phase inverter is provided with a solid-state switch for uninterrupted changeover to the main supply.

INTERNATIONAL ACCOUNTING EQUIPMENT (AVR)

The international accounting equipment keeps record of the accumulated effective call duration time for all international traffic outgoing from the Mollison unit. This record is used for accounting purpose between administrations. The accounting is carried out separately for each route destination.

A route destination (R-D) is defined as the combination of the outgoing international route and the destination country. During the setting up of a call, all information about the R-D is available in the register organization of the ARM 20.

The answer signal (B-answer) and the clear-forward signal which are necessary to determine the effective call duration time are available in the incoming line relay set (FIR) in the outgoing unit. Therefore the accounting equipment has interface both to the register organization and to the incoming line relay sets.

The accounting system used at Mollison is designed to serve simultaneously a maximum of 8,000 incoming circuits and 198 route destinations. The number of outgoing circuits is not relevant. By scanning all incoming line relay sets at appropriate intervals the specified accounting accuracy is achieved.

Hardware system

The hardware of the accounting system comprises 3 main parts:

The switching equipment which consists of the accounting circuits in the exchange including switch matrixes common to groups of 1,000 incoming line relay sets and 198 R-D outlets.

The interface equipment which is physically located in the switching room. It consists basically of pulse generator and receiver units. Built in check-functions are continuously monitoring the interface equipment.

The computer equipment which is located in a computer room. It consists of 2 identical LM Ericsson UAC 1610 computer systems and two magnetic tape units.

A switch unit is provided by which any of the two or both magnetic tape units can be connected to the active computer, which handles the accounting. A panel facilitates monitoring of computer operation and manual switchover.

Software system

The software comprises 3 functional parts:

The on-line realtime system of the computer analyses all 8,000 incoming circuits. Scanning is performed at appropriate intervals. Information will then be stored on counters in a core store for one calender month in number of call periods to each route destination and divided in 3 different tariffs depending on the time of the day. (See fig. 11 for principles of scanning.) At the the end of the month the information will be recorded on magnetic tape and the information on the counters erased.

In addition for security reasons the information on the tariff counter is dumped daily to magnetic tape.

During normal operation the computer will perform routine checks of the equipment and maintain alarm frequency counters.

If the preset error limit should be exceeded, an alarm is given to the central alarm system in the exchange. Error printout can be obtained.

The service system handles all printouts, changes of route destinations, tariff pattern and various system constants.

All service functions normally need intervention at the computer console, typewriter or paper reader.

The maintenance system provides facilities for normal testing of the accounting function in all incoming line relay sets.

Reliability

To provide a high degree of reliability, the computer system is duplicated. One computer system is active and the other normally functions as passive

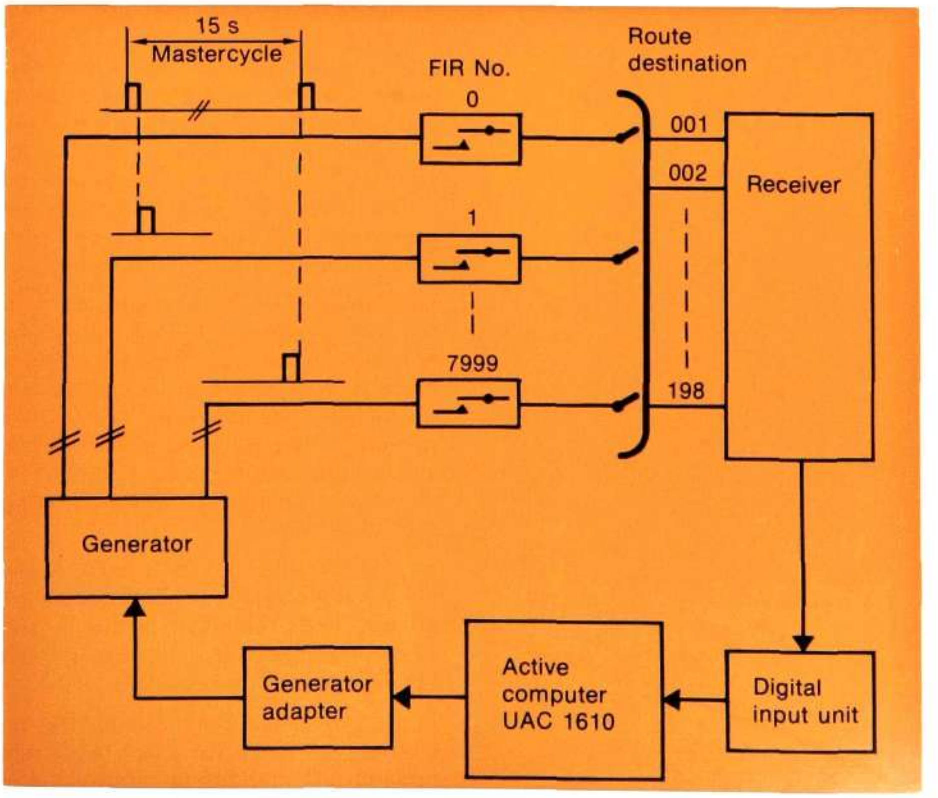


Fig. 11
Scanning principle for accounting equipment

stand-by. Both computers run a program for testing the hardware.

If, because of a defect in the active system, switchover is carried out, the interface equipment is switched to the stand-by computer which will be made active and perform the accounting.

Monthly processing of the record is done in an off line computer. This record consists of day-by-day accumulated data, recorded identically on the two magnetic tapes of which any can be used for processing. Normally the accumulated total for the month is read from the tape. If, however, switchover to the stand-by computer has occurred during the actual calender month the subtotals from both computers are added to obtain a monthly total for each accounting subject.

Conclusions

Phase I of the Mollison International Switching Centre which forms part of the Stag Lane International Telephone Service Centre situated 16 km from central London was successfully brought into service in October 1974.

In accordance with the Post Office planning strategy the exchange caters primarily for international subscriber dialled telephone traffic originating and terminating in the United Kingdom. At the end of 1974 approx. 65% of all international telephone calls originated in the United Kingdom were directly dialled by the subscribers and this class of tariff is rapidly increasing.

The introduction of Mollison ISC into the network affects the network function of the two existing ISCs since much of the growth in ISD traffic will be diverted via Mollison. Only traffic for which full facilities are essential will be directed to United Kingdom International Switching Centres offering such facilities.

With 25,000 ARM crossbar multiple positions, equivalent to 150,000 local exchange lines, Mollison is the largest single international exchange project LM Ericsson has undertaken.

In the contracted final capacity the exchange will comprise 4,300 racks and provide terminations for approximately 23,000 national and international telephone circuits.

A large international maintenance centre to supervise the performance of the transmission network and the switching equipment has been provided.

The success of this public crossbar exchange project — the first for LM Ericsson in the United Kingdom — has been a result of the joint effort of all those involved both within the United Kingdom Post Office and LM Ericsson.

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Long Distance Traffic in Mexico

Sune Lindblad and Bengt Johansson

The article deals with the development of the Mexican long distance traffic (LD), the network for which is to more than 80 % built up with LM Ericsson transit exchanges ARM 20, ARM 50 and AKE 13. These systems have been described earlier[1, 2], so that the emphasis in this article is laid on the development of the LD network and the adaptation of the exchanges to the conditions existing in Mexico.

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Mexico is a country with an ancient civilization with many relics from the Pre-Columbian epoch and from the Spanish colonial period. Since the beginning of the century the country has undergone a rapid development on all fronts.

A map of the country is shown in fig. 1. Mexico covers an area of about a quarter of that covered by the USA. Practically the whole of the country consists of a high plateau in which certain areas are devoted to large scale agriculture. Fruit, coffee and cocoa are also grown on the eastern and western coastal slopes. The population today is just over 50 million inhabitants.

A rapid industrialization has taken place. Mining, iron and steel works and the extraction of oil are some examples of today's multifarious industry. A vigorous workshop industry has also developed. For example, there are a number of car manufactory factories and the telecommunication factory Teleindustria Ericsson, S.A., which is partly owned by LM Ericsson.

In the heart of the country lies the capital city Mexico D.F. or Mexico City, the cultural and industrial centre of the country with 9.2 million inhabitants. Other important centres are the industrial towns of Guadalajara, Monterrey, Puebla and Veracruz.

In 1926 LM Ericsson's Mexican subsidiary company, Empresa de Teléfonos Ericsson, S.A., obtained a concession for the operation of the national and international trunk traffic in Mexico, a concession that the company retained and exploited until 1948. The operation of all telephone traffic was taken over by a company formed for the purpose, Teléfonos de México, S.A., in which LM Ericsson was one of the interested parties. In 1958 the company passed over completely to Mexican ownership.

Fig. 1
Map of Mexico

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Development of the telephone traffic

Mexico has a long telephone history. As long ago as 1883 the first international telephone call was exchanged between Mexico and Texas, USA. This was a manually connected call between the border towns of Tamaulipas and Brownsville, a distance of 3.5 km. Thus Mexico came into the picture very early on as regards international telephone connections. A brief resumé of developments since then is given below.

In 1914 manual traffic with Washington was introduced, and in 1927 with London and Canada. All LD traffic was handled manually until 1959, when the first ARM 20 exchange was taken into service in Puebla. ARM traffic was initially semi-automatic, but with the introduction of Toll Ticketing in 1965 the national traffic was gradually fully automatized. The LD network has been expanded very rapidly — 19% per year during the last five-year period. In 1970 fully automatic traffic, via an ARM 20 exchange in Toluca, was introduced with USA—CANADA, which constitutes a common automatization area. This was an extremely advanced and early step, since the traffic with Canada and the USA constitutes about 90% of the total Mexican international traffic.

A total of 21 ARM exchanges and one AKE 13 exchange, with together 65,680 multiple positions, have been in service since January 1st, 1975.

Network structure

The structure of the Mexican telephone network is shown in principle in figs. 2 and 3. The exchanges in the network are divided up into the following main types:

(1) Local exchanges OT, for a total of just over two million subscribers
(2) Primary centres, CZ, about 220
(3) Secondary centres, CA, about 60
(4) Tertiary centres, CR, a total of 15, of which three also handle international traffic to USA—CANADA
(5) The national centre, CN, in Mexico City

The long distance network is to a great extent built up of carrier systems over radio links or physical lines. The total number of channel kilometres now amounts to about 5,700,000 km.

When extending the telephone network, one of the most important goals, even during the semi-automatic phase, was to eliminate waiting times but nevertheless maintain good utilization. Today Mexico has a network with well developed alternative routing, full availability in the transit exchanges and limited single operator working, which has made it possible to eliminate waiting times in an economic way while maintaining good line utilization.

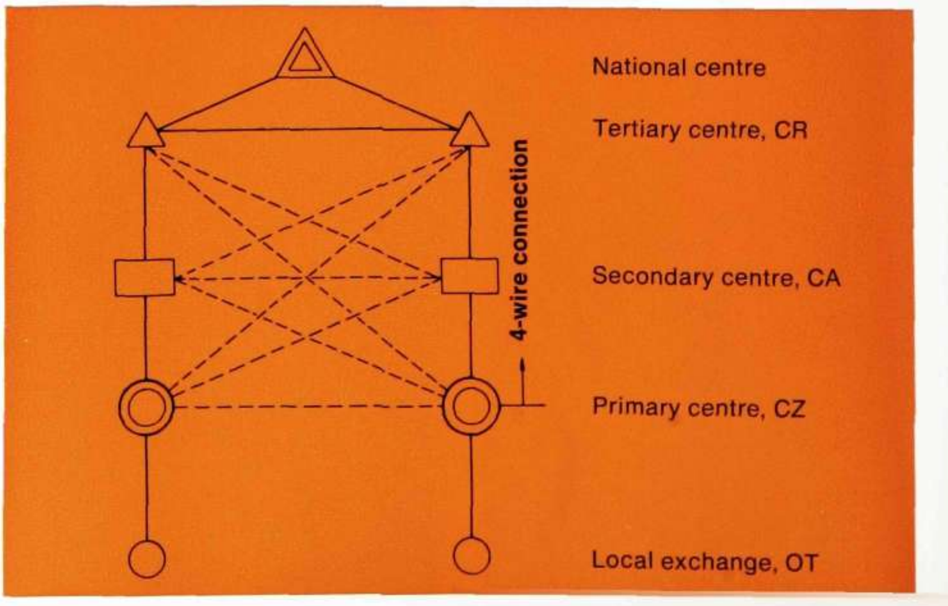


Fig. 2
Network structure in Mexico
———— **Low-usage routes**
– – – – **Normally high-usage routes**

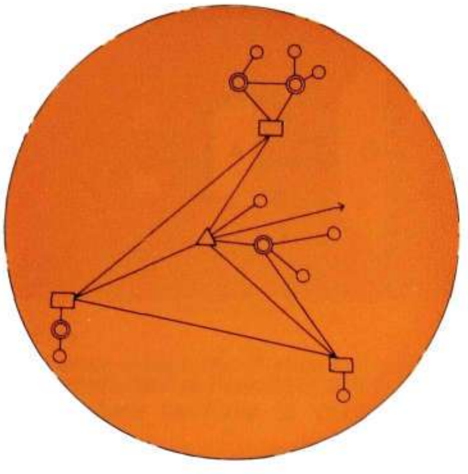


Fig. 3
Network structure within a tertiary area

- △ **Tertiary centres CR, connected to each others and also to certain secondary centres in other regions**
- ▭ **Secondary centres CA, also connected to certain tertiary and secondary centres in other regions**
- ◎ **Primary centres CZ**
- ○ **Local exchanges OT**

Fig. 4
Trunking diagram for the AKE 13 exchange in San Juan

Transit exchanges ARM 20 and ARM 50

ARM exchanges handle national traffic, ARM 20 being used at all levels and ARM 50 only as primary centres in small primary groups. Three ARM 20 exchanges also handle international traffic to USA—Canada.

The ARM exchanges interwork with several types of LM Ericsson and ITT urban and rural exchanges and also with transit exchanges of ITT type PC-1000 and LM Ericsson type AKE 13 (SPC).

MFC signalling is mainly used for interworking with the local exchanges. When interworking with older types of local exchanges of both LM Ericsson and ITT design with other signalling systems, the conversion to MFC is normally arranged at the local exchange.

All automatic national LD traffic and all international traffic is charged on the basis of specified call information. Consequently the ARM exchanges are equipped with fully automatic, centralized toll ticketing equipment.

Stored Program Controlled transit exchange AKE 13

In the capital, Mexico City, the need for transit exchange equipment increases very rapidly and this makes great demands on the final capacity of the exchanges. It is for this reason that the Administration ordered an SPC exchange AKE 13. This exchange, the trunking diagram for which is shown in fig. 4, was connected in at San Juan, Mexico City, in 1973 and was the first SPC exchange to be brought into service in Latin America. Together with two existing ARM exchanges it constitutes the national centre in Mexico City and has lines to North, Central and South America and satellite connection with Europe and Japan. At present the SPC exchange contains 3,600 in-

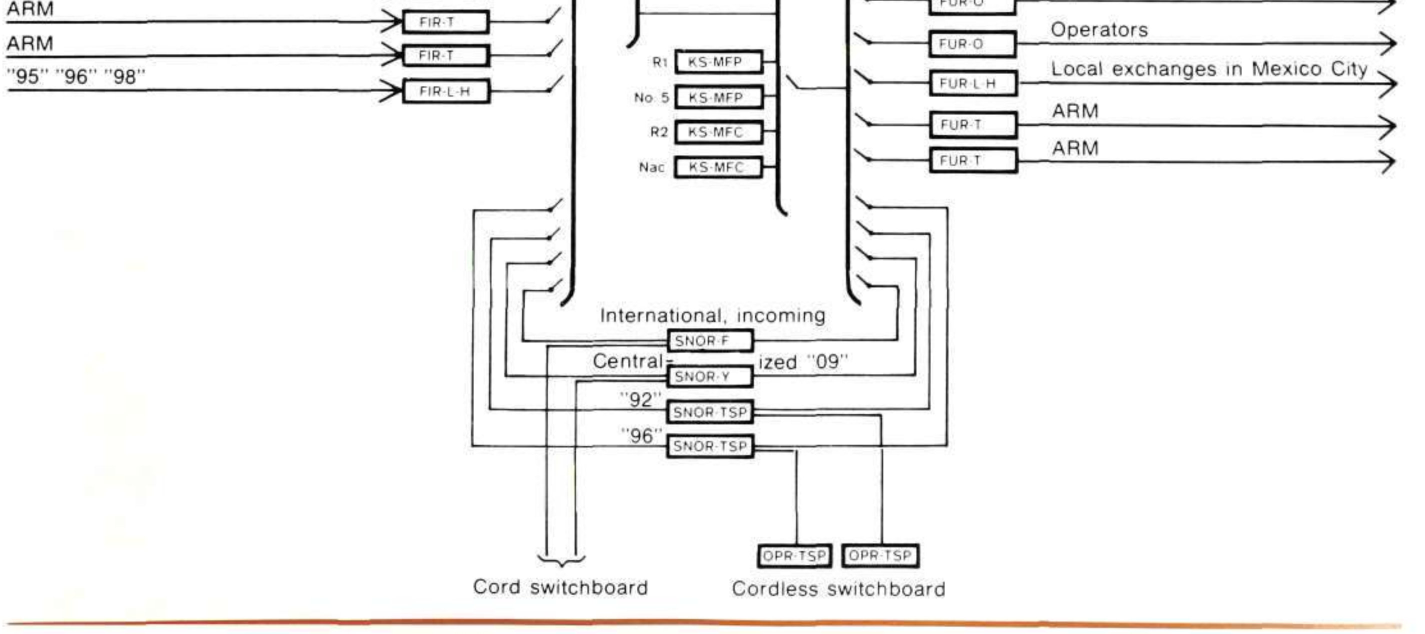
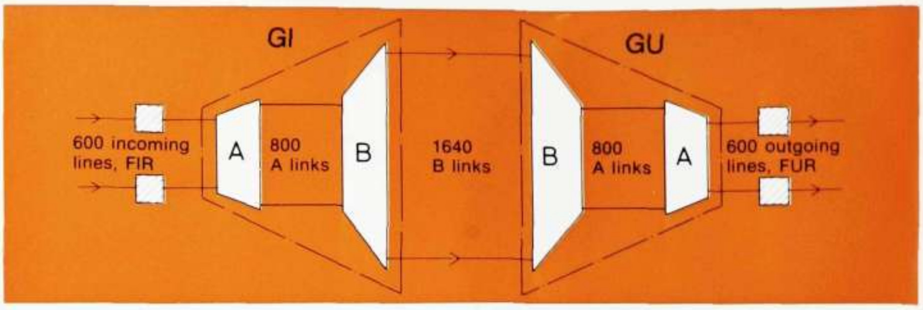


Fig. 6
Switching stages GI and GU interconnected by 1,640 B links



coming and 4,200 outgoing multiple positions and two duplicated processors which operate in a multiprocessor arrangement.

To a great extent it is on the administrative plane, especially as regards operation and maintenance functions, that AKE 13 offers a series of new and valuable facilities. Above all these consist of an automatization and centralization of the operation and maintenance functions and an effective supervision of the telephone plant and the associated network, for maintaining a thoroughly good service and transmission quality. For this purpose there is a control room with input and output devices for providing efficient communication between the operating and maintenance staff and the AKE equipment, in the form of electric typewriters, tape reader, tape punch and magnetic tape units, fig. 5.

The switching stages are one-way and are built up of partial stages for incoming traffic GI and outgoing traffic GU, which are interconnected with B links, fig. 6. Each partial stage has 600 inputs, 800 A links and 1,640 B links. The selector stage is dimensioned for high input load with a high degree of insensitivity to overload and uneven loading.

MFC signalling and CCITT signalling systems No. 5, R1 and R2 are all used in the exchange. One of the advantages of AKE 13 is that other signalling systems can easily be included if necessary.

As Toll Ticketing is used, the exchange is equipped with magnetic tape units for storing the required call charging information. Automatic transmission measuring equipment is also being introduced.

Long distance traffic in Mexico City

Mexico City constitutes the central point for the LD traffic. Owing to the size and geographical extent of the city, with about 85 local exchanges, the handling of the LD traffic has been divided up among several exchanges. The traffic routing applied provides good line utilization.

Mexico City has the following (1—8) exchange systems and other LD equip-

Fig. 5
Control room in San Juan with typewriter, for communication between service staff and the plant, and the control panel for the processors

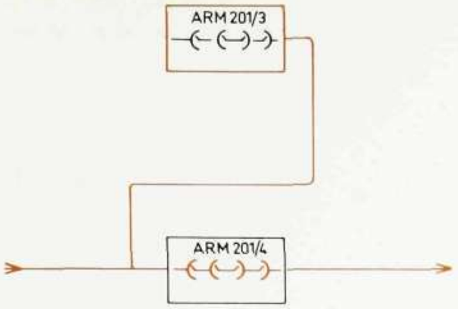


Fig. 7 a
Distribution of the traffic via expansion stage ARM 201/4 to the local exchanges in Mexico City

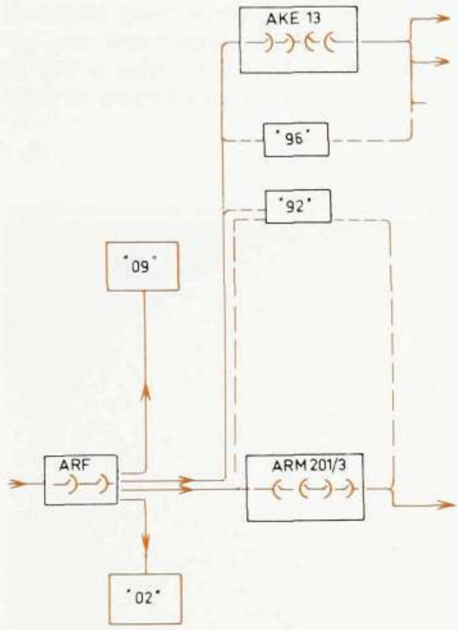


Fig. 7 b
Distribution of the traffic from the AGF exchanges and a number of ARF exchanges via distribution stage ARF

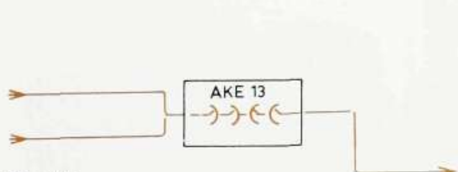


Fig. 7 c
Terminating national and international traffic from AKE 13 is distributed over direct routes to each local exchange

ment, see fig. 7. The equipment is installed in two buildings, the AKE 13 with the associated operator equipment in San Juan, fig. 8, and all other equipment in Victoria. The buildings are situated in the centre of the city at a distance of 1 km from each other.

(1) Transit exchange AKE 13 serves completely or partly a successively increasing number of national routes, and all international routes to and from North, Central and South America, Europe and Japan. There are also direct routes to all the local exchanges in Mexico City.
(2) Transit exchange ARM 201/3 serves completely or partly a certain number of national routes.
(3) Expansion stage ARM 201/4 serves terminating high-usage routes from the national network and also a route from transit stage ARM 201/3. The traffic is distributed via the expansion stage over outgoing direct routes to the approximately 85 local exchanges in the city, see fig. 7a.
(4) Distribution stage ARF, for the distribution of the outgoing traffic from AGF exchanges and a number of ARF exchanges in Mexico City. This unit distributes national traffic to ARM 201/3 and national and international traffic to AKE 13. In addition, telephone operator services (92 and 96) are requested and national (02) and international (69) positions are called via this distribution stage. The remaining exchanges in the city are directly connected to the AKE 13 unit without a distribution stage, see fig. 7b.
(5) Traffic service positions NAT-TSP "92". For automatic national calls these positions provide assistance in connection with personal calls and the reversing of call charges.
(6) Traffic service positions INT-TSP "96" provide the same service as in (5) but for automatic international calls to USA—Canada.
(7) Manual positions "02" for ordering and setting up national calls, primarily delay traffic and traffic to manual exchanges.

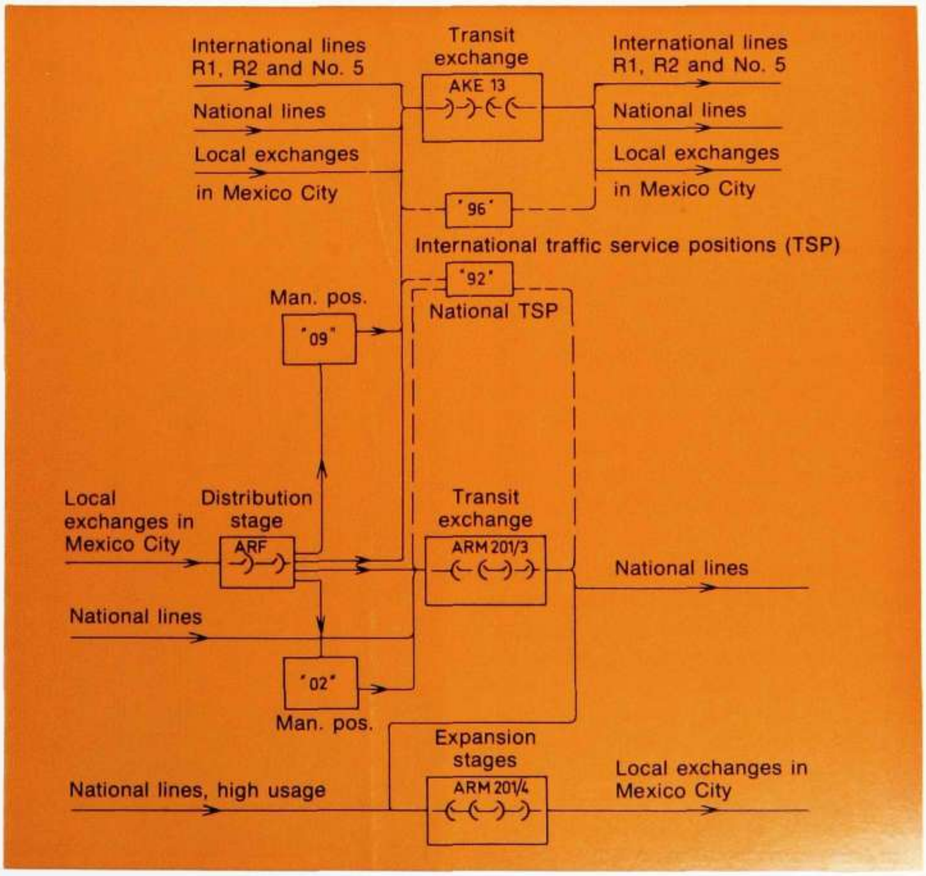


Fig. 7
The distribution, in principle, of the LD traffic in San Juan and Mexico City

(8) Manual positions "09" for ordering and setting up international calls.

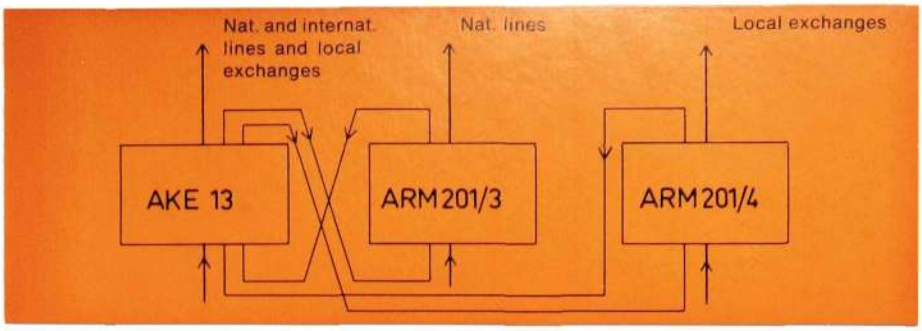
Terminating traffic from AKE 13 is distributed over outgoing direct routes to each local exchange in Mexico City, fig. 7c, in a corresponding way to that from the expansion stage ARM 201/4, see (3).

Overflow routes have been included between the stages in order to increase the utilization on both the national LD lines and the direct routes to the local exchanges, see fig. 9. Thus there are routes in both directions between AKE 13 and ARM 201/3. If, for example, all lines on a route are engaged in one of the stages, rerouting takes place via the overflow route to the other stages, where a search is made for a free line on the wanted route.

Alternative routing is also applied in order to achieve the best possible utilization of the national lines. When all lines on a high usage route are engaged, as a first alternative a line is selected on the wanted route to AKE 13.

Fig. 8
San Juan exchange in Mexico City

Fig. 9
Overflow routes between different stages



Long distance traffic in the rest of the country

The automatized local exchanges in the rest of the country are connected to transit exchanges, system ARM, or in some cases to another system for fully automatic LD traffic.

The LD network is so designed that subscribers connected to manual exchanges are also able to get the full benefit of automatization. Thus telephone operators at a place with manual operation are connected to the nearest automatic transit exchange, and with a push-button set they can connect in to the whole of the automatic network. An incoming LD call to a manual local exchange is also connected up automatically to the operator in that exchange, who then connects up the call to the wanted subscriber.

International traffic

There are four international exchanges in Mexico. Three of these are ARM 20 exchanges, which are installed in Monterrey, Chihuahua and Hermosillo. They are used only for automatic traffic with USA—Canada and are designated CT3 exchanges, in accordance with CCITT nomenclature. The fourth, the AKE 13 exchange at San Juan, which has already been discussed, handles the traffic with the whole world and is called a CT2 exchange. All four exchanges have international ordering and traffic service positions, but all other international operator services are centralized in the exchange at San Juan (fig. 8).

Numbering

Four to seven digits are used in Mexico for the subscriber numbers. These numbers are used alone when calling subscribers in the same numbering area, which usually coincides with the primary group.

When calling a subscriber not in the same numbering area there is always an additional trunk code, which consists of one to four digits. The numbering scheme is arranged so that the national or significant number, which is the combination of the subscriber number and the trunk code, always contains eight digits.

Trunk code	*Subscriber number*
A	BCDEFGH
AB	CDEFGH
ABC	DEFGH
ABCD	EFGH

Apart from these numbers there is an additional two-digit trunk prefix, so that altogether a subscriber has to dial ten digits. The first digit of the prefix is always 9, but the second digit, the traffic class digit, varies according to the traffic case. In this connection the prefix also differentiates between traffic cases for international and national traffic as is shown in the following list.

Trunk prefix	*Traffic case*
91	Fully automatic national traffic without TSP service
92	Ditto with TSP service
93	Spare
94	Spare
95	International traffic to USA—Canada without TSP service
96	Ditto with TSP service
97	Spare
98	International traffic to the rest of the world without TSP service
99	Spare
90	Spare

For traffic routing technical reasons the traffic class digit has been used to separate the traffic to USA—Canada from the traffic to the rest of the world. As has been mentioned before, the traffic to these two countries constitutes 90% of the total international traffic. The traffic with the rest of the world, on the other hand, is handled only by the AKE exchange in Mexico City.

The international number for traffic towards USA—Canada does not include a country code, since this traffic direction has been separated from the traffic to the rest of the world by a traffic class digit in accordance with the above list. When calling USA—Canada a subscriber dials 12 digits, two as the trunk prefix, three as the numbering area code in USA—Canada, three as the exchange code and four as the subscriber number. For international traffic to other countries a subscriber must dial *the trunk prefix + the country code +* the national number.

Special services usually have a two-digit number beginning with 0, but there are certain services, such as the fire brigade, rescue service etc., that have normal subscriber numbers.

Transmission plan

In order to permit an economic transmission plan, 4-wire connections are used in the transit exchanges right down to the lowest level, i.e. the primary centres. The plan satisfies the requirements of CCITT Recommendation G121. This means that the maximum permissible reference equivalent in the national network up to the international exchange is 21 dB for sending (SRE) and 12 dB for receiving (RRE). A variant of the method with distributed loss, *which is generally used, has been applied in Mexico. This variant is* advantageous from the point of view of transmission loss. As may be seen from fig. 10, in Mexico the loss in the transit exchange where the changeover from 4-wire to 2-wire occurs is 0 dB instead of 2 dB, as in the case of the method normally used, on condition that the loss between this transit exchange and the subordinate local exchange is at least 2 dB. This allows a correspondingly higher loss in the 2-wire network up to the subscribers than would be possible with the method generally used. This extra loss can most suitably be allocated to the 2-wire trunk and subscriber network, which will thus be cheaper.

In order to be able to realize this transmission plan the 4-wire exchanges are provided with attenuators having higher attenuation than normal. When 4-wire and 2-wire lines are interconnected these attenuators are taken out of *circuit and thus provide the extra* contribution of 2 dB that is required according to the transmission plan.

The 4-wire transit exchanges are provided with facilities for individually balancing the hybrids, which are impedance matched and have sufficiently high balance attenuation. An extra 2 dB attenuator has also been included for lines where the transmission loss between the transit exchange and the *subordinate local exchange* is less than 2 dB. This enables the stability requirements of the transmission plan to be met.

Signalling

In 1964 the first ARF 10 exchange with LM Ericsson's compelled MFC register signalling system was introduced in Mexico. Since then MFC has gradually become the predominant signalling system both on the local and the LD plane. MFC signalling is also used for interworking with older local exchanges, the necessary signalling conversion taking place at the local exchange, as has been mentioned earlier. On the international plane CCITT signalling system R1 is used for traffic with USA—Canada, R2 for traffic with Central America and No. 5 for traffic with Europe and South America.

A discontinuous line signalling system is normally used, with a short element (150 ± 30 ms) and a long element (600 ± 120 ms).

Call charging

Local calls are charged on the basis of unit charge metering on call meters. This includes all calls where the distance as the crow flies does not exceed

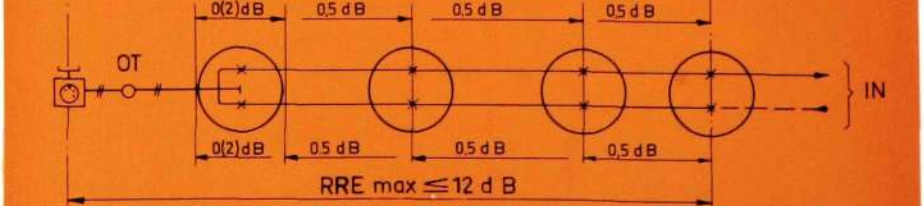


Fig. 10

Transmission plan for Mexico

OT Local exchange
CZ Primary centre
CA Secondary centre
CR Tertiary centre
IC International exchange
IN International network

12 km. In large local exchanges areas, where another method of charging would be complicated, unit charge metering is used also when the distance exceeds 12 km.

LD calls, i.e. all other calls than those mentioned above, are charged by means of Toll Ticketing (TT). For this purpose 29 different tariffs are used which are dependent on distance. For this reason the country is divided up to form a coordinate network. The positions of the subscribers in this network are determined by the first digits in their significant eight-digit number. When calls are charged using TT, the relevant distance and tariff are calculated by a computer. Higher tariffs are applied for traffic handled by a telephone operator and charging is done manually.

When the TT system is used for call charging, the identity of the calling subscriber (subscriber number + category) is transmitted to the charging transit exchange. The TT equipment also records the number of the called subscriber, the times at which the call commences and finishes, and in connection with output it calculates the length of the call. At large transit exchanges this information is fed direct on to magnetic tape in a magnetic tape unit, fig. 11, which contains two tape recorders. Normally both of these are in use and take it in turns to record calls. However, when a tape has to be changed or if one of the recorders develops a fault, the other recorder will record all the calls.

Small transit exchanges are not equipped with a complete TT equipment. Instead, they are connected to a terminal equipment, which transmits its information via a point-to-point data link to the appropriate TT equipment at the parent exchange. Several data links from exchanges with incomplete TT

Fig. 11
Magnetic tape unit

equipment can be connected to the terminal equipment at the parent exchange.

Older exchanges which did not have equipment for identifying the calling subscriber, have since been provided with separate equipment for this purpose. This is connected in circuit by a special line signal from the transit exchange.

In order to avoid transporting the magnetic tapes from transit exchanges out in the country to Mexico City, the equipment permits the transmission of data from ARM exchanges with complete TT equipment to a magnetic tape unit in Mexico City. Such transmission is being applied to some extent on a data channel delivered by LM Ericsson, and when greater experience has been obtained, this type of data transmission may be extended.

Telephone operator traffic

Different forms of telephone operator service can be obtained in accordance with the following:

National calls to be set up by a telephone operator are ordered by dialling 02 (08 in certain cases in country districts), and the call is then set up by the operator direct to the called subscriber, when this subscriber is connected to the automatized network. International calls to be set up by the operator are ordered by dialling 09.

When a national or international call is set up automatically, a special service may be utilized by connecting in TSP telephone operators. When the prefix for this service is selected (see under Numbering) the operator is connected in automatically and provides the required service, which hitherto has consisted of personal calls and reversing the call charges. Having carried out the requested service the operator disconnects from the call.

The TSP operator who is connected to the TT equipment TT-TSP, see fig. 12, marks that the call is TSP controlled, and thereby causes the corresponding tariff to be connected in. The operator also controls the start point for charging.

Extension plans

The telephone network in Mexico is

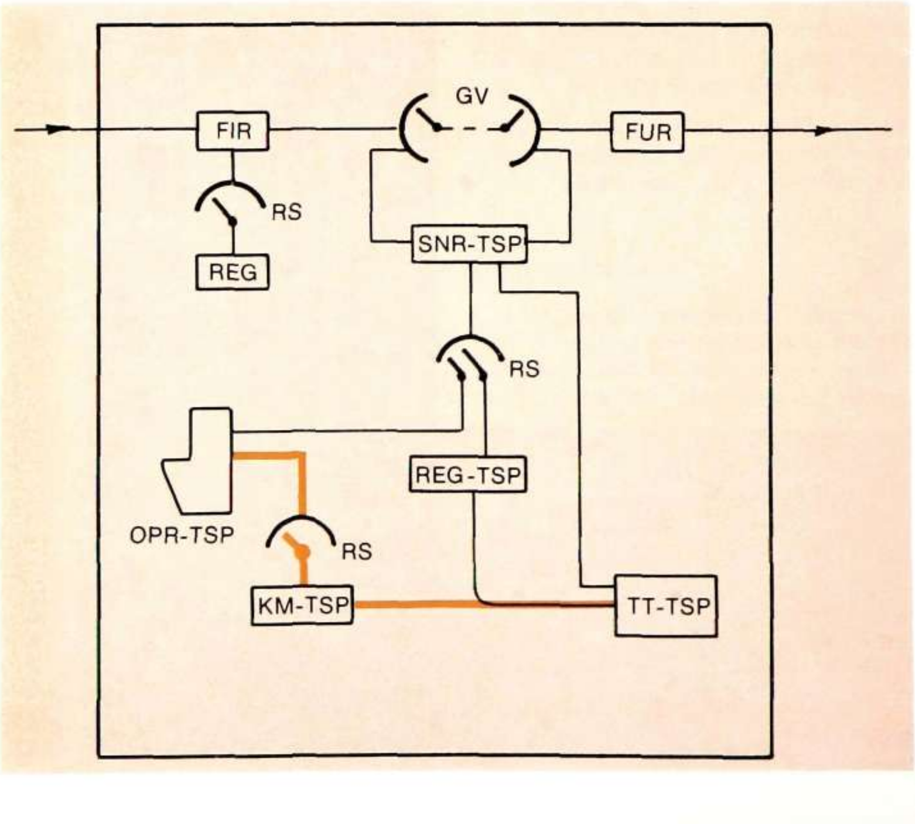


Fig. 12
The connection of the TSP telephone operator to the Toll Ticketing equipment TT-TSP

developing very rapidly and the number of telephone sets, which is now over 2.2 million (Jan. 1st, 1974), has almost doubled during the last five-year period. During the same period the long distance network has increased by about 170% and its combined length is in the region of 12,000 km.

This rapid expansion of the LD network is to continue. Thus, transit exchanges for, in all, 59,400 multiple positions have been ordered for taking into service during 1974—1975.

Domestic manufacture

In 1964 LM Ericsson bought the existing factory of Teleindustria S.A., which has since been merged in Teleindustria Ericsson S.A. (TIM), in order to be able to comply with the Mexican desire for domestic manufacture.

At first only the DIALOG type of telephone sets were manufactured. However, other products were successively introduced and the factory expanded considerably. For this reason a large building site was purchased at Tlalnepantla on the outskirts of Mexico City. A factory building of about 25,000 km^2 and also a large office building were erected on the site and were taken into use in 1970. The buildings were extended in 1974, the factory being increased by 8,300 m^2. This factory uses modern and efficient methods throughout. The total number of employees is now 1800, of which number 1150 are factory workers and 650 salaried staff.

The products manufactured comprise public and private telephone exchanges, intercom system (PAX, VOX, DYA), telephone sets, multiplex equipment for the long distance and trunk network, loading coils and power plants.

TIM is a subsidiary company of LM Ericsson, who own 70% of the company. The remaining 30% is Mexican owned.

Conclusion

Mexico is an advanced country in the field of telephony with an extremely modern technique and a rapid expansion rate. Toll Ticketing was introduced in 1965 and is now applied for all LD traffic. This has made possible the introduction of fully automatic traffic to USA—Canada, which accounts for about 90% of the total international traffic. The first SPC exchange in Latin America, an AKE 13 transit exchange, was taken into service at San Juan in 1973. Fully automatic traffic to Europe, Central America and Brazil has recently been introduced via this exchange.

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2. Meurling, J., Norén, L.-O. and Svedberg, B.: *Transit Exchange System AKE 132.* Ericsson Rev. *50* (1973): 2, pp. 34—57.

The First Installation of LM Ericsson's New 12 MHz System

Sture Lagerlund

The author discusses the test results from the installation testing of a prototype route equipped with LM Ericsson's new 12 MHz line equipment for small-core coaxial cable.

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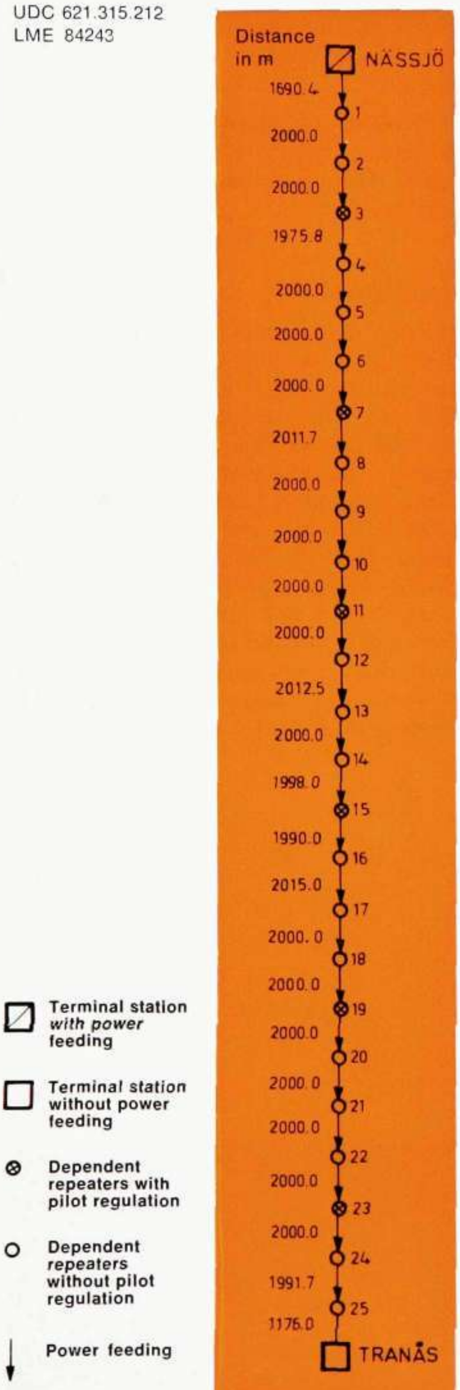

Fig. 1
Plan of the route Nässjö—Tranås

The small-core cable connection between Nässjö and Tranås, two towns in the south of Sweden, has been equipped with LM Ericsson's new 12 MHz line system ZAX 2700-4. The cable, which is 51 km long, passes through a varying countryside with woods, cultivated fields and pasture land. It contains four small-core coaxial tubes.

Twentyfive repeater housings are jointed into the cable, see fig. 1. Two systems have been installed on the route. Six of the housings are equipped with line amplifiers with pilot regulation and the remaining nineteen with fixed line amplifiers. The new housing Tvt 72, standardized by the Swedish Telecommunications Administration, has been used for the first time.

All the dependent repeater stations are fed with power from Nässjö.

Terminal rack

By using LM Ericsson's space-saving M4 mechanical construction with certain simplifications, it has been possible to mount the cable entry gland in the terminal rack instead of in a special rack.

The new cable entry gland, which is of the same type as that used in the repeater housings, is also being used for the first time. The entry gland is placed near the remote power feeding unit, which is advantageous from a protection point of view as it avoids power feeding over flexible cables between racks. The cable entry gland and the remote power feeding unit can be seen at the same time, which reduces the risk of incorrect connections.

Installation testing of the terminal rack

Installation testing was begun during August 1974. The measures taken at this stage included strapping the relevant units for the available station battery voltage of — 36 V and selecting the alarm outputs (urgent or non-urgent), measuring the transmission loss and adjusting the levels in the line terminating shelves, checking the frequency and level of the send regulation pilot, strapping in the necessary equalization to compensate for the attenuation distortion of the station cabling and connecting in the speaker circuit equipment.

Line repeaters

The line repeaters for one system were delivered towards the end of August 1974 and the work of putting them into operation began. The fixed repeaters were strapped for the correct gain taking into consideration the repeater spacing, see fig. 2. All the repeaters were equipped with their fault location crystals and were strapped to provide a suitable shunt resistance for the location of cable breaks. Each repeater was vibration tested using a dry joint tester. Amplifiers that were to be fitted at the send side of a short cable section (in this particular case the two end sections, see fig. 1) were equipped with line building-out networks. Finally, all repeaters were tested at the pilot frequency 12,435 kHz, the fixed repeaters at the nominal input level and the regulated repeaters also over the range ± 4 dB, and each fault location frequency was measured.

The cables required for connecting in the line repeaters were marked with the contact number, system number and direction. The work of preparing these cables took place at the same time that the line repeaters were being checked. Early in September 1974 all repeater housings had been equipped with their line repeaters and unequalized transmission loss curves had been measured between the terminal stations Nässjö and Tranås, fig. 3.

Phase inversion

In order to get some idea of the intermodulation characteristics of the new system at an early stage, noise loading measurements were carried out using a Wandel and Goltermann noise meas-

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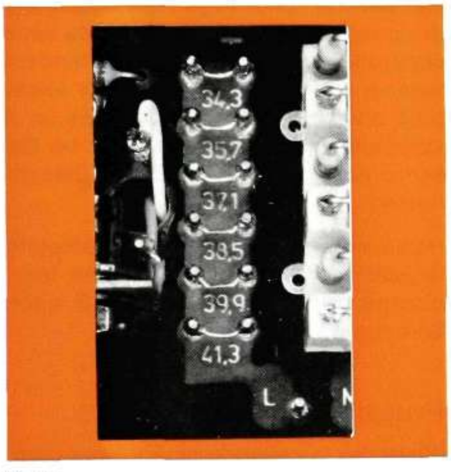


Fig. 2

The gain of an unregulated repeater can be set to any one of five values between 34.3 dB and 41.3 dB. When delivered, all straps are made. To obtain the required gain the unwanted straps are cut off

uring equipment RK-5. The noise measured was just over 5 pW/km at the nominal level, and measured in the worst measuring slot (11,700 kHz), or in other words very much greater than the 1.5 pW/km which was the highest expected value for this installation.

It was therefore decided to remove all the line repeaters and return them to LM Ericsson, where it was discovered that by mistake the outputs of the line amplifiers had not been phase inverted with respect to their inputs, which resulted in an unfavourable addition of certain intermodulation products.

Re-equipping the line repeaters

The mistake was soon rectified, and at the beginning of November 1974 it was possible to start again with the work of fitting the repeaters in the dependent repeater housings. In order to check that the phase inversion gave the desired result, a quick check was made using the noise measuring equipment. This time the measured values were less than 1.5 pW/km in the worst measuring slot, when measuring at the nominal level.

Connecting in the second system

The repeaters for the second system were delivered in the middle of November.

With the experience gained from the work of equipping the first system, the work on the second system took a very short time (about four days altogether, the 25 repeaters being fitted in one day).

Equalization

The new system can either be equipped with fixed equalizer networks or manual cosine equalizers, see fig. 4.

The line terminating shelves in the terminal racks at Nässjö and Tranås are equipped in accordance with the latter alternative.

The equalization procedure with the cosine equalizer is very simple and time saving but requires special test equipment, such as a sweep generator and a wideband double-detecting level meter. In less than 30 minutes per direction and system the spread was reduced to ± 0.3 dB (fig. 3).

Power feeding unit

The power feeding unit is equipped with special protection circuits, which in the event of a cable break reduce the voltage to zero. During the installation measurements it was observed

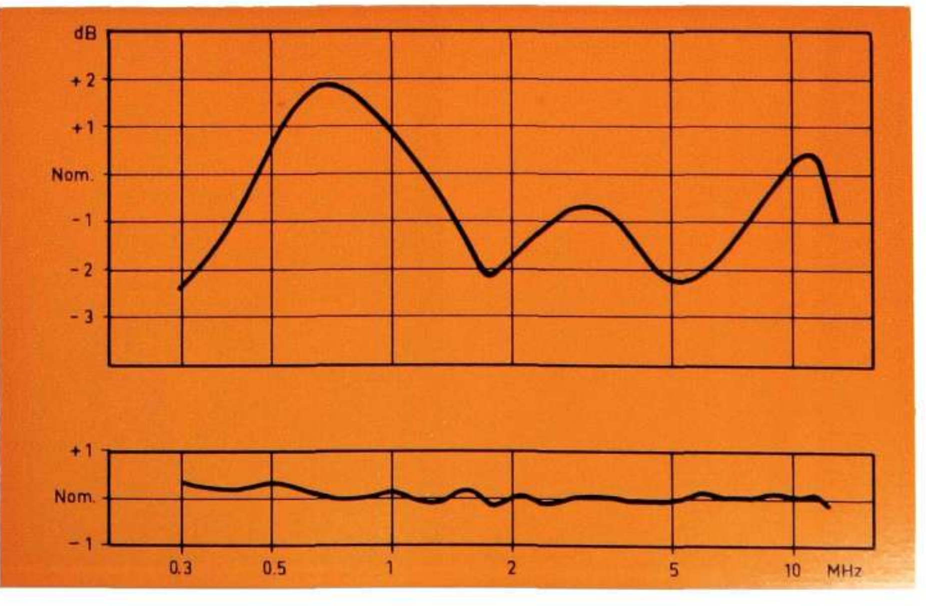


Fig. 3

Transmission loss curve. Deviation from the nominal level before and after equalization

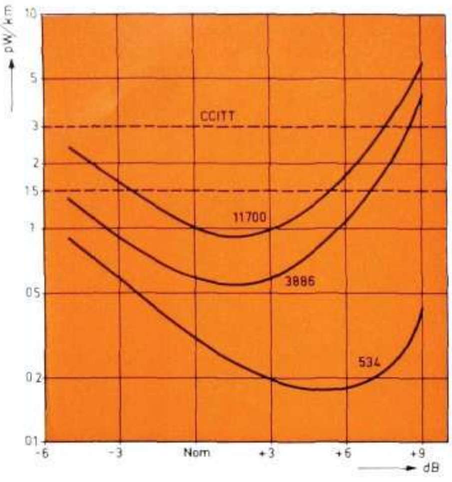


Fig. 5
Noise in a loaded system as a function of the level

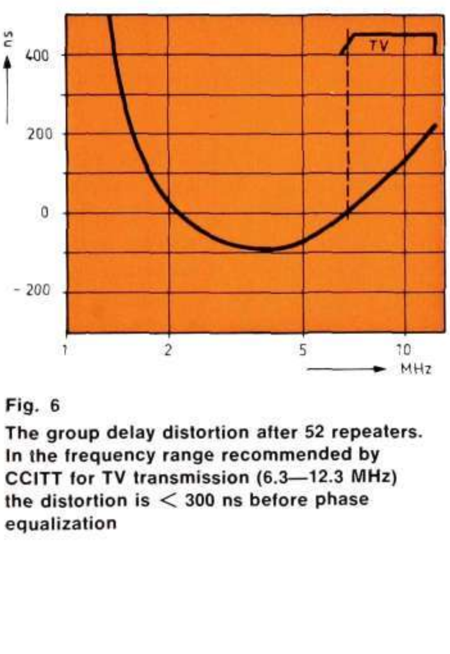


Fig. 6
The group delay distortion after 52 repeaters. In the frequency range recommended by CCITT for TV transmission (6.3—12.3 MHz) the distortion is < 300 ns before phase equalization

that the time constants chosen for the protection circuit were unsuitable, and meant that at least 15 seconds must elapse before the power feeding units could be restarted.

Once this problem had been cleared it became possible to restart the power units immediately.

Level measurements at the dependent repeater stations

Since the pilot regulation must compensate for the temperature-dependent loss variations in the cable, the pilot level into a regulated repeater should not deviate by more than ± 4 dB from the nominal level at any time of the year. For this reason it is important that the gain settings for the fixed repeaters are suitably chosen with regard to the length of the cable sections.

In order to check the level settings for the route, the input and output levels were measured at the regulated dependent repeater stations at the pilot frequency, and also at the edges of the frequency band. The results of these measurements indicated that suitable gain settings had been selected for the fixed repeaters.

Regulation memory

The pilot-regulated line repeaters are equipped with a memory, which controls the thermistor in the pilot receiver if the pilot is interrupted. The memory function is designed so that the regulation is locked in gain positions at intervals of 0.5 dB.

As several pilot-regulated repeaters are connected in cascade, and as each separate memory is locked in a random manner to the nearest higher or lower gain position, the level changes on a complete pilot section will not be the same each time the pilot is disconnected.

However, repeated tests on a complete regulation section show that the level change keeps within ± 2.0 dB each time the pilot is disconnected.

Prototype measurements

When the installation testing was completed at the beginning of December 1974, a series of prototype tests were begun, which included measurement of

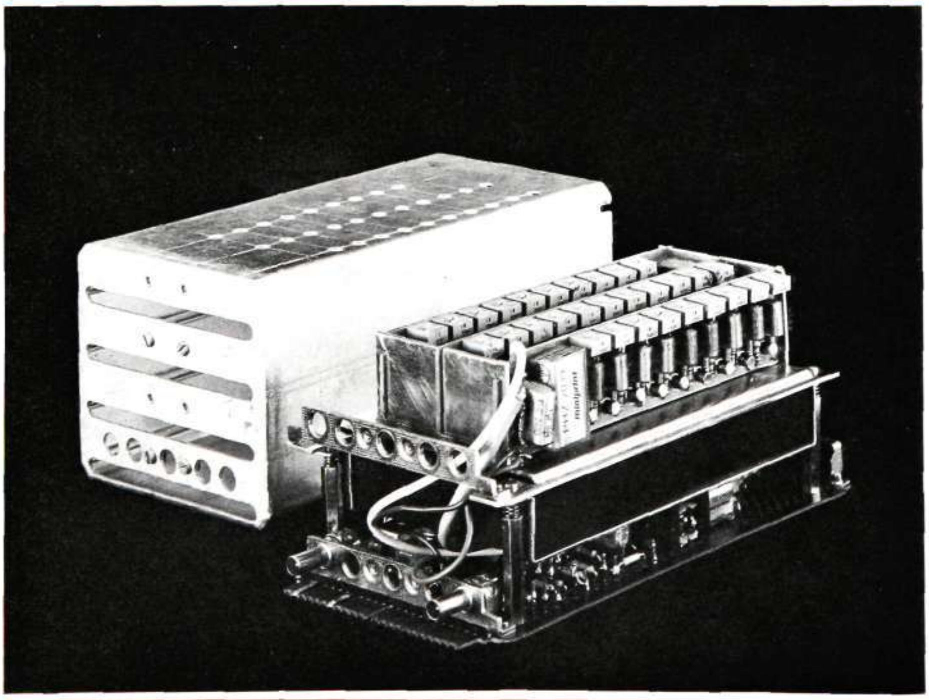
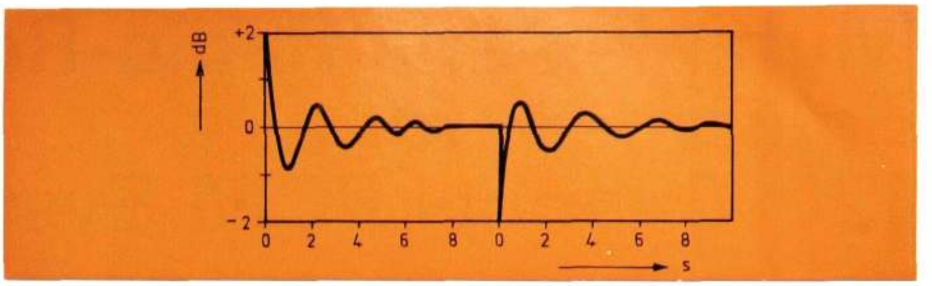


Fig. 4
Cosine equalizer

Fig. 7

Step response after 28 regulated repeaters. The first overshoot is less than 1 dB for a 2 dB change of the pilot level



crosstalk, group delay measurements, check of the envelope gain and step response and also comprehensive noise measurements, figs. 5—7. The worst measured values of crosstalk for the whole route were > 94 dB for near-end crosstalk attenuation and > 98 dB for far-end crosstalk attenuation. Noise loading measurements showed that the sum of the thermal noise and the intermodulation noise at nominal level was well under the guarantee value of 1.5 pW/km in all the measuring slots, and that the overload margin was good. These results may be considered as being very satisfactory.

Conclusion

A long-term test has been started in order to check the level stability of the new system. Experience from the installation testing shows that CCITT recommendations as well as the guarantee values are met very adequately.

Fig. 8

The terminal station at Nässjö. The newly installed rack is on the right. The racks to the left of this contain earlier generations of LM Ericsson 12 MHz and 1.3 MHz systems

Multiplex and Radio-Relay Equipment for a 120-Channel PCM System

Per Fremstad, Heinz Karl and Stig Karlsson

The digital multiplex equipment for 120 telephone-type channels which has the system designation ZAK 30/120, is a further development of PCM multiplex equipment for 30 channels. The equipment combines the signals from four different 30-channel primary multiplex equipments, each at a bit rate of 2.048 Mbit/s, into a single digital output signal at a bit rate of 8.448 Mbit/s. A radio-relay equipment suitable for this system has been developed by the Norwegian company NERA A/S. The radio-relay equipment, which has the system designation NERA 30-120/13G, operates in the 13 GHz band and the modulation principle is direct phase-shift modulation of the radio frequency with coherent demodulation in the receiver. The equipment is built together with the antenna to form a single unit.*
Apart from the multiplex and radio-relay equipments the authors describe a method developed by LM Ericsson for branching and feeding in groups of 30 channels at repeater stations.

* There is a version of this equipment for transmitting 30 PCM telephone-type channels.

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LME 8436
85103

Within the framework of the cooperation agreement between the two companies LM Ericsson and NERA A/S a digital radio-relay equipment and associated multiplex equipment have been developed for transmitting 120 PCM telephone-type channels. The equipments offer economic and flexible system solutions for the increasing traffic in the rural and urban network[1]. Thus the radio-relay equipment has been designed for installing outdoors, which means that no station buildings are required for the radio-relay equipment. Remote power feeding over the baseband cable makes the radio link independent of access to electrical power at the installation site. The multiplex equipment, which in principle is a digital multiplexer, permits direct leak dropping in the system within one and the same modem shelf assembly. This means that investment in digital multiplexers at an early stage will be very advantageous economically in a long network, where the primary groups can be branched off at repeater stations, even if the capacity requirement is moderate initially. Multiplex equipment ZAK 30/120 (also called second order multiplex equipment) constitutes the second stage in LM Ericsson's multiplex hierarchy for PCM transmission equipments[2, 3]. On the send side the equipment combines the signals from four different primary multiplex equipments, each at a nominal bit rate of 2.048 Mbit/s, into a single digital output signal at a bit rate of 8.448 Mbit/s. On the receive side this signal is again divided up into four outgoing primary multiplex signals.

By exploiting the excess capacity in the second order multiplex signal and resorting to the pulse justification method in the signal processing, no synchronism is necessary between incoming signals and the digital multiplex equipment. The frame structure is in accordance with CCITT Recommendation G.742.

The equipment is built up as a shelf stack with its own power supply, fig. 1. The units included in the equipment are mainly digital. The components consist of integrated TTL circuits with ceramic encapsulation, which give

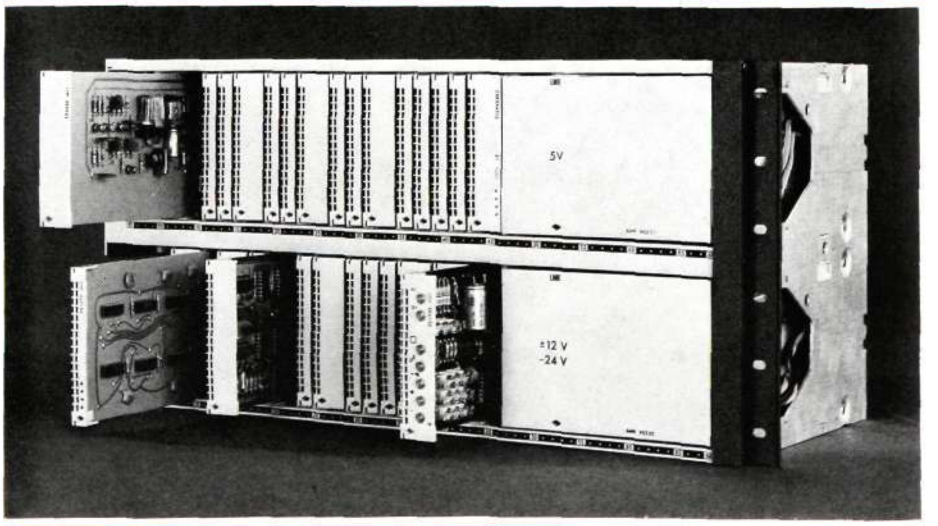

Fig. 1
LM Ericsson's second order multiplex equipment ZAK 30/120 for 120 PCM channels

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high reliability. The maintenance required has been reduced to a minimum. Test points, which are protected against short circuit, are provided on the fronts of the units, which enable measurements to be made without causing operational disturbances. All the units are built up as plug-in type printed board assemblies.

The radio-relay equipment is designed for transmission of digital signals at *radio frequencies (RF) in the band* 12.75—13.25 GHz. The digital baseband units are adapted for interworking with the PCM multiplex equipment. The digital signal modulates the radio frequency direct. The modulation principle used is two-phase-shift keying, where

— a digital 0 does not affect the phase of the radio wave

— a digital 1 shifts the phase of the radio wave by 180°.

On the receive side the equipment operates in accordance with the heterodyne principle, with 70 MHz as the intermediate frequency. The digital signal is recovered in a coherent demodulator.

Thanks to the use of the 13 GHz band, the radio frequency and the waveguide components are small. This, in combination with the digital building blocks for the baseband units, makes for an equipment that is mechanically extremely compact. The equipment is built together with the antenna to form a single unit designed for mounting on an antenna tower, see fig. 2. This has eliminated the waveguide attenuation, which would otherwise be in the region of 12 dB. (This assumes that with a normal system design, with the radio-relay equipment at ground level and the antenna mounted on a tower, about 40 metres of waveguide would be required on both the send and receive sides.) The elimination of the waveguide attenuation has made it possible to limit the diameter of the antenna *to 1 m and the output power to* 100 mW. (For certain applications the antenna diameter can be increased to 2 m.)

The radio-relay and multiplex equipments are connected together by a symmetrical cable (the baseband cable), which on the multiplex side is connected to a radio link terminating equipment which has almost the same function as in the case of cable equipments[4]. The terminating equipment also provides the power for the radio-relay equipment via the baseband cable. The distance between the terminating

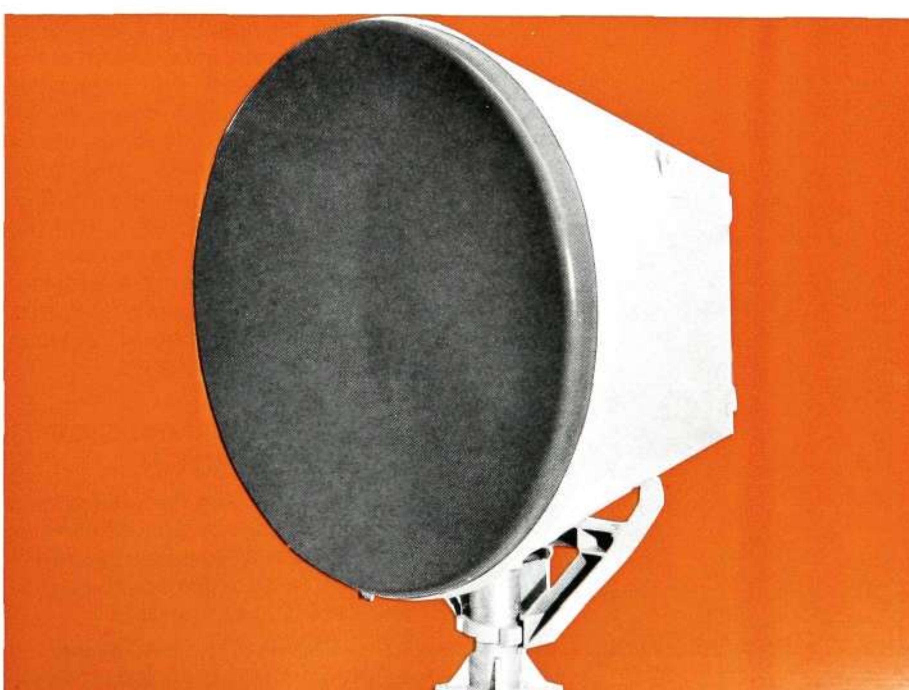


Fig. 2
NERA's radio-relay equipment 30-120/13G for 120 PCM channels

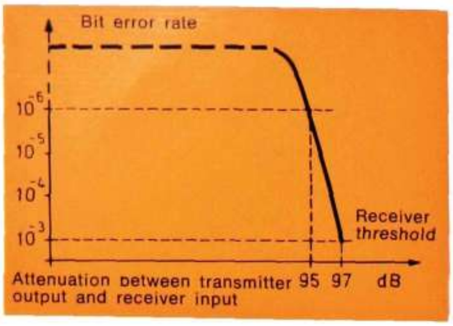
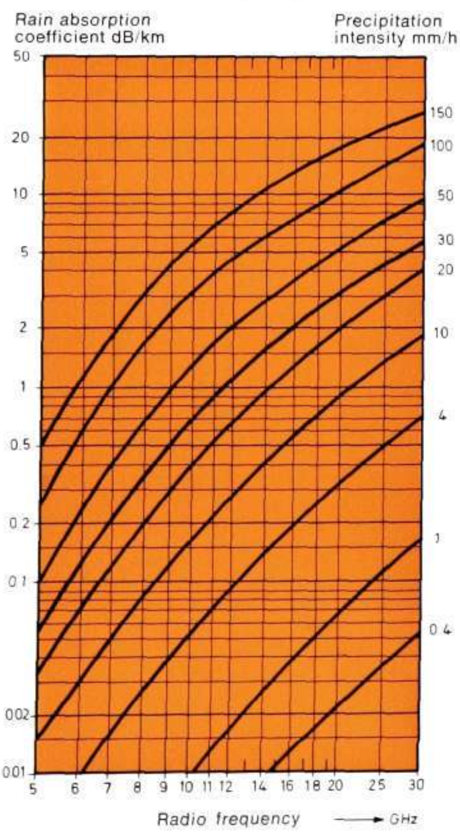


Fig. 3
Bit error rate for a digital radio-relay system

Fig. 4
Attenuation, caused by precipitation, as a function of the radio frequency



equipment and the radio-relay equipment can vary from a few metres to a number of kilometres.

The mast mounting and remote power feeding of the radio-relay system equipment provides great flexibility when planning the network, since the equipment may be installed at any selected site. Thus it is possible to take into consideration the radio wave propagation conditions as well as town planning (no high towers in the town etc.).

Quality requirements of digital radio-relay systems

The transmission quality of a radio-relay system for transmission of digital signals is determined primarily by the bit error rate. As these transmission systems are relatively new, there are no international recommendations for the transmission quality corresponding to CCIR Recommendations 393-2 and 395-1 for FDM-FM radio-relay systems, especially as regards bit errors as a function of time. However, in general it may be said that a bit error rate of $< 10^{-6}$ is indicative of good speech quality whereas a bit error rate of $\geq 10^{-3}$ corresponds to a break in the circuit.

A typical bit error rate curve for radio-relay system NERA 30-120/13G is shown in fig. 3. As may be seen from the diagram, the quality of a radio-relay circuit is practically independent of the attenuation between the transmitter and the receiver right down to the threshold value for the receiver, unlike in the case of FDM-FM radio links where the signal-to-noise ratio changes proportionally with the fading. On the other hand, as can be seen from the curve, the changeover from satisfactory quality (bit error rate $= 10^{-6}$) to a break (10^{-3}) is very abrupt, it takes place within a matter of 2 dB.

Propagation conditions for radio waves at 13 GHz

When comparing with the propagation conditions for conventional radio-relay systems (FDM-FM systems in the RF band 2—8 GHz) attention should be paid to the following points:

— at 13 GHz the attenuation caused by precipitation is no longer negligible

— digital radio-relay systems are less sensitive to interference than FDM-FM systems.

As may be seen from fig. 4[5], the rain absorption coefficient at 13 GHz, for a rain intensity of 30 mm/h, is about 1.3 dB/km, whereas at 7 GHz it is only 0.2 dB/km. This and the higher free space attenuation at 13 GHz — 16 dB higher than at 2 GHz and 5 dB higher than at 7 GHz — means that the lengths of the radio hops must be reduced compared with those normally used at 2 and 7 GHz. It is not a good solution to compensate for the higher free space attenuation with a higher antenna gain. A larger antenna would also have a greater directional effect, which would increase the stability requirement for the radio mast and thus make it more expensive. Hence the lengths of the hops should be limited to between 25 and 30 km.

Moreover shorter hop lengths have the advantage that the probability of fading derived from multi-path propagation is reduced, since the fading probability increases in accordance with the cube of the hop length but only linearly with the radio frequency. For practical planning this means that the fading margin may be lower than for radio links that have greater hop lengths than 30 km.

As regards the sensitivity to interference from other radio channels it is interesting to compare the following figures:

— an FDM-FM link requires that the level of an interference signal shall be 65 dB under the wanted signal if the interference signal is not to contribute more than 2 pWOp to the total noise power in a telephone channel

— for a digital radio link a discrimination of 20 dB between the interference signal and the wanted signal is all that is required in order to hold the bit error rate under the 10^{-6} value.

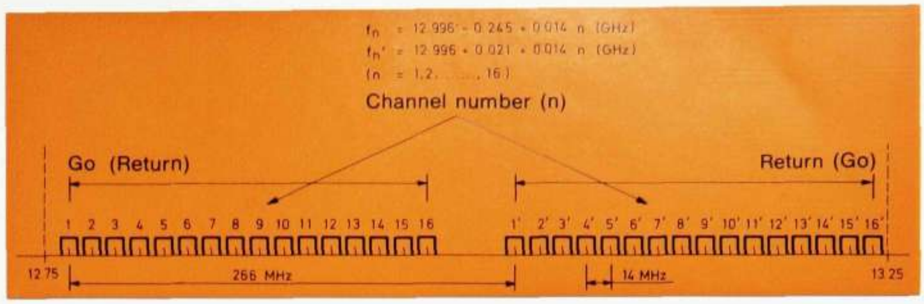
The low carrier-to-noise power ratio requirement of 20 dB may be exploited economically in various ways:

— the angular distance between different radio channels, which converge on the same network node, may be reduced, and hence the

Fig. 5

Radio-frequency channel arrangement for radio-relay systems in the 13 GHz band

Capacity: 300 FDM or 240 digital telephone circuits



number of radio channels per node can be increased compared with FDM-FM systems

— a less stringent side lobe attenuation requirement may be applied for the antennas

— radio hops that use the same radio frequency may be placed closer to each other

— two radio signals may be transmitted in parallel at the same radio frequency, on condition that the two radio waves are cross-polarized.

The latter facility is applicable primarily for parallel transmission of the same information over two radio channels, 1 + 1 operation.

Radio-relay equipment (RL)

RF channel arrangement

In Recommendation 479 CCIR has laid down a frequency plan for the RF band 12.75—13.25 GHz. NERA's 30-120/13G system uses the version of the frequency plan proposed by CCIR for 300 FDM or 240 digital telephone circuits, fig. 5, with a frequency spacing of 14 MHz between adjacent radio channels and 266 MHz between the transmitter and the associated receiver.

Modulation and demodulation

The equipment works with direct modulation of the radio wave, which is phase-shift modulated in the transmitter output circuit by means of a PIN diode. On the receive side a coherent demodulator is used to recover the digital information. The carrier is recovered using the remodulation principle.

Two-phase-shift keying (2-PSK) modulation with coherent demodulation is the best method of obtaining a low receiver threshold value and insensitivity to interference between adjacent radio channels. The digital signal transmitted by the radio link is also differentially coded. This is done because the coherent demodulator is unable to distinguish the absolute phases of the modulated signal, only the signal phase changes.

Another advantage of coherent demodulators is that a frequency modulated signal is always automatically demodulated. This simplifies the setting up of service channels between the radio link terminal and the radio link repeater stations.

Transmitter and receiver equipment

The transmitter output power is generated in a 2 GHz microstrip oscillator, which generates 1 W, fig. 7. This is followed by a wideband frequency multiplier (×3×2).

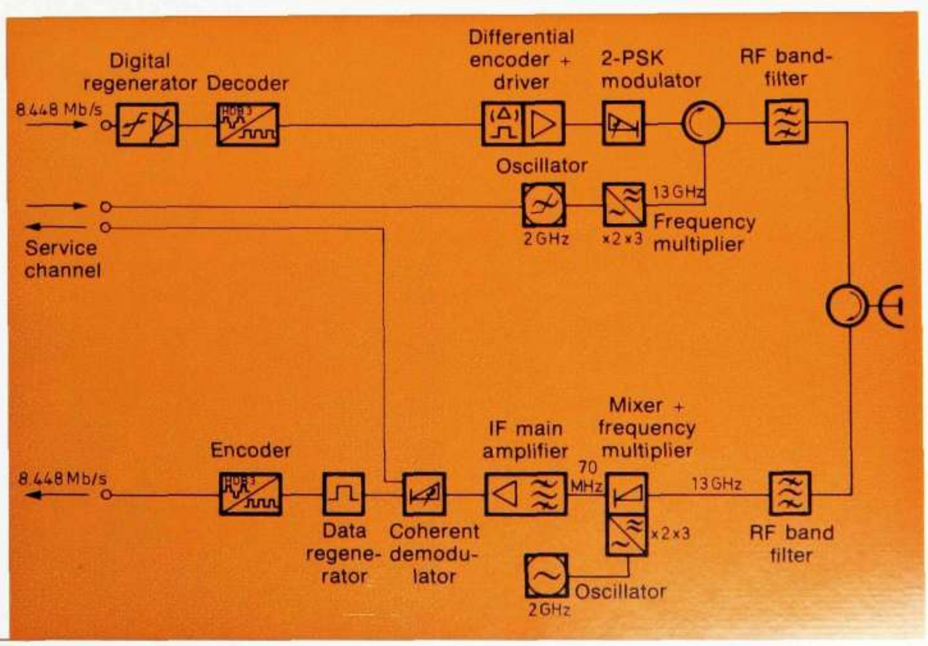


Fig. 6

Block diagram of radio-relay equipment NERA 30-120/13G

(The circuit symbols are explained in fig. 13)

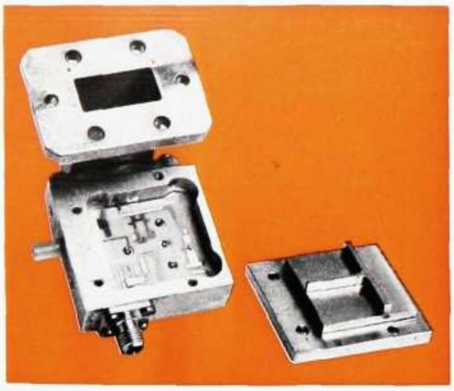


Fig. 8
Frequency multiplier and balanced mixer

The phase-shift modulator and RF oscillator chain are interconnected via a circulator.

The nominal power at the transmitter output is + 20 dBm.

The receiver operates in accordance with the heterodyne principle, the incoming radio frequency being transposed to an intermediate frequency of 70 MHz by a frequency generated locally in the receiver. The local oscillator is a 2 GHz oscillator of coaxial construction. The frequency multiplier that follows is built up together with the RF mixer on an alumina substrate to form a common wideband circuit, see fig. 8.

The variations of the receiver input signal, caused by the varying propagation conditions, are equalized by the IF amplifier, which operates with automatic gain control.

Baseband equipment

At the baseband input on the transmit side the bipolar digital line signal is regenerated in a digital amplifier, which provides automatic equalization for the attenuation of the cable between the terminating equipment and the radio-relay equipment. The HDB3 (or AMI) code, which cannot be transmitted over the radio link, is converted to a monopolar pulse train before being fed into the phase-shift modulator.

On the receive side the bipolar line signal is reconstructed with the aid of a regenerator and an HDB3 (or AMI) encoder.

Phase jitter on the demodulated pulse train, and/or the occurrence of more than 128 successive identical bits, is used as the switching criterium for switching to the protection channel. The reason for this choice is that there is an almost linear relationship between phase jitter and bit error rate and that it is improbable that an 8.448 Mbit/s line signal contains more than 128 successive identical bits.

Remote power feeding

The radio-relay equipment may be fed with power over the phantom circuit in the balanced baseband cable. The feeding voltage to the terminating equipment is usually — 48 V. The maxi-

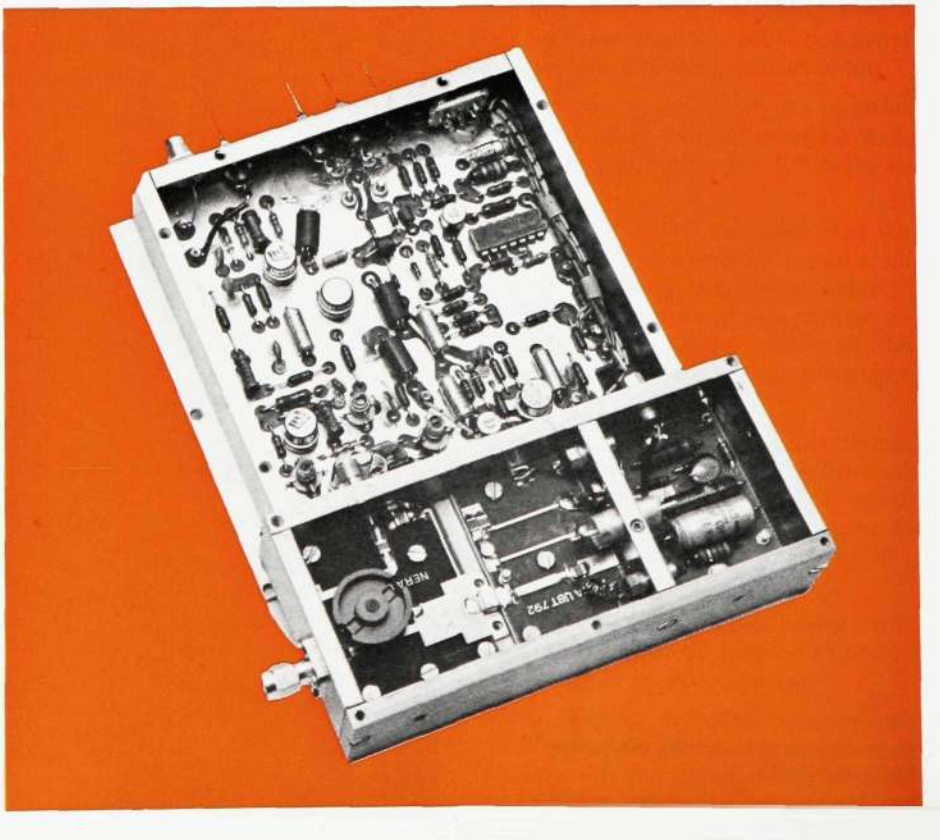


Fig. 7
2 GHz microstrip transistor oscillator

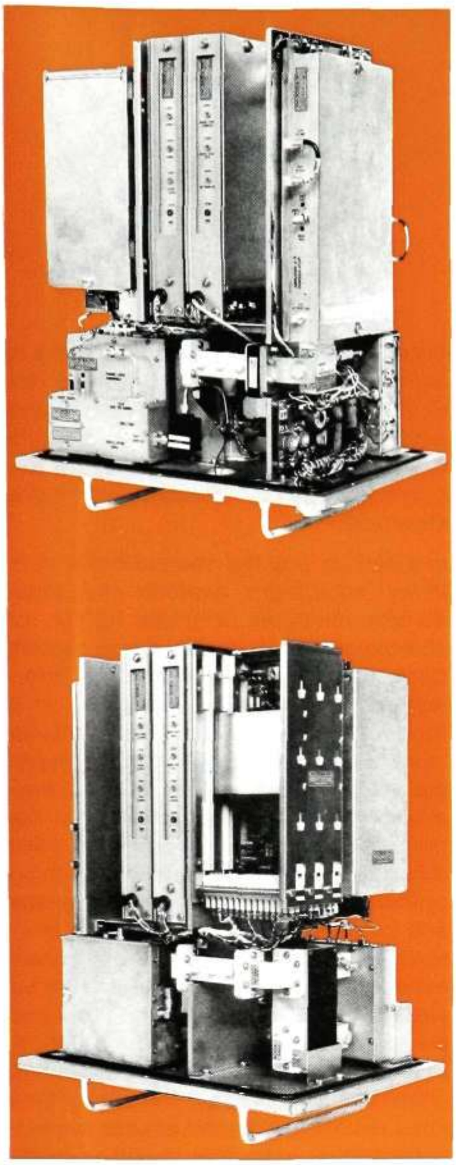


Fig. 10

The radio-relay equipment with the protective cover removed. The upper illustration shows the equipment from the front and the lower from the rear

mum permissible resistance in the feeding loop is about 25 ohms.

The power consumption for a radio-relay equipment is approximately 25 W.

Maintenance, alarm and supervision

A portable test equipment is available for carrying out maintenance tests on the radio-relay equipment. It can be connected in with a plug and socket.

The radio-relay equipment can be supervised remotely from the terminating equipment by means of alarm indications and remote measurements of the most important equipment parameters. The terminating equipment also has facilities for connecting in a service channel telephone. In addition, protection channel switching and local looping of the transmit and receive equipments can be remotely controlled from the terminating equipment.

Up to 20 indications per radio-relay station can be remotely transmitted over the service channel.

Mechanical construction

The radio-relay equipment is enclosed in a waterproof case, which is mounted in a frame on the rear of the antenna. Two radio-relay equipments can be mounted in the same frame, see fig. 9. The radio-relay equipments are protected against direct insolation and precipitation by a screen, which encloses the exterior of the antenna and the frame (fig. 2). The equipments are accessible through doors on the rear of the frame.

The waveguide output of the radio-relay equipment is connected to the antenna feeder horn by means of a quick-acting locking device which permits rapid conection and disconnection without tools. Consequently the whole radio-relay equipment can be replaced quite easily if a fault develops. Faulty units will be replaced indoors.

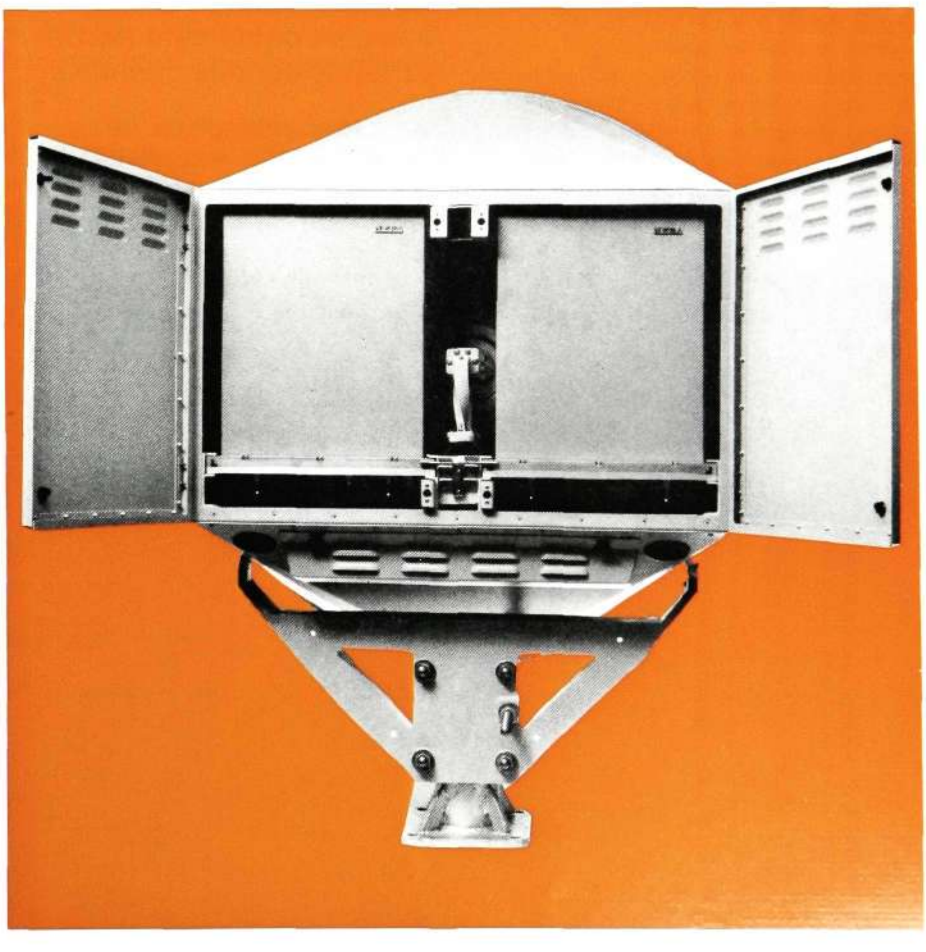


Fig. 9

The radio-relay equipment with the antenna, seen from the rear

Fig. 10 shows the mechanical design of the radio-relay equipment. Each unit is an electrical functional unit, and may be replaced in the field by a similar spare unit.

The baseband and auxiliary units are built up as printed board assemblies, which are mounted in screening boxes that can be swung out.

The transmitter and receiver oscillators, which have been described earlier, are also mounted in screening boxes, which are positioned in such a way that frequency adjustments or changes can be carried out without dismantling the equipment. The remaining RF units, of which a number are designed as microstrip circuits and others in a coaxial construction, and the IF units are also mechanically individual units placed in screening boxes. The signals between them are taken via waveguides or coaxial cables.

Multiplex equipment (MUX) for 120 telephone channels

THE BASIC PRINCIPLES OF SECOND ORDER MULTIPLEX EQUIPMENT

The primary multiplex equipment, the basic principles of which have been described previously in Ericsson Review[3], converts analog speech signals from 30 different telephone channels to digital signals. These are combined together with the frame alignment and signalling information to form a single time-divided digital bit stream in accordance with a standardized frame structure.

In a similar way the second order multiplex equipment exploits the time-division multiplex principle, fig. 11, for combining the incoming digital signals from four primary systems. The information must then be organized in a frame structure so that synchronism can be established between the sending and receiving ends of the transmission link. The problem is that the primary systems are controlled from different clocks. Hence the incoming primary bit streams differ both in phase and frequency. This problem can, however, be solved by introducing a certain excess capacity in the second order bit stream, and using a buffer memory and the justification method[8]. The justification method implies that the second order multiplex fills up the empty time slots resulting from the excess capacity by adding extra bits (positive justification).

The higher the bit rate of the primary system the lower will be the justification rate and vice versa. Justifying bits may only be included once in each frame of the second order bit stream, and then always in a particular bit position. Positive justification is signalled in advance in a separate justification

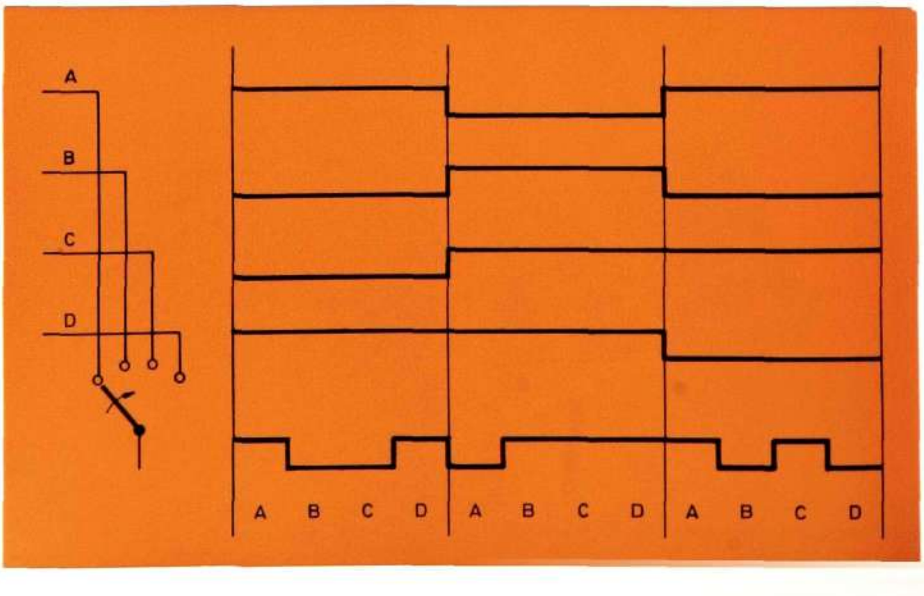


Fig. 11
Time-multiplex principle for four digital primary bit streams A—D

channel. This enables the receive logic to delete the inserted bits and to recover the original bit rate of the primary data.

The frame structure for an 8.448 Mbit/s digital multiplex equipment is laid down in CCITT Recommendation G.742. The basic frame structure is shown in fig. 12.

SYSTEM DESIGN FOR LM ERICSSON'S DIGITAL MULTIPLEX EQUIPMENT ZAK 30/120

The design and function of the digital multiplex equipment is illustrated in fig. 13. The primary group units are individual for each primary system included. The remainder of the units are common for the whole system.

The send side is controlled by pulses generated in the send logic adjustable oscillator 8.448 Mbit/s, which is normally oscillating freely. It can also be controlled by the received signal or an external signal via interface T2. This form of control is used in connection with branching or in future integrated networks.

The signals from the primary systems are each stored in their particular buffer memory. The send logic checks how many bits are stored in each memory. When the number of stored bits is less than a certain value a justification message is sent to the receiver. Read-out from the memory is then inhibited in the justifying bit position. The memory thus has time to fill up and is prevented from becoming empty.

After time-division multiplexing and addition of the frame alignment signal, the 8.448 Mbit/s signal is fed to the 8.448 Mbit/s digital line adapter, where the binary signal is converted to the bipolar line signal (HDB 3 or AMI code).

The function of the receive equipment is the inverse of that of the send equipment. The bipolar line signal is received in the 8.448 Mbit/s digital line adapter, where it is converted to binary form. It is then taken together with the timing signal to the receive justification and framing logic units where the receive side is synchronized with the send side and the justifying bits are removed. The signal information is then taken to the respective buffer memories. The primary information is fed out from the buffer memory with the aid of the controlled send clock 2.048 Mbit/s. The read-out bit rate is determined by the mean value of the number of bits stored in the buffer memory. If the number of bits in the memory tends to increase, the read-out rate is increased, and vice versa. The jitter is reduced considerably by means of an internal regulation loop.

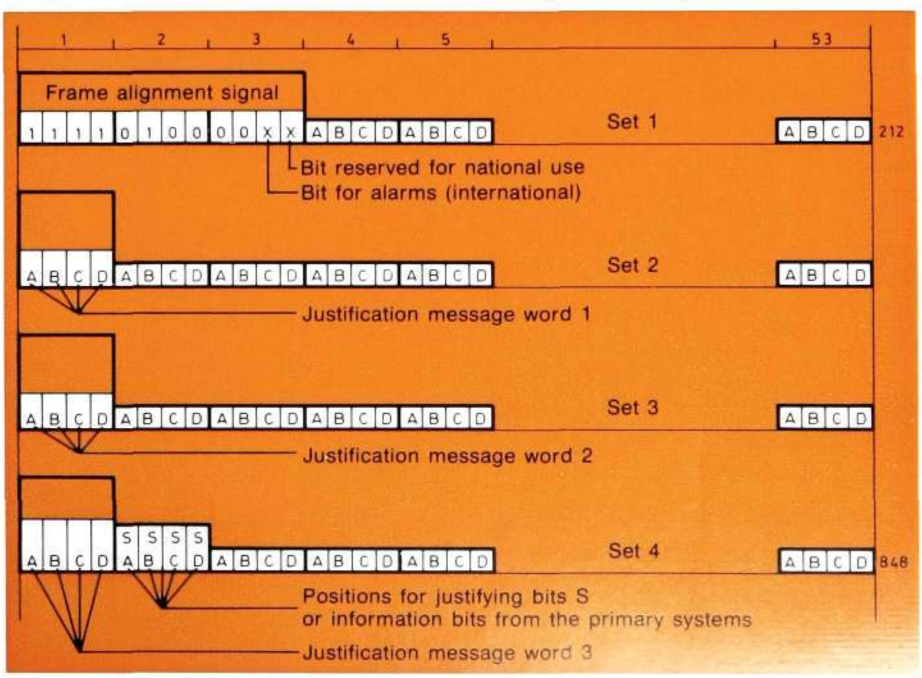


Fig. 12
Frame structure for the second order multiplex equipment

Interfaces

A high degree of flexibility has been achieved by the selection of suitable interfaces. All the data interfaces, D1, D2 and D2B, are bipolar and HDB 3 (or AMI) coded. Each of them is connected to 75 ohm coaxial cables, one for each direction of transmission. The extra 8 Mbit/s interface D2B is used in connection with branching.

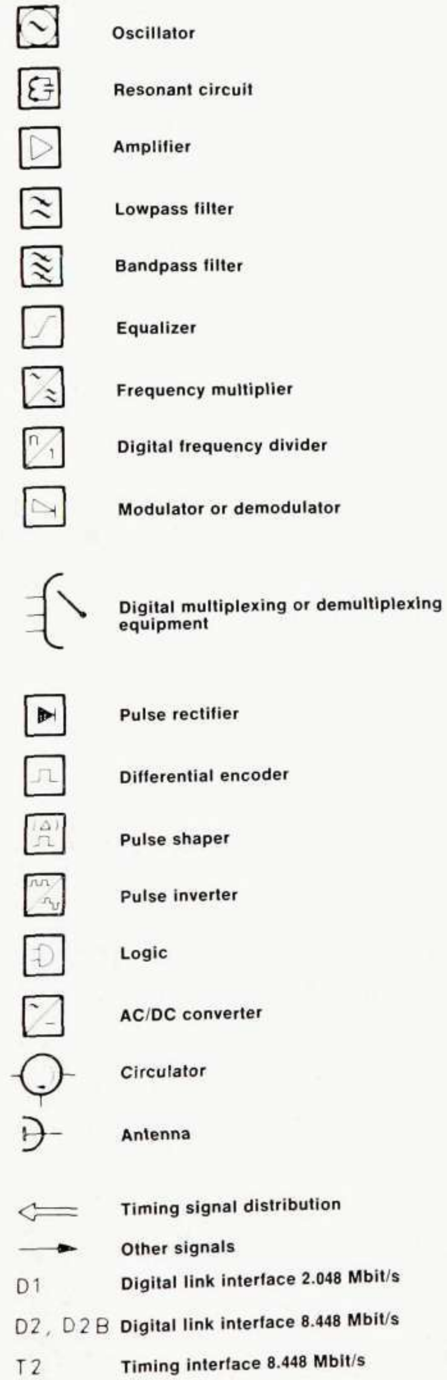
Fig. 14 shows how the second order multiplex equipment ZAK 30/120 can be connected via its various interfaces to different line equipments and to the nearest higher or lower order multiplex equipment.

Maintenance and alarms

The need for maintenance in the second order multiplex equipment has been reduced to a minimum. The frequency of the crystal controlled send clock 8.448 Mbit/s should be checked once a year in order to verify that the limits have not been exceeded. In other respects the system is supervised by built-in alarm circuits. The distant terminal transmits information regarding its operational state by means of two bits in the frame alignment signal.

Faults are combined in the alarm unit of the multiplex equipment to provide a sum alarm which after a delay of a few seconds is fed, in the form of an urgent or non-urgent alarm, to the rack alarm unit.

The alarm unit in the multiplex equipment has a number of alarm lamps that represent different types of faults and also outputs that can be connected to, for example, a common maintenance centre.



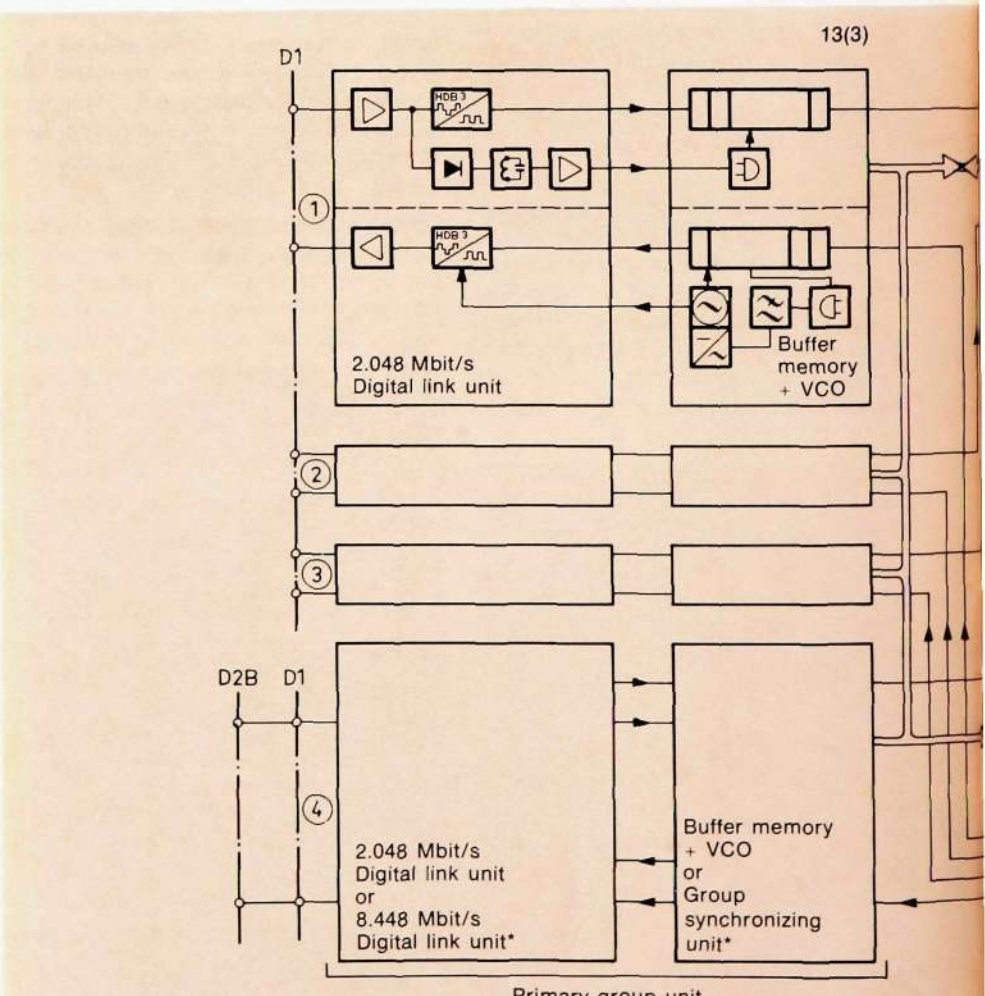
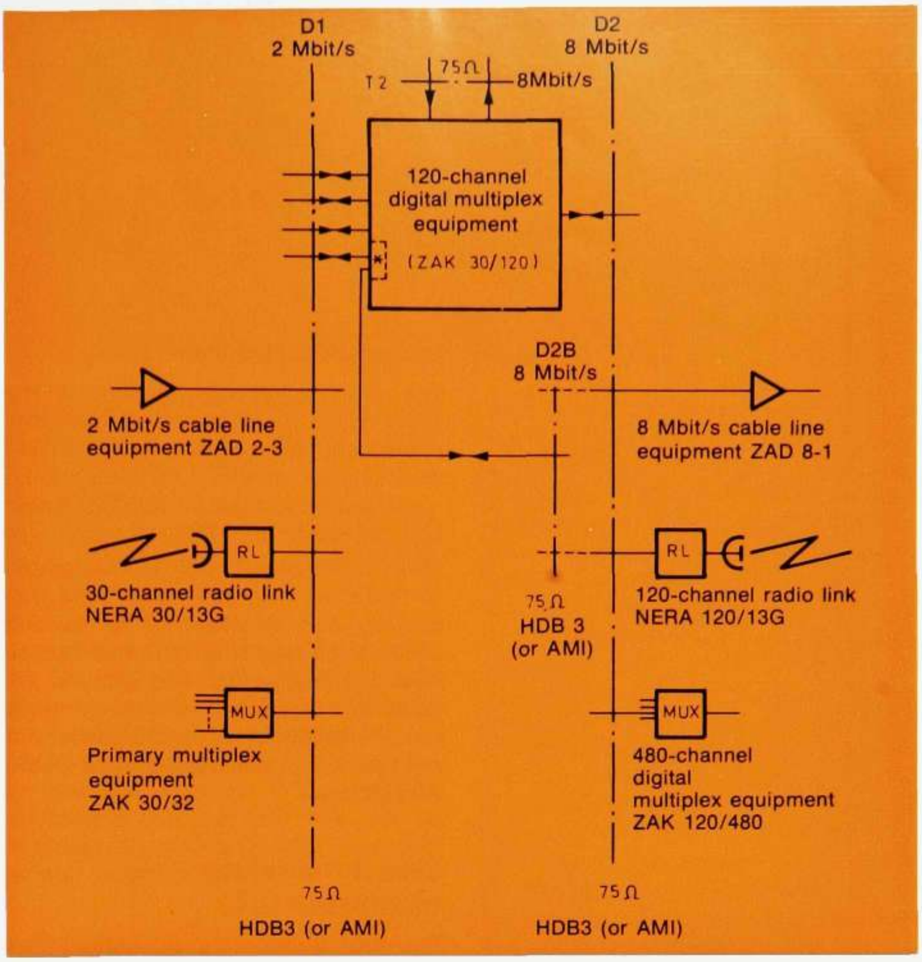
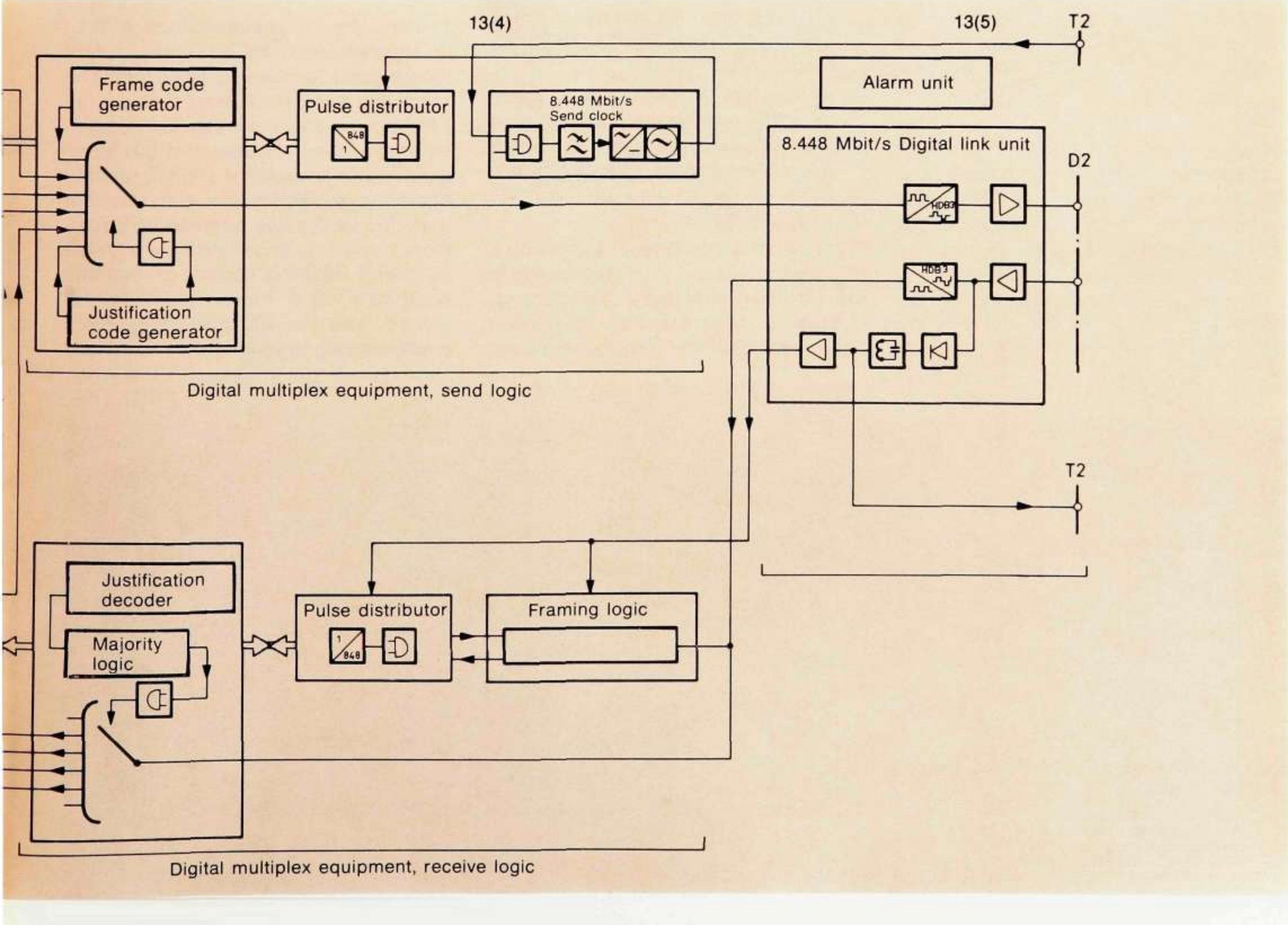


Fig. 13
Block diagram of second order multiplex equipment ZAK 30/120

Fig. 14

Connection of second order multiplex equipment to line system and other multiplex equipments





Mechanical construction

The mechanical construction is the same as for the PCM primary multiplex equipment ZAK 30/32. The unit and shelf design and the build-up of the racks are described in detail in Ericsson Review No. 2, 1972[3].

The second order multiplex equipment is contained in a shelf stack, the modem shelf stack shown in fig. 15, and consists of two shelves combined to form one mechanical unit with the addition of a ventilation unit. All the units with the exception of the DC converters are built up of standard printed board assemblies.

Line terminating equipment (LT)

The line terminating equipment has two functions, namely:

- adaptation of the digital line signal received from the multiplex equipment to the radio link baseband cable and vice versa
- termination of alarm signals, measuring the operational parameters of the radio-relay equipment, connection of the service channel and remote power feeding of the radio-relay equipment.

Different arrangements of the terminating equipment are used depending on the distance between the radio-relay equipment and the line terminating equipment and the type of cable used:

a) *The distance between the MUX and RL equipments is only a few metres.*

The line terminating equipment comprises a transformer unit, for impedance matching between MUX and the baseband cable to RL, and alarm and test units.

b) *The distance between the MUX and RL equipments is less than 2 to 3 km.*

The equipment in accordance with a) is supplemented by a digital repeater for the incoming signal and a connection unit, which contains overvoltage protection.

Tre radio-relay equipment is fed with power over the phantom circuit of the baseband cable.

c) *The distance between the MUX and RL equipments is more than 2 to 3 km. The baseband cable is equipped with one or more line repeaters.*

The equipment in accordance with b) is supplemented by a remote power feeding unit for the line repeaters. The radio link equipment must then be fed with power via separate cable pairs since the phantom circuit of the baseband cable is used for remote feeding of the line repeaters. It is also possible to divide up the line terminating equipment physically in accordance with the functions outlined above, so that the equipment for cable matching is placed with the multiplex equipment and the equipment for supervising and

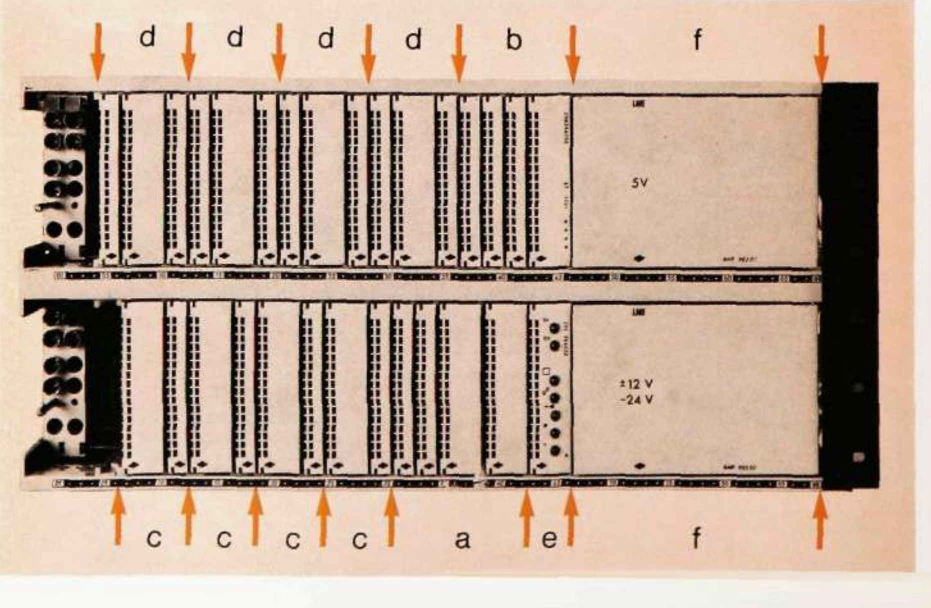


Fig. 15

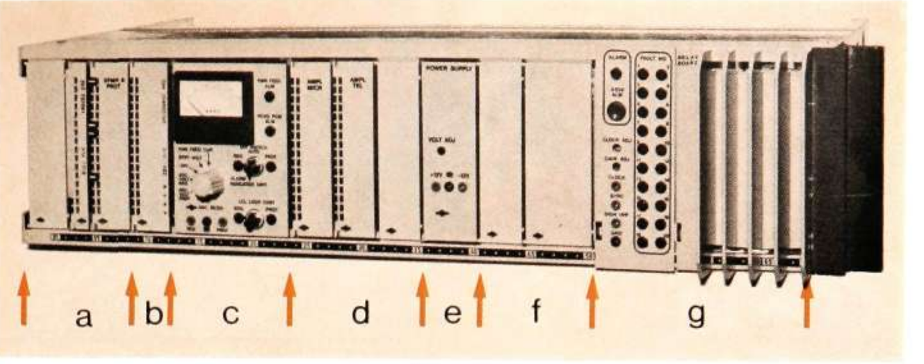
Mechanical construction of the second order multiplex equipment

a) Digital multiplexer, send logic
b) Digital multiplexer, receive logic
c) Primary group unit, send side
d) Primary group unit, receive side
e) Supervisory unit
f) DC converter +5 V and ±12 V

Fig. 16

Mechanical construction of the line terminating equipment

a) Cable connecting and matching units
b) Digital repeater
c) Alarm and test unit
d) Service channel units
e) Power supply for units a—d
f) Spare positions
g) Remote supervision units (including power supply)



feeding the radio-relay equipment is placed in its vicinity, if there is a suitable building available.

The mechanical design of the terminating equipment is the same as that for the multiplex equipment, that is to say, the functional units are built up as printed board assemblies that are placed in a shelf of standard size, fig. 16. The equipment in accordance with arrangements a) and b) is contained in one shelf. For arrangement c) two shelves are needed. The shelves may be mounted anywhere in the multiplex equipment rack but they can also be mounted separately in their own rack or wall-mounted frames.

Branching at repeater stations

The introduction of high order multiplexes in a digital network makes it essential to be able to branch off lower order bitstreams, for example when connecting together a number of exchanges along a common route, fig. 17. It may be a question of traffic between two adjacent exchanges (exchange 1 ⟷ exchange 2 in fig. 17) or/and traffic that goes to a superior exchange (exchange 2 → group centre in fig. 17). In digital networks both stop and leak dropping are used. As can be seen, this can be realized by using two digital multiplex equipments.

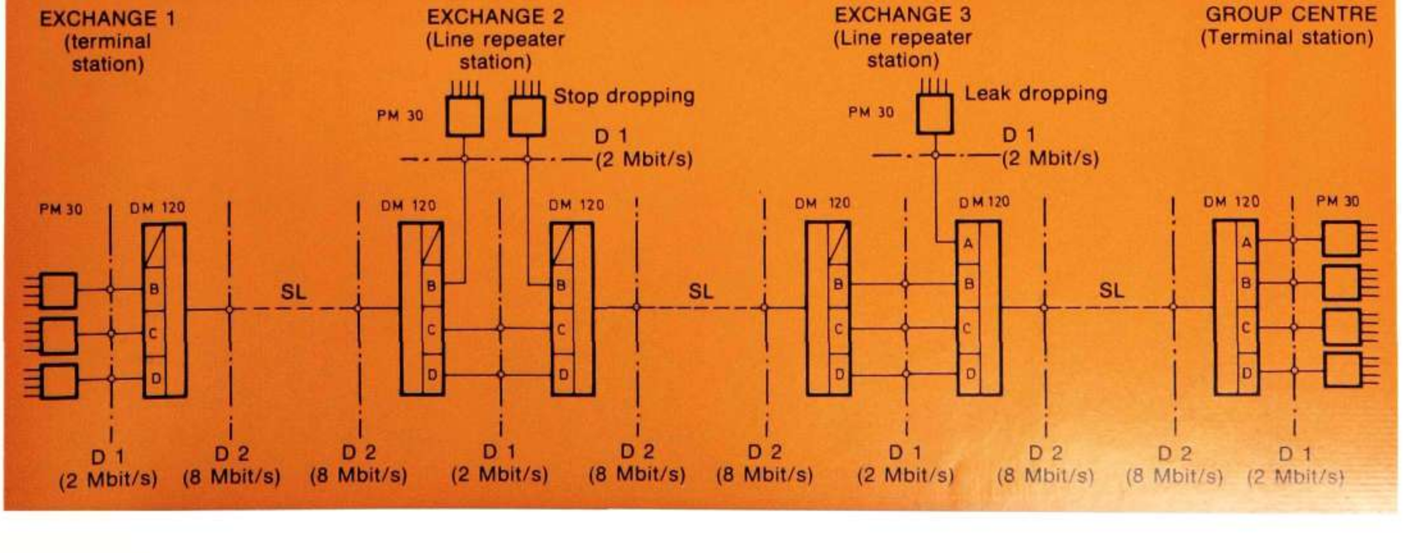
Studies of a number of networks show that leak dropping is often of value. In order to be able to offer a simple and economic solution, LM Ericsson have developed a method which permits leak dropping using only one digital multiplex equipment ZAK 30/120, fig. 18. This is achieved by utilizing the extra 8.448 Mbit/s interface D2B in the equipment, figs. 13 and 18. From a system point of view interface D2B has the same function as interface D1 for a primary system in the most distant exchange. In the 120-channel multiplexer at the exchange before this, a digital link adapter 2.048 Mbit/s is replaced by a digital link adapter 8.448 Mbit/s. Its interface D2B is connected to the 120-channel line system that connects this exchange with the one that follows. The associated buffer memory in the multiplex equipment is replaced by a special unit, the group synchronizing unit, which synchronizes the data flow coming into D2B with the data flow generated in the local multiplexer.

The combined pulse trains are taken via interface D2 to the next exchange. In fig. 18 the whole capacity is utilized up to the group centre, but this need not be the case. By introducing 120-channel digital multiplexers with associated line equipment at an early stage, the capacity can be increased successively as the traffic grows.

Fig. 17

Stop and leak dropping at repeater stations using two digital multiplex equipments

SL 8 Mbit/s line system
Radio link or cable
PM 30 PCM multiplex equipment for 30 telephone channels
DM 120 Digital multiplexer for 120 PCM telephone channels



Technical data

RADIO-RELAY EQUIPMENT

NERA 30-120/13G (RL)

System capacity	120 PCM telephone channels (8.448 Mbit/s)
Radio-frequency band	12.75—13.25 GHz
RF channel spacing	14 MHz
RF channel arrangement	CCIR Rec. 479
Modulation	2-PSK differential coding
Demodulation	Coherent

Interface between RL and baseband cable

Line code	HDB 3 or AMI
Impedance	120 Ω balanced
Pulse amplitude, RL output	± 3.0 V
Pulse amplitude, RL input	± 3.0 V
The RL input stage automatically equalizes a cable attenuation of related to 4.2 MHz	0—45 dB
Service channel	Frequency modulated

Transmitter

Nom. RF output power	+ 20 dBm
Frequency stability	$\pm 2 \cdot 10^{-5}$ over the temperature range — 40° C to + 55° C

Receiver

RF input level	— 20 to — 90 dBm
Bit error rate	$<10^{-3}$ at – 77 dBm $<10^{-6}$ at – 75 dBm
Noise factor	≤ 10 dB

Antenna

Type of antenna	Cassegrain, *dual polarised*
Antenna gain	1 m Ø: 39 dB 2 m Ø: 45 dB
Remote power feeding	
Voltage	— 48 V/— 60 V, + 20 % — 15 %
Current consumption	< 0.85 A
Power consumption	< 25 W
Weight	< 20 kg
Dimensions H × W × D	370 × 200 × 300 mm

LINE TERMINATING EQUIPMENT (LT)

Bit rate	8.448 Mbit/s $\pm 30 \cdot 10^{-6}$
Line code	HDB 3 or AMI

Interface between LT and MUX

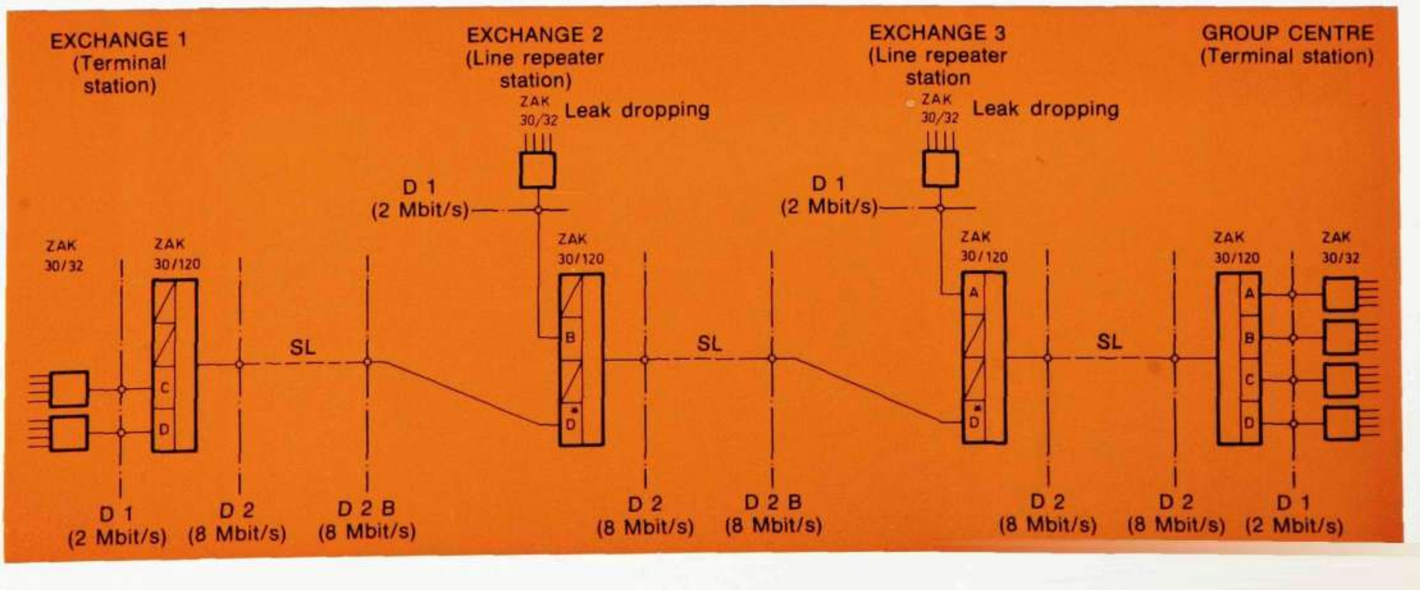
Pulse amplitude, LT output	± 2.37 V
Pulse amplitude, LT input	±1.19 . . . ±2.37 V
Impedance	75 Ω, unbal.

Interface between LT and baseband cable

Impedance	120 Ω balanced
Pulse amplitude, LT output	±3.0 V
Pulse amplitude, LT input without a digital repeater	±1.5 . . . ±3.0 V
with a digital repeater, nominal value	±3.0 V
The digital repeater automatically equalizes a cable attenuation of related to	0 . . . 45 dB 4.2 MHz

Fig. 18

Leak dropping at line repeater stations using LM Ericsson's digital multiplex equipments ZAK 30/120



DIGITAL MULTIPLEX EQUIPMENT MUX (including branching equipment)	
Primary systems that can be connected	4×30-channel systems in accordance with CCITT Rec. G.732
Mode of operation	Asynchronous with positive justification
Bit rate	8.448 Mbit/s ± 30 · 10^{-6}
Frame structure	CCITT Rec. G.742
Frame alignment strategy	CCITT Rec. G.742
Justification control	Single error correction of the justification message by means of majority decision
8 Mbit/s digital interfaces D2 and D2B	
Bit rate	8.448 Mbit/s ± 30 · 10^{-6}
Line code	HDB 3 or AMI
Pulse amplitude, input and output	± 2.37 V
Impedance	75 Ω, unbal.
Permissible attenuation of the input signal	0—6 dB
2 Mbit/s digital interface D1	
Bit rate	2.048 Mbit/s ± 50 · 10^{-6}
Remaining data as for D2	
Power supply	
Battery	— 24, — 36, — 48 or — 60 V
Mains connection to	110, 127 or 220 V a.c. (48—65 Hz)

Dimensions

The multiplex equipment consists of two shelves and one ventilation unit

H×W×D	280×480×326 mm

The multiplex equipment may be placed in the same rack as the primary multiplex equipment ZAK 30/32

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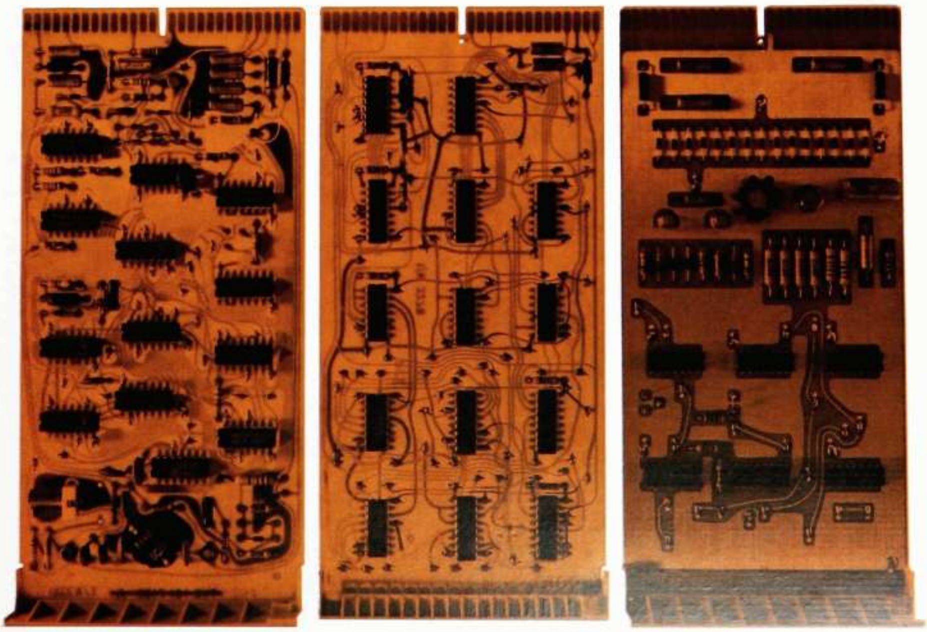


Fig. 19

Units for leak dropping, left to right: 8.448 Mbit/s digital link adapter, receive side; group synchronizing unit; 8.448 Mbit/s digital link adapter, send side

WORLDWIDE NEWS

From the Annual Report of the Ericsson Group:

Summary of the technical development during 1974

During 1974 LM Ericsson assigned a total of 410 MSKr for research and development. This corresponds to 7 % of the Group's sales. During recent years particularly large investments have been necessary within the field of automatic switching in connection with the development of the stored-program-controlled exchanges.

● Within the telephone exchange field several large computer-controlled automatic trunk exchanges were taken into service during 1974. The program volume was further increased to include new traffic cases.

● The first large installation with stored program control of an existing crossbar exchange was put into operation in Århus, Denmark, with very good results.

● Within ELLEMTEL work was continued on the development of a new computer-controlled local exchange system. The switching part of the system consists of a newly developed cross-point switch built up of small reed switches developed by RIFA. The system can alternatively be supplied with a digital group selector stage.

● In order to standardize the mechanical design of equipments of the future, ELLEMTEL have developed a new mechanical construction directly adapted to the requirements of modern telecommunication systems. With this construction plants can be built up on a modular basis with easily handled units.

● Within the field of traffic research may be mentioned studies concerning traffic supervision problems, optimization of the starting time for digit sending, methods for calculating the present value of replacement costs, investigation of telex traffic and analysis of data communication systems.

● Whithin the transmission field the parent company has developed a multiplex equipment that combines four 30-channel PCM systems to form a 120-channel system with a bit rate of 8.448 Mbit/s. The system is in accordance with CCITT recommendations and is primarily intended to work with radio links as the transmission medium.

In the Italian subsidiary company FATME the design was completed of a 24-channel carrier system for symmetrical cable pairs.

● During 1974 equipment was delivered to the Swedish Telecommunications Administration for a subscriber-controlled public data network that permits traffic between subscribers in Stockholm, Gothenburg and Malmö. The network is intended to provide experience for a future permanent subscriber-controlled data network. The major part of the equipment in the present network has been developed by ELLEMTEL.

● A valuable contribution to the many years of development work on picture telephones has been the field trials undertaken during the year, in which subscribers from the design, planning and production departments at the parent company's main plant have taken part. The trials demonstrated how picture telephones can be used to advantage in organizations and can save a considerable amount of time.

● Within the private branch exchange field the development of an electronically controlled private branch exchange ERITRONIC ASD 501 for 16 extensions was continued. The exchange, which requires no operators, was demonstrated as a prototype at the USITA exhibition in San Francisco, where it attracted great attention. The PABX is characterized by rapid installation and high operational reliability.

The development of a new central memory for the very largest types of private branch exchanges was completed, and the first prototype is to be delivered for field trials during 1975. The central memory provides the possibility of changing the number, class, night service, reference etc. of an extension from a terminal.

● During 1974 orders were received from the European space organization ESRO for over 10 MSKr for the development and manufacture of different units for the maritime communication satellite MAROTS and microwave antennas for another scientific satellite.

The LM Ericsson globe on the cover of the Annual Report exists in reality, in the form of large wall decorations at the airports of Stockholm, Malmö and Gothenburg

● The design work on a computer-controlled interlocking system continued in collaboration with the Swedish State Railways, SJ. The new system is to replace the existing relay interlocking system at large railway stations. In the railway signalling field the development of an ATC (automatic train control) system is in progress.

● Among the development projects in microcircuit technique at RIFA were the application of very thin epitaxial layers for obtaining high component density and the use of ion implantation for the production of high quality resistors in monolithic microcircuits.

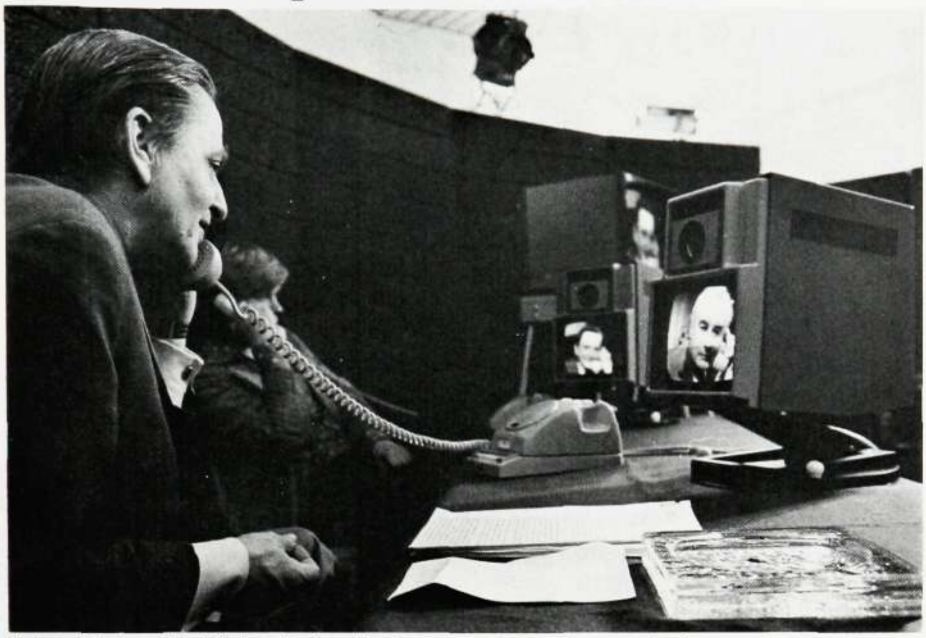
● Svenska Radio AB, SRA, concluded the development of a new mobile telephone for the manual public telephone network, which uses frequency synthesis and is switchable for up to 80 radio frequencies.

Marketing began of SRA's paging system ERICALL CONTACTOR.

● LM Ericsson Telematerial AB designed a new advanced fire alarm system, BRANDLARM 80.

A new alarm equipment for the safety supervision of large areas such as airports

Picture telephone call Stockholm—Melbourne opens technical week



Prime Minister Olof Palme in Stockholm converses via picture telephone with the Australian Prime Minister Gough Whitlam in Melbourne

A call was exchanged via an LM Ericsson picture telephone between the Swedish Prime Minister *Olof Palme*, in the new Parliament building in Stockholm, and the Australian Prime Minister *Gough Whitlam*, in Melbourne, to mark the opening of a Swedish technical week in Melbourne on the 26th of May. A number of Swedish companies, including LM Ericsson, took part. The visiting expert delegation was headed by the Swedish Minister of Labour *Ingemund Bengtsson*.

Addresses were delivered by Dr *Christian Jacobæus* of LM Ericsson Stockholm, "Some problems within the telecommunications field", *Göran Sundelöf* of LM Ericsson Stockholm, "The AXE telephone switching system — basic concept", *B. J. Mc Kay* LM Ericsson Australia, "Digital systems in telecommunication", and *P. B. Janson* LM Ericsson Telematerial AB Stockholm, "Intercom systems".

The picture telephone connection went via TV links between Sweden and Lille in France, over the English Channel to the ground station at Goonhilly, England, and then via satellite over the Indian Ocean to Australia and the earth station Ceduna near Adelaide. Then via APO links to Melbourne where the outside broadcast link of a TV company was used for the final stage of the connection.

Cont. from p. 90

was developed. The system is based on microwave technique.

- A new method of manufacturing vaseline-filled cables was developed on the basis of ideas that originated in the telephone cable division.
- The experimental resources of the Central Material Laboratory were augmented.

Modular component system for printed circuit boards

LM Ericsson have developed a component system, Modular Built Component System (MBC), for use particularly in printed board assemblies. The components are designed with the module M = 2.54 mm as the basic unit and are produced as single modules (4 × 3 M) and double modules (8 × 3 M) with a length of 6 M.

The system comprises test instruments, control and indicating devices. The components are built up on a graphite-coloured polyamide plastic base.

The securing method, with fixing pins for holding the components securely before soldering, is patented in most industrial countries. The tinned connecting wires are square-shaped to permit a number of different connecting methods, such as for example soldering or wrapping.

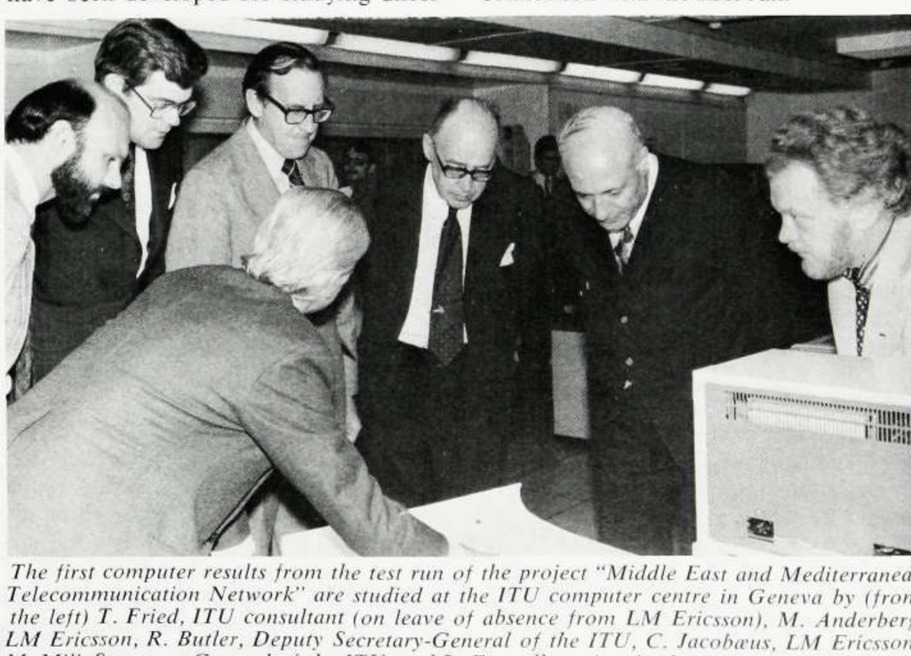
Network planning program delivered to ITU in Geneva

Development work in the field of network planning has been going on at LM Ericsson for many years and has to a great extent been carried out within the framework of a cooperation agreement in this field between the Swedish Telecommunications Administration and LM Ericsson. Theoretical studies by *Fried, Jacobæus, Rapp, Wallström* and others have provided models that have made possible correct dimensioning as well as optimization of exchanges and networks.

In the telephone traffic section at LM Ericsson a number of computer programs have been developed for studying different types of networks.

One of these programs, specially intended for the dimensioning of international networks, was prepared in connection with a study of the telephone and telex network in West Africa for ITU. This program has since been used for an ITU study of the Middle East and Mediterranean Telecommunication Network.

In order to simplify the work of ITU it was decided that this computer program should be entered on the ITU computer in Geneva. The program was formally handed over by LM Ericsson in connection with the first run.



The first computer results from the test run of the project "Middle East and Mediterranean Telecommunication Network" are studied at the ITU computer centre in Geneva by (from the left) T. Fried, ITU consultant (on leave of absence from LM Ericsson), M. Anderberg, LM Ericsson, R. Butler, Deputy Secretary-General of the ITU, C. Jacobæus, LM Ericsson, M. Mili, Secretary-General of the ITU, and L. Engvall, project leader at ITU. With his back to the camera I. Uygur, Head of the ITU Data Division

What happens when LM Ericsson celebrate their centenary?

Next year is centenary year for Telefonaktiebolaget LM Ericsson — the company is thus as old as the telephone. It was on April 1st, 1876 that Lars Magnus Ericsson set up a precision tool workshop in Stockholm, which was later to become the foundation on which the present parent company of the LM Ericsson Group was built up.

The various jubilee activities that are to take place to celebrate the centenary will to a great extent be directed towards the company's customers in different countries, with a view to strengthening even further the good personal relationships that already exist today.

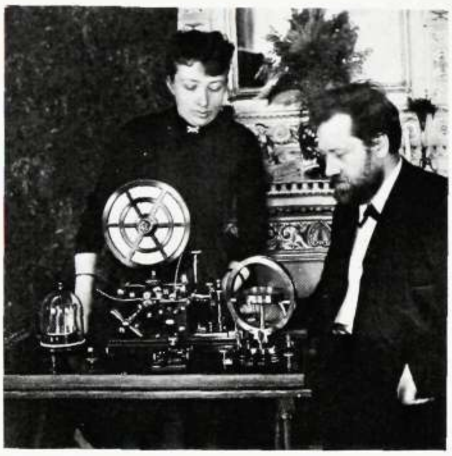
The main feature of the jubilee activities, with their "heavy" customer bias, is to be a symposium on telecommunication at which international experts will be the speakers. The symposium is to take place on the 4th and 5th of May.

Furthermore the international telecommunication prize, founded by LM Ericsson in connection with the centenary celebrations, is to be awarded for the first time. There is also to be a reinauguration of the LM Ericsson Memorial Room at the Technical Museum in Stockholm on May 5th, the birthday of Lars Magnus Ericsson.

On the same day a celebration dinner, to be attended by HM King Carl Gustaf of Sweden, is to be held at Stockholm Stadshus (Town Hall) for the symposium delegates, important customers and specially invited guests.

Among the more general activities during the jubilee year may be mentioned the publication of a book in three volumes entitled "LM Ericsson 100 Years". Two of the volumes are devoted to the company's economic and commercial activities and one volume to the technical development.

Two films are to have their premiére. One of these, with the title "On speaking terms", shows how LM Ericsson solve



Lars Magnus Ericsson and his wife with a telegraph apparatus manufactured by the company

communication problems throughout the world. The other film is on historical, documentary lines and portrays the company's first 100 years against the background of world events during that period.

The jubilee year will also be reflected in Ericsson Review, among other things by the publication of a jubilee number containing papers read during the symposium and the speech of the winner of the LM Ericsson prize.

Other jubilee activities will be held specially for present and pensioned employees of the company. The form that these activities are to take is at present being investigated. The staff organizations are among those taking part in the investigation.

New literature

Elementary Treatment of Reliability and Spare Parts Calculations is the title of a new compendium published by Telefonaktiebolaget LM Ericsson (No. T/S 7025-5 e). The language is English and the author Dr. *Branko Tigerman* of the Transmission Division in Stockholm.

The aim of the compendium is to explain in simple and elementary ways the more common reliability concepts. It is intended for all those who in their work require information and opinions in the fields of reliability and spares calculations, without being specialists in these fields.

In the main, the practical examples are taken from the transmission and carrier field.

PABX to Alaska

LM Ericsson's French subsidiary company, Société Française des Telephones Ericsson, in collaboration with Ericsson Centrum Inc. in New York, have delivered a PABX of type CP 100 F for 1300 extensions to ALEYASKA PIPELINE SERVICE in Fairbanks. CP 100 F, which has a maximum capacity of 2400 extensions, is based on the crossbar switch technique and was developed and manufactured by the French company.

The exchange in Alaska has, among other features, 140 bothway junction lines for automatic traffic with 17 work camps engaged in the large pipeline project.

PABX to Poland

The largest private branch exchange that LM Ericsson have delivered to Poland hitherto, has been handed over to the state-owned iron works Huta Bieruta in the town of Czestochowa. The exchange was ordered by the Polish foreign trade organization ELEKTRIM.

The exchange is of the type AKD 791, which thus makes it debut on the Polish market. The plant in question comprises 2000 extensions and 94 exchange lines. The number of internal call possibilities is 142.

Only four operators are required to serve the 2000 extensions. This has been made possible by the fact that 30 of the incoming lines from the public network have been provided with direct in-dialling facilities, so that the extension numbers can be dialled direct without operator assistance.

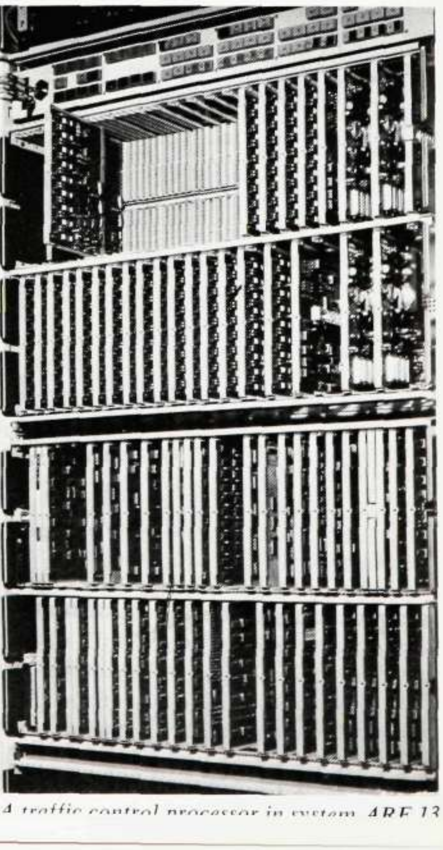
Computer-controlled ARE 13 to Kuwait

LM Ericsson have received another large order from the Kuwait Ministry of Communications. The order is for a new stored-program-controlled, international transit exchange with crossbar switches, type ARE 13, for both fully automatic and manually handled traffic. The exchange includes equipment for 1400 international lines, mainly satellite circuits to all continents.

The order also includes a new processor-controlled toll ticketing system for both the fully automatic and manually handled traffic and modern operator consoles with display panels for the calling and called subscriber numbers etc.

The exchange is controlled by processors in the control equipment ANA 30, which belongs to the same family as the control equipment in the local exchange system ARE 11. ARE 13 also includes a new version for national traffic.

Since 1966 Kuwait has been an important market for LM Ericsson. During 1973 and 1974 the company received orders worth a total of 85 MSKr.



A traffic control processor in system ARE 13

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With associated companies and representatives

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ERICSSON REVIEW

M5 – A NEW CONSTRUCTION PRACTICE

CHANNEL TRANSLATING EQUIPMENT IN THE M5 PRACTICE

SPC TRANSIT EXCHANGE

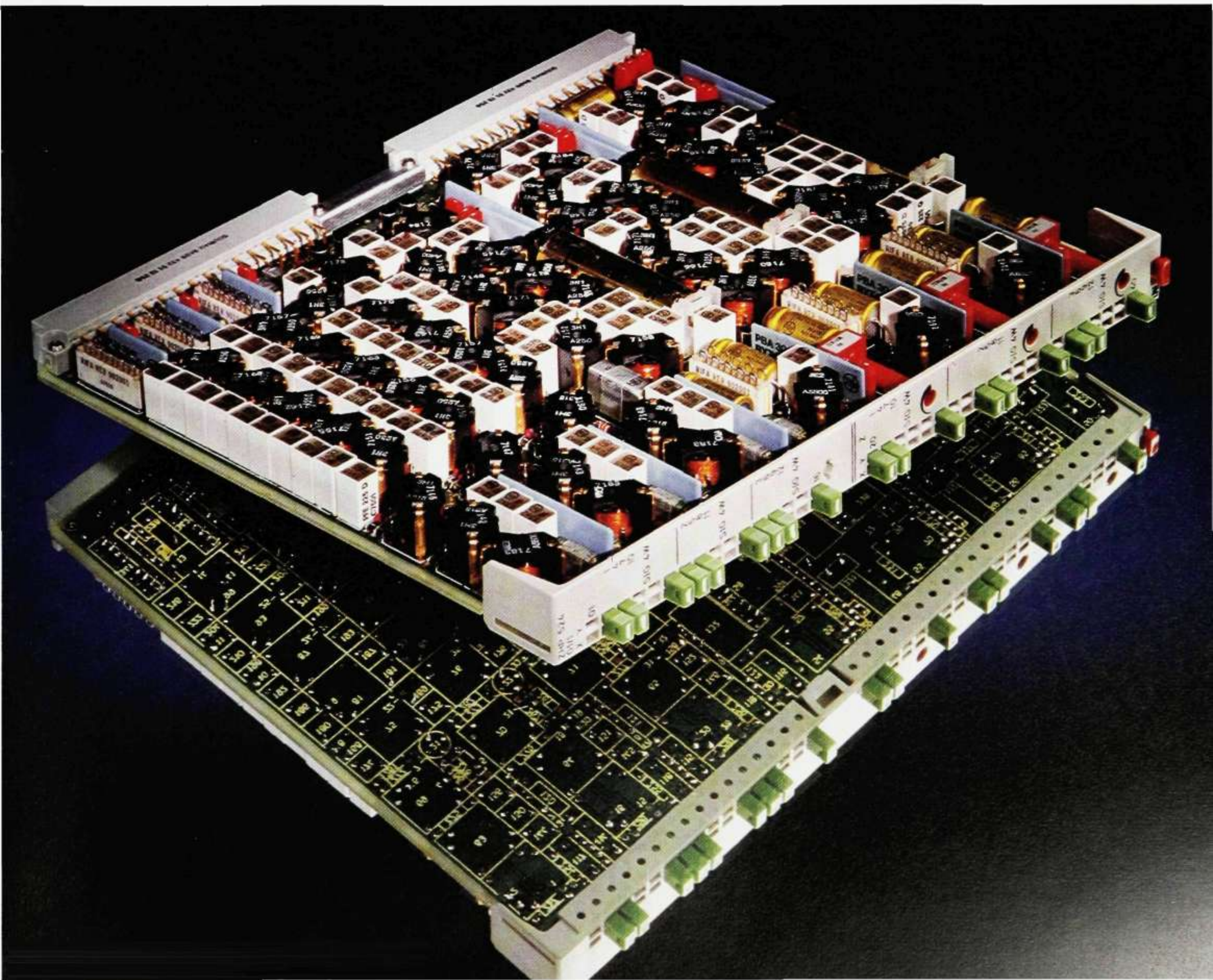
THE QUALITY OF THE SWEDISH WIDEBAND NETWORK

ERICALL CONTACTOR

CHARACTERISTICS OF LOUDSPEAKING TELEPHONES

WORLDWIDE NEWS

3/4 1975



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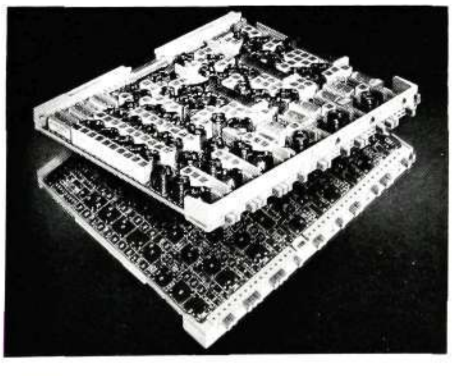

COVER

Channel modem for FDM equipment in the new M5 construction practice

M5 Construction Practice for Transmission Equipment

Knut Axelson, Per-Olof Harris and Erling Storesund

The rapid technical advances made in the component field have resulted in changed prerequisites and new possibilities for the design of transmission equipment. These technical advances can be exploited for new types of equipment and also for new designs of existing equipment but without changing its function. For both the user and the manufacturer there are good reasons for not introducing a new equipment generation too often, and a period of 7—8 years between such changes has become fairly general. Equipment in the Long Distance Division's M4 construction practice was introduced towards the end of the sixties, and in this number of Ericsson Review the first equipment in the new M5 construction practice is presented[1]. This article describes the mechanical solutions and the power supply principles applied in the M5 construction practice, and some of the new components that are used in the equipment.

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The guide lines for the development of the M5 construction practice have been to utilize the principles of the earlier construction practice that have proved to be tenable, to further develop these by adaption to the new prerequisites and to exploit the new technical advances.

The introduction of the M4 construction practice for LM Ericsson's transmission equipment during the latter half of the sixties meant not only the introduction of a new mechanical design but also the utilization of a number of radical principles for the construction of the equipment[2–4]. Without doubt the construction principles that are characteristic for M4 have been appreciated by customers, and in many details other manufacturers have arrived at similar solutions.

Consequently, when designing the M5 construction practice LM Ericsson has had good reason to exploit the positive experience from M4. For example, the build-up of the equipment into shelves, which constitute functional and mechanical units, has been retained as an important principle. This offers such important advantages as, for example, that the systems can be extended in stages in step with the increase in traffic, that planning and allocation of installation work can be carried out in the most rational way etc. Furthermore it is possible to use prefabricated station cables. This has proved to be particularly valuable for projects that require short installation times.

The development of a new equipment generation means that new components will come into use, which will make it possible to give the equipment a higher packing density. New materials and new manufacturing methods will facilitate rationalization, which can counteract the continuously rising labour costs.

One factor that has necessitated a thorough overhaul and review of the construction principles has been the desire to use the same construction practice for analogue and digital equipment. In future both these types of equipment will to an ever increasing extent be installed in the same stations, so that the advantages to the user of having the same mechanical construction are obvious. Moreover the equipment for the first multiplex stages in FDM and PCM systems have the same mechanical construction requirements as regards volume of station cabling, crosstalk characteristics etc. This equipment, which constitutes the economically most important part of the transmission system terminals, has influenced the design of the construction practice to a far greater extent than hitherto. This means, in its turn, that M5 has been given a greater differentiation in the mechanical design of the units than in, for example, M4, primarily in order to be able to satisfy the requirements of the higher order multiplexes.

One important question has been whether LM Ericsson should continue with shelves that have traditionally been mounted horizontally in the bay frames, or to go over to the socalled vertical construction. The latter can popularly be described as a construction practice with "shelves" placed vertically in narrow bay frames. This means that the individual printed board assemblies are placed horizontally in the shelves, which seriously reduces the possibility of obtaining a natural circulation of air between the boards, and hence selfcooling. This limitation can give rise to problems, particularly in the case of digital equipment, which has integrated circuits that require a relatively large power. Horizontal shelves provide greater freedom to vary the size of the printed board assem-

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blies. This means that it is easier to adapt the boards to the circuit functions, and hence the number of connections between boards can be reduced. Similarly the sizes of horizontal shelves can be better adapted to the space requirements of the different complete system functions. Among other reasons that justify keeping to the horizontal shelf construction is that the mechanical rigidity of the bay is better, and that there are greater possibilities of arranging the bay cabling in a way that facilitates installation.

Mechanical Design

The M5 construction practice has been adapted to the component height of 13.5 mm recommended by IEC, and permits the build up of separate functional units which can be plugged into a shelf. In this way the shelf forms a complete system function. The shelves are mounted in a bay frame containing certain common equipment. Each mechanical module has a designation, so that it is easy to find any particular part of the equipment, fig. 1.

The equipment is supplied in two shades of grey; light grey, which is the basic colour, and dark grey. Control devices and suchlike are finished in a contrasting colour.

Units

The components included in the units are mounted on single-sided or double-sided printed wiring boards of epoxy fibreglass laminate. Where necessary plated-through holes have been used.

The printed boards for lower frequencies are available in two sizes, 100× 178 (single board) and 222×178 mm (double board), and at the contact end they can be equipped with one or two 32-pole plug connectors, so-called Euro-Connector type. The connectors contain two pins for earthing which are elongated in order to avoid the risk of damaging semiconductor components when plugging in or out the board with the power switched on.

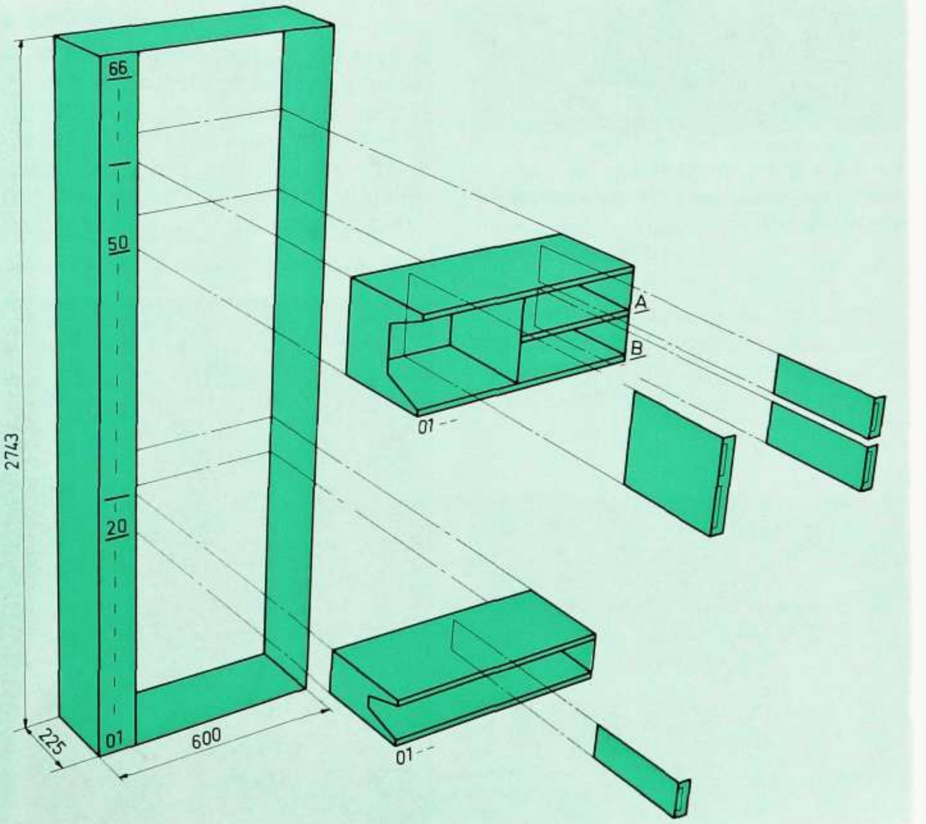


Fig. 1
Main dimensions of the bay and design principles. Bay module numbering

Fig. 2
Units (printed board assembly) for the M5 construction practice. The unit to the left has the component side downwards in order to show the screen

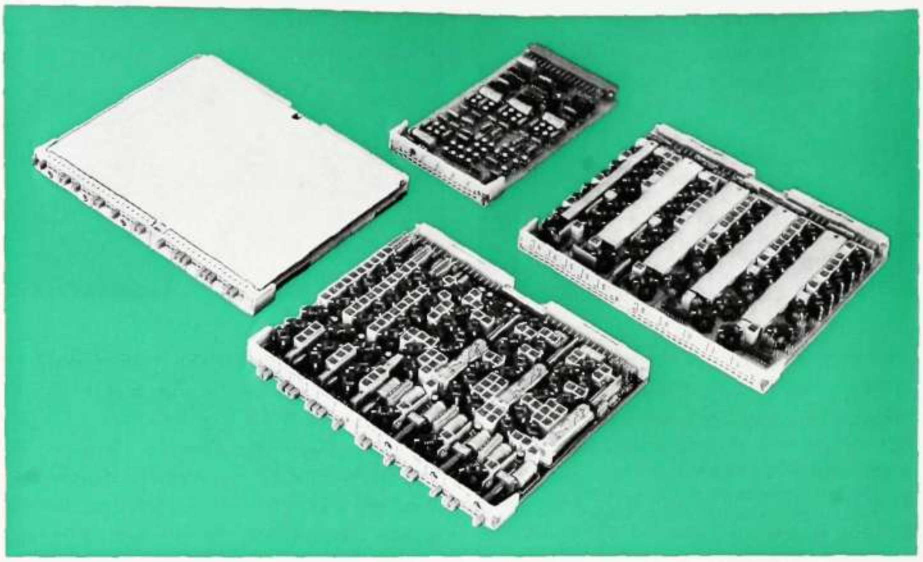


Fig. 3
Unit for high frequencies with the component side to the right

When necessary the front edge of the board is provided with gold-plated contact fingers for test purposes, etc., and also indicating and control facilities. The front edge has a snap-on plastic front with sockets for the above-mentioned facilities and for unit extractor. The front is provided with designations for unit identification, installation and maintenance, and in its lower edge it has a locking lug, which prevents the board from being pulled out of its shelf socket unintentionally.

The solder side of the unit is usually provided with a metal screen which is coated with an insulation paint. The screen also serves as a handling protector. Screens are used on the component side only if required. Examples of such units are shown in fig. 2.

Equipment for high frequencies often requires coaxial connectors and better screening between the functions included in the units. For such equipment a type of unit has been developed, which is adapted to the case unit construction that was first used in the M4 construction practice, and which fulfils these requirements excellently. The units, which are built up on printed boards (98 × 207 mm) of epoxy fibreglass have separate screening covers on the solder side and the component side, and can be obtained with or without a longitudinal screening partition, see fig. 3. The contact end is designed in the same way as in the M4 units.

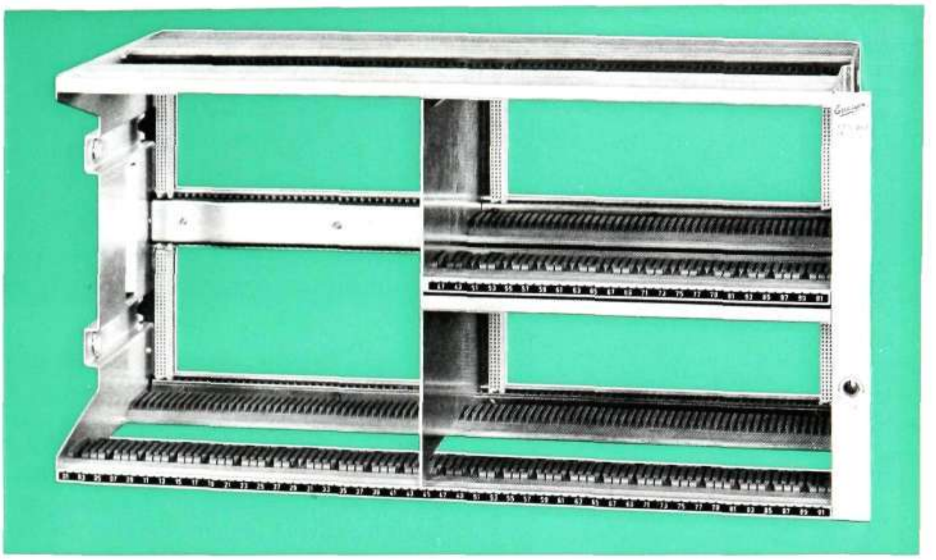
Shelf

The shelf for lower frequencies, which is available in two versions adapted to the two board sizes, permits simple and correct positioning, connection and locking of the units, see fig. 4.

The shelf frame is built up of four or five extruded aluminium profiled bars, which are fastened with screws between two aluminium side plates. Plastic strips with guide grooves for the units at intervals of 5.08 mm are fitted on the profiled bars. However, only those guide grooves that are to be used for the insertion of units are open. The rear plastic strips also contain

Fig. 4
Single and double shelves

Fig. 5
Double shelf with internal wall and partition plate for single boards



pegs for locating the socket connectors for unit connection. This ensures a good alignment between the guide grooves and the position of the connectors and thus facilitates insertion of the units.

The open framework construction of the shelf permits good ventilation through the units. If required the openings at the top and bottom can quite easily be covered by fitting snap-on plates.

The front edge of the front bars is shaped to take the designations required for installation, maintenance and operation. The normal module numbers are given along the front edge of the bottom bar, while the top bar has been left empty for the customer's own designations.

One or more screwdriver-controlled break points for the power supply to the shelf are provided on the front of the right-hand side plate. The front of this plate also contains a label, which under a plastic protector, gives the complete code of the shelf and has space for the customer's own designation.

The positions in the shelf not equipped with units can be provided with dummy fronts.

The double shelf can be equipped with a vertical internal partition wall supporting a horizontal profiled bar, so that single boards can be inserted in the right-hand part of the shelf, see fig. 5.

Connections between the socket connectors at the rear of the shelf are made with insulated connecting wires, screened cable or with copper bars for the power supply and earthing. For the time being all joints are soldered. The connections at the rear are protected by a removable cover plate. The power supply and alarm connections are connected in at the right-hand side plate of the shelf. The transmission path connections, on the other hand, i.e. the station cabling, are brought in on the left-hand side of the shelf, and are connected either by a plug to a socket connector at the rear of the shelf in the positions not equipped with units or are taken via the outside of the left-hand side plate to the connection side at the rear of the shelf. Here the cabling is connected to special connector inserts which snap into the actual connectors themselves.

Up to six coaxial sockets for connecting station cables can be mounted on the outside of the left-hand side plate of the shelf.

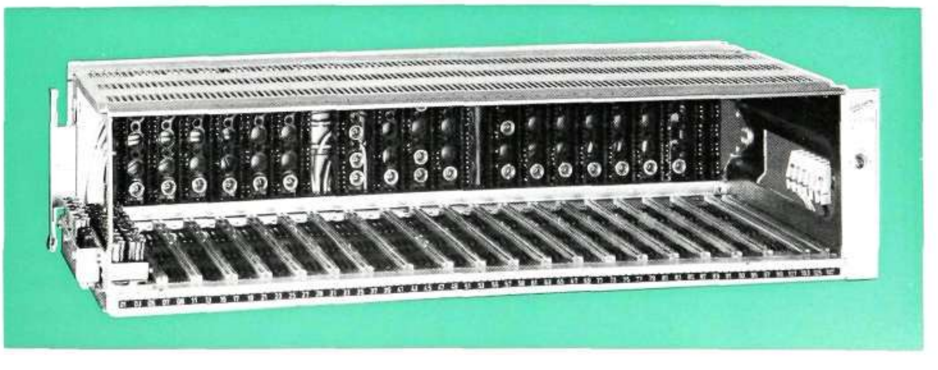
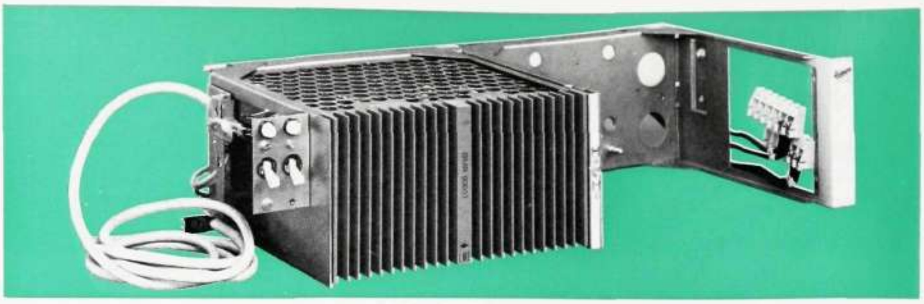


Fig. 6
Shelf for high frequencies

Fig. 7
Power supply shelf equipped with one power unit



Certain special connecting devices have been developed, for example a connector for multiplied, screened connection between several shelves along the right-hand side plate, plug connector for front connection of a screened station cable to units farthest to the left in the shelf and a U-link for front connection between two adjacent units.

The shelf version, fig. 6, that is used for units for higher frequencies, is equipped at the rear with modified M4 connectors, and can also be used for units built in accordance with the M4 case unit construction principle. The transmission path cabling is connected by means of plugs and sockets on the left-hand sideplate of the shelf and the power supply and alarms are connected at the right-hand side plate.

Power unit
A shelf has been developed for power units having space for up to two plug-in power units. A special arrangement prevents the wrong power unit being connected in. Alarm lamps and circuit breakers are fitted at the left-hand side plate of the shelf, see fig. 7.

Each plug-in power unit is built up in a steel plate box, which, together with a red aluminium cooling flange mounted on the front, completely encloses the unit.

Bay frame
The bay frame is built up of a left-hand and a right-hand upright. At the bottom the uprights are joined to the bottom plate and at the top to two horizontal iron members. The bottom plate has adjusting screws for aligning the bay frame, see fig. 8.

The wider left-hand upright, which is of steel plate, has space for the station cabling and cable fasteners.

The narrower right-hand upright consists of an extruded aluminium profiled bar formed with one narrow and two wide vertical channels on the inside. Six vertical U-shaped copper bars for the power supply and alarm concentration are mounted by means of snap-in plastic blocks in the wide channel at the front. The bars are protected with plastic covers in order to prevent them being touched accidentally where shelves are not equipped. The other wide channel behind can be equipped with three such bars using the same type of plastic blocks or it can be used for other internal rack interconnections. The narrow channel at the rear is used for running the incoming power cables down to the power units at the bottom of the bay frame.

A vertical copper earthing strip is fitted on the inside of the rear of each upright. The fixing holes for mounting the shelves, with the associated module numbers, are also on the insides of the two uprights.

The left-hand upright is covered at the front by hinged cover strips which are held closed by magnetic locks. Equipment necessary for operation and maintenance such as alarm lamps, bay assembly chart, telephone set, test instrument, station trunks etc. are fitted on these cover strips. The common alarm unit for the bay is fitted on the inside of the cover strips and also a pocket for the diagrams and instructions required for the maintenance of the bay, see fig. 9.

A wider left-hand upright can be supplied for stations with a fixed bay module of 670 mm.

Mounting and connecting the shelves into the bay
Mounting the shelf in the bay, either direct or via guides, and screwing it to the bay uprights, causes the shelf to be earthed to the above-mentioned copper strips through special earthing tabs.

The shelf connections to the power supply and alarm concentration bars are very easily made by pressing down the contact tabs, which terminate the shelf cabling, into the relevant copper bars via a cut-out in the right-hand side plate of the shelf, and then securing with screws. In order to simplify this and to avoid the possibility of mixing up the contact tabs, the tabs are fixed in a plastic block, see fig. 10.

The connection of the station cabling, which runs to the shelf in the left-hand bay upright, is arranged so that at an early stage of the installation, i.e. before the shelves have been delivered, it is possible to equip the cabling with

Fig. 8
Bay frame (left)

Fig. 9
Part of the left-hand bay upright with the cover strip in the open position (right)

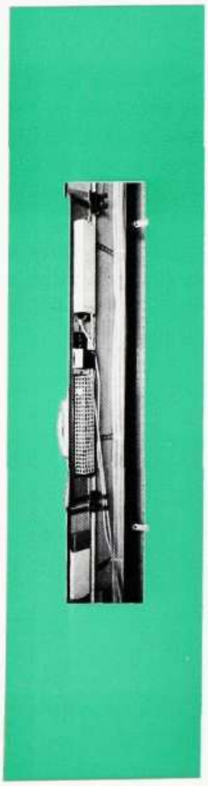
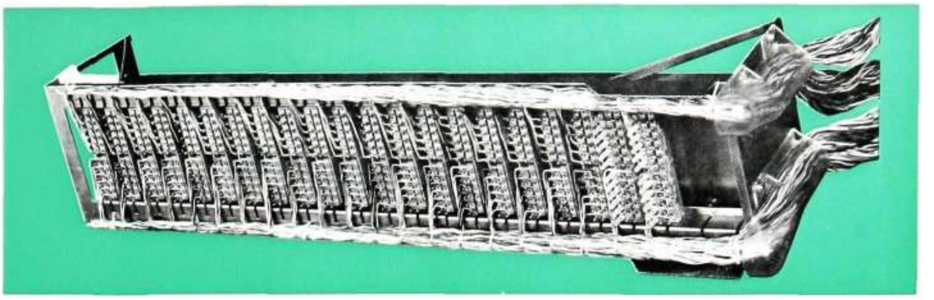


Fig. 11

Station cable connected to connector inserts mounted in the formboard frame



the required connectors or connector inserts. These are therefore delivered separately. This procedure means that for a very moderate outlay the customer is able to fully cable a bay that is initially only partially equipped, and also makes possible the use of prefabricated station cables.

When carrying out the wiring work it is advantageous to use formboards when the station cabling is to be connected direct to the rear of the shelf. In such cases a formboard frame, in which connector inserts with handling protectors have been snapped into the required positions, is placed by the left-hand upright. The handling protectors have a number of pins to simplify the running of the wires, see fig. 11. Once this has been done and the wires have been stripped and soldered to the tags, the handling protectors with the inserts can easily be removed from the frame and the cabling fixed to the upright. When the shelf is to be mounted in the bay, the connector inserts can be removed from their handling protectors by means of a slight pressure, and snapped into position in the appropriate connectors at the rear of the shelf, see fig. 12. The shelf can then be inserted and screwed into the bay. All wiring work can be done from the front of the bay.

In special cases, where increased natural circulation of cooling air is required, horizontal ventilation units can be placed between shelves. The ventilation units take in cooling air in the central part of the front and let out heated air at the outer edges of the front.

Power supply

The power supply for the equipment has been arranged in a flexible way, with one or more power units placed at the bottom of the bay frame. An arrangement with common power units for all the equipment in the bay has been chosen primarily for economic reasons. The type and number of units depends on the primary voltage of the station, the secondary voltage required, the power consumption of the bay and any requirements as regards standby operation.

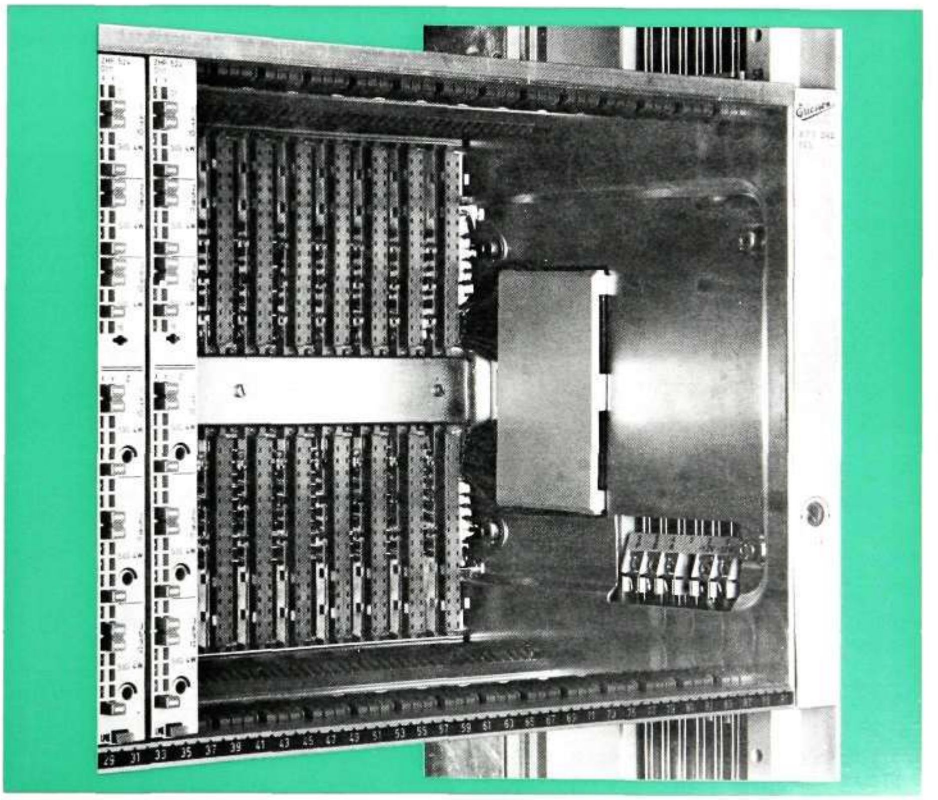


Fig. 10

Connection of a shelf to the right-hand bay upright

For battery operation with 24, 36, 48 or 60 V the bay is equipped with d.c./d.c. converters, each of which is fused on the primary side with a circuit breaker. These are mounted either at the left-hand side plate of the shelf or in the bay suite cabinet. In the latter case the fuse box in the suite cabinet serves as a distribution centre for all the converters in the bay suite.

For mains operation from 110, 127, 220 or 240 V the bay is equipped with mains voltage rectifiers together with d.c./d.c. converters. Each mains voltage rectifier is fused on the primary side with a glass-tube fuse inside the rectifier.

The following secondary voltages are met with in the bay:

- − 12 V in practically all equipment
- + 12 V and + 5 V in PCM equipment
- − 21 V in certain equipment

The different d.c./d.c. converters used for the generation of the secondary voltages are mechanically identical, and each converter takes up half the shelf width in the power supply shelf for battery operation (see fig. 7). In the shelf for mains operation the left half of the shelf is intended for the mains voltage rectifier and the right half for a d.c./d.c. converter for one of the secondary voltages.

The various secondary voltages are cabled from the power supply shelf to the distribution bars in the right-hand upright. From the bars the voltages are taken to the power consuming shelves. The output power from the d.c./d.c. converters varies between 160 and 200 W depending on the value of the secondary voltage. If the power from one converter is insufficient to supply a whole bay, the bay can be equipped initially with two rectifiers or, what is perhaps more expedient when the bay equipment is extended in stages, a second converter can be added at a later stage.

Alarm equipment

Depending on their function, units in the different shelves can be provided with alarm circuits to indicate faults.

Examples of the conditions that cause alarms are faulty secondary voltage from a d.c./d.c. converter, incorrect reference pilot level, loss of synchronization in a PCM system etc.

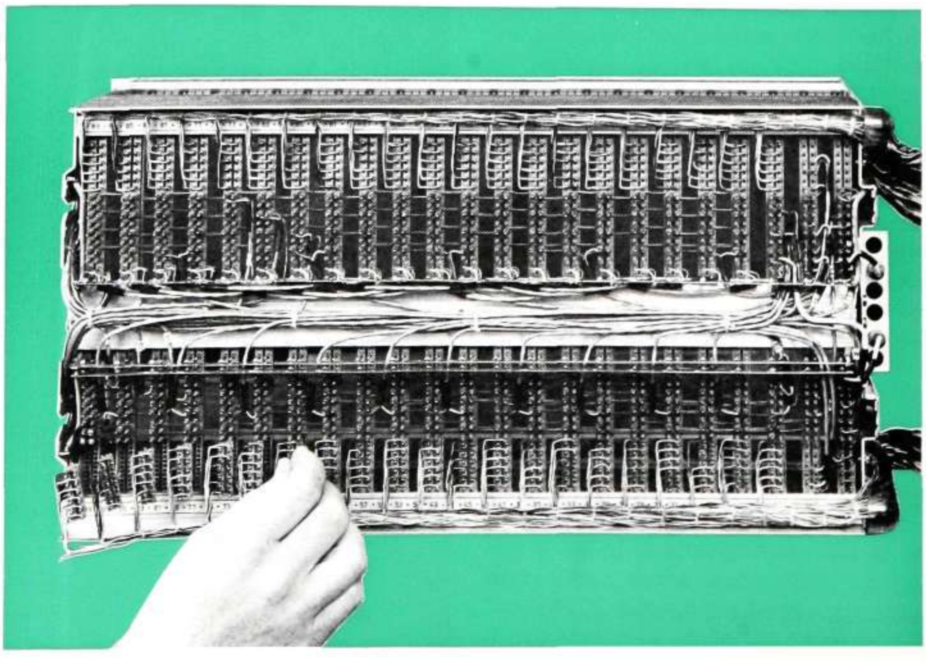


Fig. 12
Snapping in connector inserts in the shelf connectors

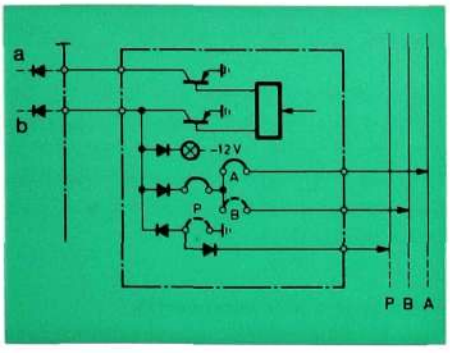


Fig. 13
Example of a unit alarm circuit

PBA Alarm concentration bar in the bay upright
a Alarm output for switching groups of channels
b Individual alarm output

The design of a typical alarm circuit is shown in principle, in fig. 13. Each such alarm is usually indicated visually by a light emitting diode on the front of the unit. The individual alarm output provides the possibility of giving a central indication of individual alarms. In certain cases the alarm device for pilot receivers in an FDM system is provided with a special output for use in connection with stand-by swtiching of groups of channels.

The alarm category required, A for urgent alarm and B for non-urgent alarm, can be selected by means of a strap in the alarm circuit.

Certain alarm outputs can be changed to "reminder" indications (P) so that the station staff are not disturbed by false alarms caused by, for example, maintenance work. Connection to the central alarm unit of the bay takes place via bars for alarm concentration in the right-hand upright.

The bay alarm unit, which is placed in the cover strip of the left-hand upright, has a number of separate outputs for the different alarm categories. These are intended for connection to the bay alarm lamps and to the external alarm circuits in the suite end cabinet and/or in the office alarm equipment for the station. The alarm unit also contains acknowledgement relays, by means of which an external alarm bell for a particular alarm category can be switched off without disconnecting the alarm lamps.

Components

Selection and design

The most important demands made on electrical components used in transmission equipment are as follows:

— the electrical characteristics must satisfy the circuit requirements

— the component data must be stable during the operational life of the equipment, i.e. 20—40 years. The main properties, such as inductance of coils and capacitance of capacitors must not change by more than 0.2%

— the life must be at least 40 years for wear failures

— ability to withstand adverse environmental conditions as regards temperature and humidity and also good resistance to mechanical stresses etc.

— high reliability. The mean failure rate during the best period should be $< 1 \times 10^{-9}$ failures/h, i.e. a maximum of one failure/year for a system with 100,000 components

— small dimensions, height a maximum of 13.5 mm and the space requirement on a printed board must be adapted to a 0.635 mm modular grid, with terminals placed on a 2.54 mm grid

— the components must be suitable for automatic assembly, have terminals with good soldering properties, spacing shoulders to facilitate the escape of gas when wave soldering etc.

— flammability must be so little that the risk of maintaining a fire is negligible.

The properties and the reliability of the components have been studied very carefully before being included in the system. The testing methods used for type testing have included those standardized by the International Electrotechnical Commission (IEC) and also methods prepared by LM Ericsson. The latter are more stringent and decisive. Life tests are usually carried out for up to 10,000 hours instead of 1000 hours as applied within IEC. This more stringent type testing, combined with a rigorous receiving and manufacturing inspection of all components and periodically recurring type checks, is a guarantee that the components used satisfy all the specified requirements.

The more important of the new components are described below. Particular stress has been laid on those properties that have been decisive for the inclusion of the components in the equipment, and on how the functional and quality requirements have been met.

Semiconductor components

Modern glass, metal or ceramic encapsulated silicon diodes, silicon

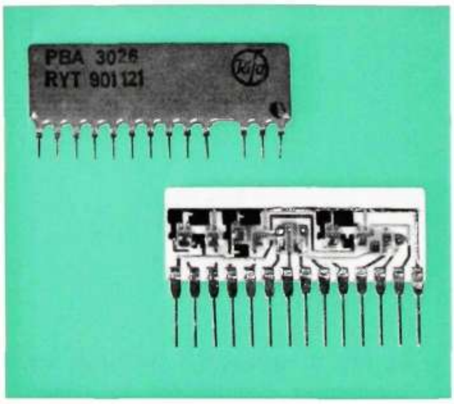


Fig. 14
Hybrid circuit, with encapsulation and without

Fig. 15
Inductors with RM-6 and RM-5 cores

transistors, zener diodes and monolithic integrated circuits are used as in previous construction practices, but apart from these components, newer semiconductor components have been introduced for certain purposes. These include thick-film hybrid circuits, CMOS type of monolithic integrated circuits and field effect transistors. The main reason for introducing hybrid circuits is naturally because of the miniaturization obtained. In the long run a saving in costs can also be made by introducing process-controlled production, for which it is not expected that costs will rise at the same rate as for manual work. Hybrid circuits, fig. 14, are produced by printing conductor and resistor patterns on a ceramic substrate, firing, adjusting resistance values with laser, eutectic soldering of semiconductor and capacitor chips, connecting with gold wire and encapsulating in a selected plastic.

When selecting semiconductor chips and capacitors, type tests for these have been carried out separately on a substrate in the actual encapsulation. The stability of the component properties have then been studied in both long-term operation and accelerating environments in order to be able to ensure that the selected passivation and encapsulation materials do not have any unacceptable long-term effects. This is difficult to investigate in circuits in which the components cannot be studied separately. The circuit properties have of course been studied in parallel with this.

CMOS circuits have been introduced mainly because of their low power consumption and large operating voltage range, 3—15 V, which permits the use of a single feeding voltage for FDM equipment. Another factor that has influenced the selection of CMOS circuits is their good noise margin.

Field effect transistors are used for modulation purposes and, owing to the high impedance on the gate, the load on the carrier generation is quite small. When investigating CMOS and field effect components, apart from the normal component property, long-term and climatic tests, great emphasis has been placed on the study of input protection and the ability to withstand transients.

Light emitting diodes are used on the printed board assemblies for indicating purposes. They require only a tenth of the power needed for normal incandescent lamps and they also have a very much longer life.

Inductors and transformers

The development of ferrite core shapes that facilitate production, which was started when the M3 construction practice was introduced, has been continued in the M5 construction practice through the use of RM-5 and RM-6 cores. These cores, which have been standardized by IEC, are a further development of the X core invented by LM Ericsson and the earlier developed wing core W 17. The cores take up a rectangular space on a printed board of 5×2.54 mm and 6×2.54 mm respectively. When developing inductors with these cores great emphasis has been laid on making them easy to manufacture, both manually and automatically. For example the terminals have been designed so that they are suitable for automatic winding and connection, which will be the method applied for most of the production.

After winding, connection of the winding tags, taping, soldering and bending the tags, all of which can be done in automatic machines, the core and coil are assembled. By holding the core together with a spring strap, epoxy resin can be applied on the outside of the joint where it is sucked in by capillary action, which simplifies the operation and makes it less expensive.

The two inductor types are shown on fig. 15. The nut for the trimming core has been designed with an insulating disc to provide insulation against the printed wiring on the component side of the board. As only one of the two spring straps is connected to the board, the coil cannot be mounted the wrong way round on the printed board.

Capacitors

The new filter capacitor, a polystyrene capacitor with a 7.5 mm square base, is shown in fig. 16. The design has been

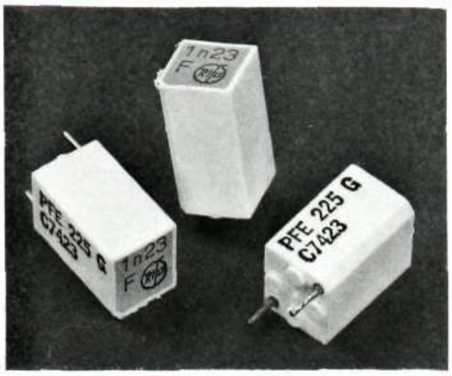


Fig. 16
Polystyrene capacitors

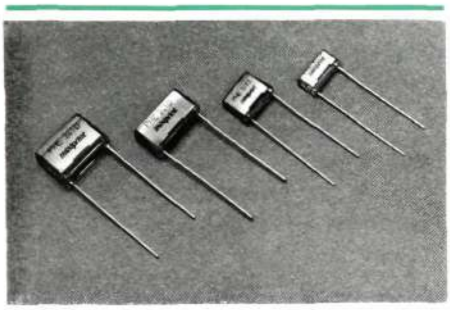


Fig. 17
Metallized polyester capacitors

chosen partly because four of these capacitors can be fitted in the space required by an RM-6 inductor.

The capacitor consists of a vertical winding with extended tinfoil, cast with a special epoxy resin in a polypropylene case. This encapsulation provides excellent humidity protection. In order to ensure good reliability it is necessary to carry out voltage tests at six times the rated voltage, as against twice the rated voltage in accordance with the IEC requirement, which must be considered as too low to sort out potentially weak samples.

In the earlier construction practice capacitors with two matched windings have been used in order to obtain close capacitance tolerances. As a result of improved production methods it is now possible to achieve tolerances of ±2% and ±1% with a single winding. Considerable attention has been paid to the spread of the temperature coefficient in order to ensure that there shall be good temperature compensation between the negative temperature coefficient of the polystyrene capacitor and the positive temperature coefficient of the inductor.

The capacitors used for coupling and decoupling purposes are metallized polyester capacitors, fig. 17, dry tantalum oxide capacitors and aluminium electrolytic capacitors with an electrolyte that is free from water. The latter are also used as filter capacitors in power supplies, and they have a considerably longer life and are better able to withstand ripple currents than conventional aluminium electrolytic capacitors.

Resistors

A metal film resistor with small dimensions, fig. 18, is used as the standard resistor. It is built up in the same way as the carbon film resistors that were used earlier, but because of the metal resistance film it has a better long-term stability. Owing to the smaller dimensions a very much higher packing density can be obtained, namely one module (2.54 mm) in the transverse direction.

A thick-film circuit has been developed for use as a channel attenuator, fig. 19. This consists of two substrates with a printed resistor pattern. Short-circuiting straps have been taken out on the top side of the attenuator, and by cut-

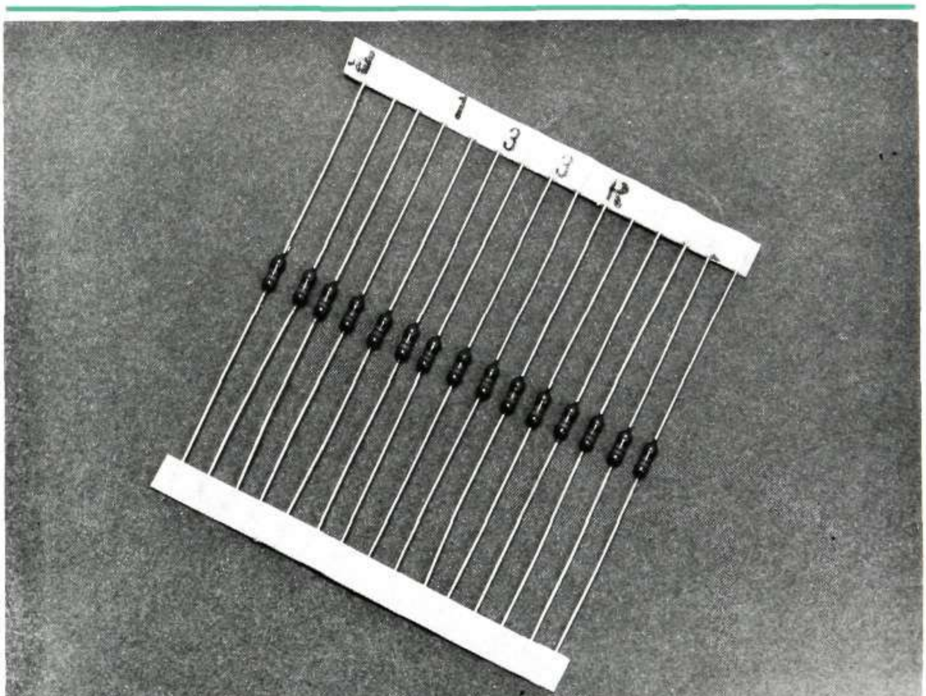
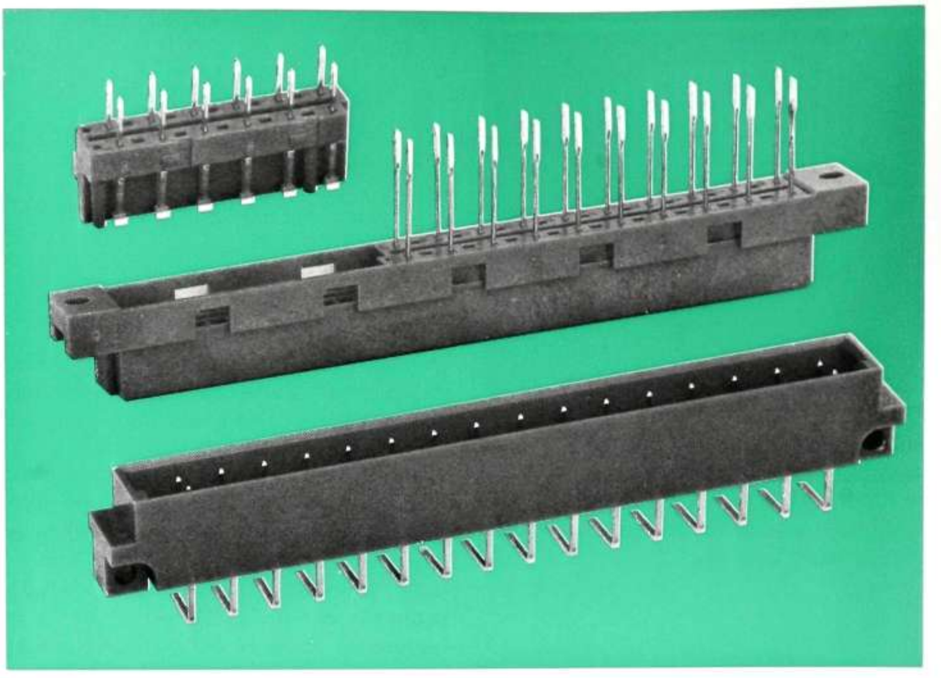


Fig. 18
Taped metal-film resistors for automatic assembly

Fig. 21
Euro-type connector for printed board assemblies. The top half is mounted in the shelf. The connector insert (above left) is snapped into the contact housing



ting the appropriate straps an attenuation of between 0.5 and 15.5 dB can be connected in circuit. To change the attenuation it is only necessary to solder together the two ends of the cut straps and cut other straps as required.

The circuit contains 13 resistors and the stability of these and their dependence on the manufacturing and trimming process have been studied thoroughly, both as regards long-term effect and the effect of different environments.

In earlier transmission equipment potentiometers have not been allowed because the contact between the sliding contact and the resistance path had been unreliable in potentiometers available at the time. However, through the introduction of potentiometers with a so-called cermet path and multifingered precious metal contacts, fig. 20, a reliable product is now available.

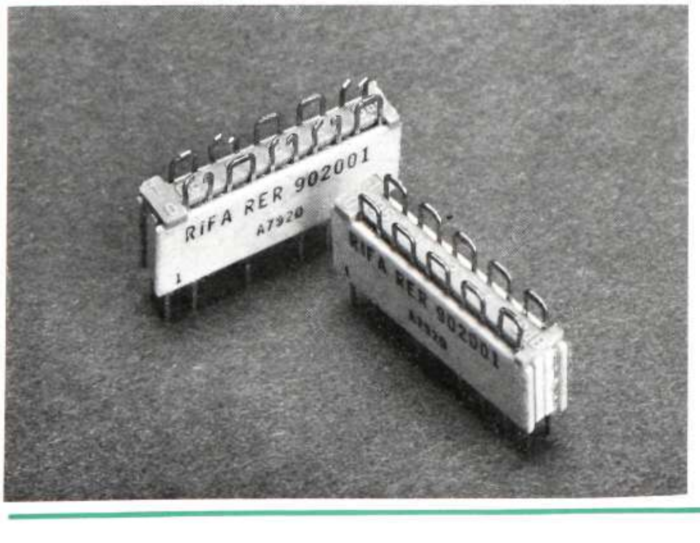
According to the cermet technique, a thick-film resistance pattern is printed and fixed by firing on to a ceramic substrate and is connected to terminals via a conducting pattern. The moving contact consisting of 30 parallel wire springs of a precious metal alloy provide the contact between the resistance path and the terminal. The stability of the contact resistances has been studied exhaustively using a testing method developed by LM Ericsson which has also obtained international recognition. The testing method will very likely be standardized by IEC.

Electromechanical components

The connector for the printed circuit boards, fig. 21, is designed as a two part connector, one part of which is mounted on the printed board. The printed board part of the connector has electrolytically gold-plated pins, while the multipoint socket connector has rolled plated contact surfaces, in both cases with a barrier layer of nickel under the gold. Connectors of the M4

Fig. 19
Adjustable attenuator built up as a thick-film circuit

Fig. 20
Potentiometer with a cermet resistance path



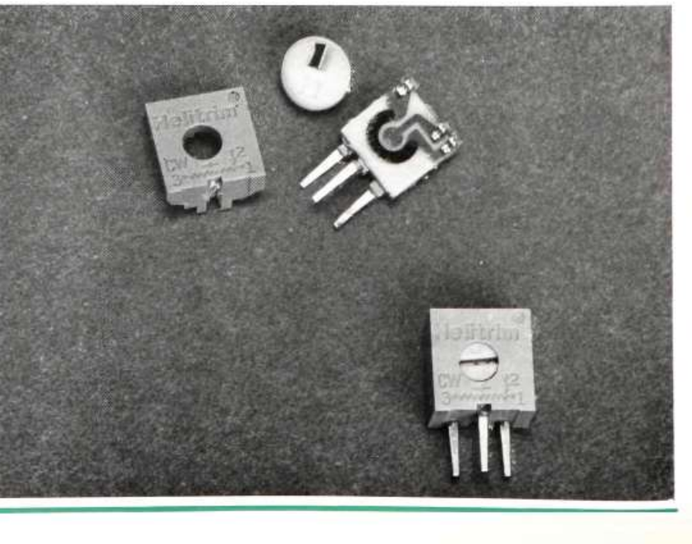


Fig. 22
Plug-in U-links mounted on a printed board assembly. The further U-links is in its parking position

Technical Data

SHELF type	ZF- 23-	ZF- 24-	ZF- 25-
For unit type	ZH- 51-	ZH- 52-	ZH- 4- (M4)
Vertical space in bays, mm	3 × 40.64	6 × 40.64	3 × 40.64
Horizontal unit space, mm	92 × 5.08	92 × 5.08	110 × 4.25
Weight excl. units kg approx.	3.2	4.3	7
BAY FRAME type	ZEZ 230	ZEZ 231	
Width mm	600	600	
Depth mm	225	225	
Height mm	2743	2143	
Vertical shelf space, mm	66 × 40.64	51 × 40.64	
Weight excl. shelfs kg approx.	50	40	
POWER SUPPLY			
Battery operation	24, 36, 48, 60 V		
Mains operation 45—65 Hz	110, 127, 220, 240 V		

type are also used for certain applications.

The advantages of the new connector are, among others, its smaller dimensions and closer mechanical tolerances, which result in more even insertion and extraction forces. The connector is a modification of the Euro-connector standardized by IEC, in which the plug connector has been equipped with two elongated earth connecting pins, the contact-carrying insert of the connector has been divided up and made detachable and the contact sockets have been provided with LM Ericsson's special, easily soldered top wiring tags. Tests have shown that the contact resistance is normally 7 to 10 mΩ and that when in use the changes to this value do not exceed one or two mΩ.

In order to simplify the making of changeovers on the printed circuit boards a plug-in type U-link has been produced. This consists, fig. 22, of a gold-plated contact strip in a plastic sleeve, which is pushed over and short-circuits two square gold-plated contact tags on the board. The distance between contacts is 2.54 mm. When the U-link is not used it can be turned upside down and fitted in a parking position.

For test purposes the front edge of the printed boards can be equipped with gold-plated contacts and special test devices, and U-links have been produced for connecting to these, fig. 23.

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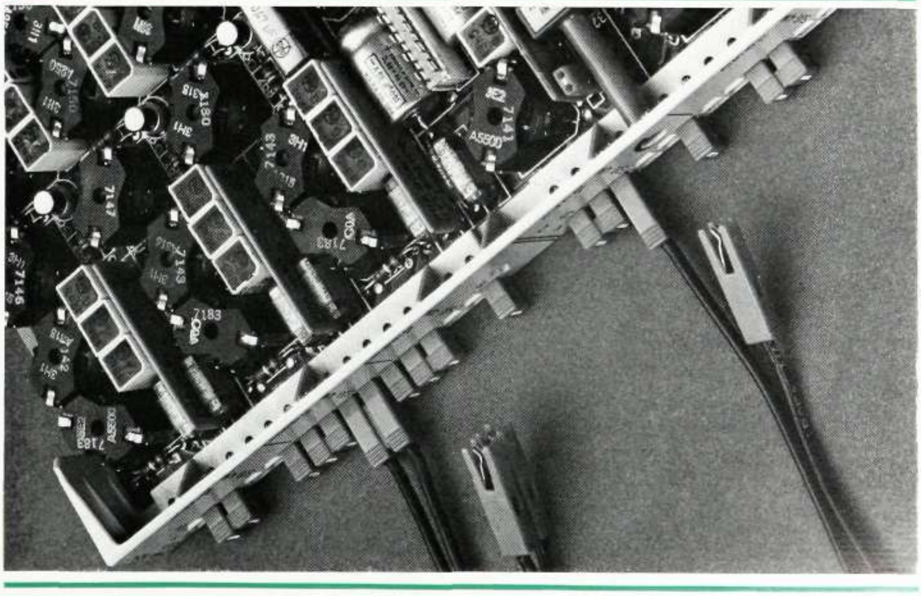

Fig. 23
Front of a printed board assembly with gold-plated contact fingers and U-links, and also test sockets

Channel Translating Equipment in the M5 Construction Practice

Rolf Asarnoj, Istvan Fekete and Bengt Löfmark

This article presents LM Ericsson's channel translating equipment in the new M5 Construction Practice. The equipment is a mechanical and functional package based on 60 channels which are assembled into either five 12-channel basic groups or one supergroup. A fully equipped bay contains channel translating equipment for 600 channels, including the associated carrier and power supply equipment.
The design principles that have been applied have resulted in an equipment which is reliable, flexible and easy to install and which requires no routine maintenance.

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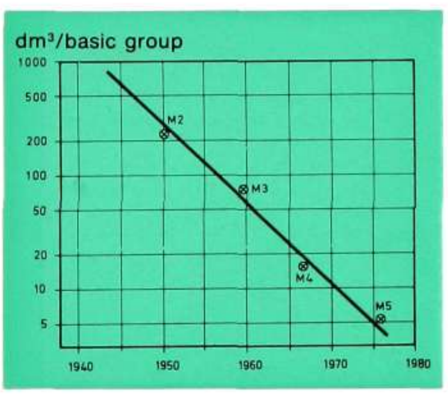

Fig. 1
Curve showing the reduction in volume for each new generation (M2—M5) of channel translating equipment

Technical progress makes possible a continuous development of FDM terminal equipment. The incentive for further development is particularly strong in the case of the channel translating equipment, as this constitutes the major part of the multiplex, and hence its economic importance is considerable.

The channel translating equipment has therefore been modernized with the use of the new M5 Construction Practice[1]. The new equipment has excellent performance characteristics and meets all values recommended by CCITT with good margins.

System Design

Volume reduction

The channel translating equipment in the M5 Construction Practice is very much more compact than in earlier construction practices. The volume taken up by the equipment now is about one third of the volume needed for the preceeding generation, fig. 1. As an example it may be mentioned that the bay frame in which the channel equipment is mounted accommodates 600 channels, corresponding to ten basic supergroups or alternatively fifty basic groups, with the associated carrier and power supply equipment.

This miniaturization is made possible by modern component techniques and the optimum utilization of the common functions in the translating equipment, bay frame, power, alarms, etc.

One factor that has contributed to the reduction of the space requirement is the use of thick-film hybrid technique for all active circuits. The discrete components, above all coils and capacitors, have also undergone a considerable volume reduction.

Modulation plan

Translation from channel to basic supergroup takes place via the basic group band recommended by CCITT.

The modulation plan used for "channel to group" is the so-called 4×3 plan, fig. 2, with four subgroups, each of three channels. Subgroup modulation has the advantage that the number of

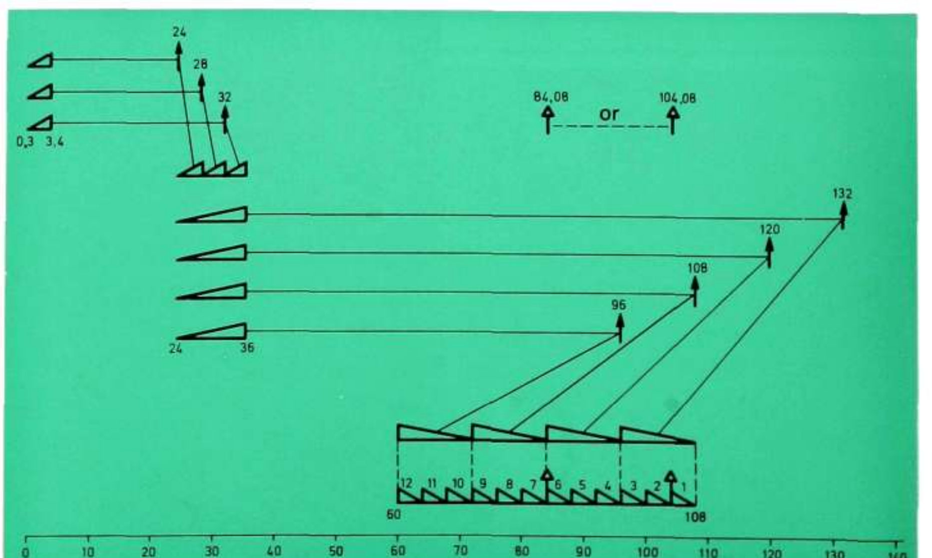

Fig. 2
Modulation plan for translating from channel to group

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modulators and carrier frequencies in the equipment is less than with other modulation plans.

The frequency band used hitherto for the subgroup in the 4×3 plan has been 12—24 kHz. As a result of the development in the component field, in combination with an advanced filter design, it has now become possible to place the subgroup in the frequency band 24—36 kHz. This is a very suitable frequency band because the filtering that is necessary in connection with the translation from subgroup to basic group can then be carried out in one filter that is common for the group in each direction of transmission.

The modulation plan for group to supergroup is shown in fig. 3.

Translation from channel to supergroup and group

The increase in the number of long distance circuits in the countries that constitute LM Ericsson's transmission equipment market is, in general, very considerable. A rate of increase of 15 per cent or more each year is not unusual. It is therefore important that the channel translating equipment is designed so that it satisfies the demands that this rapid rate of increase makes on planning, transport, storage, installation etc.

Experience gained from cooperation with various telephone administrations has shown that 60 channels is often the most suitable extension unit as regards extensions in the network. The channel translating equipment in the M5 construction practice has been designed so that the 60 channels can be arranged either as a complete supergroup, i.e. translation from the channel band to the basic supergroup band, or as a unit consisting of five basic groups. In both cases the equipment will be almost identical, both electrically and mechanically.

The use of a complete supergroup as the smallest extension unit, see fig. 4 a, has advantages both as regards administration and handling. One advantage that deserves special mention is that, with a supergroup as the smallest unit in the network or in parts of it, the group distribution frame can be dispensed with.

In the complete supergroup, the group interface is accessible for the connection of programme channel, wideband data, through-connections etc., see fig. 4 b.

To obtain the alternative application case with five groups as the extension unit, it is only necessary to leave out the group to supergroup translating stage from the channel to supergroup equipment, see fig. 4 c. Like the channel to supergroup equipment, the channel to group equipment thereby obtained constitutes an easy to handle package that is well adapted to the requirements that may be placed on this frequently occurring equipment.

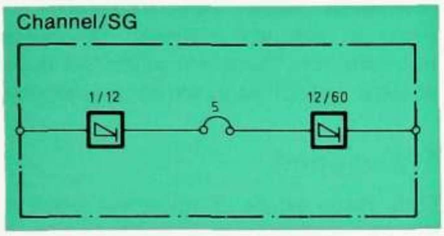


Fig. 4 a
Channel and group translating equipment

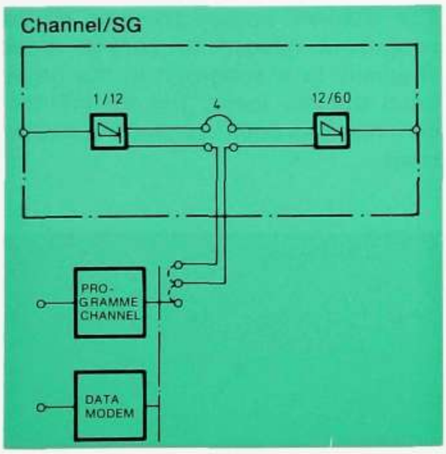


Fig. 4 b
Channel and group translating equipment with group access

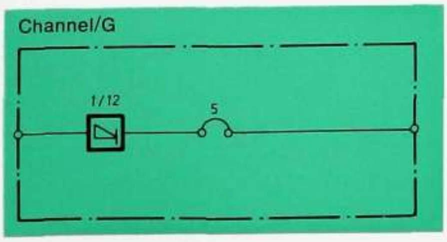


Fig. 4 c
Channel translating equipment

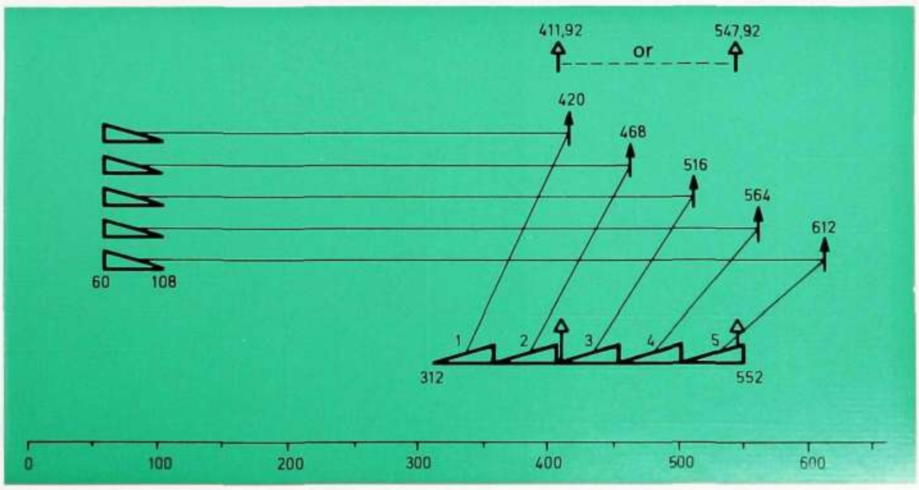


Fig. 3
Modulation plan for translating from group to supergroup

Partial equipping is of course also possible.

Reliability

Reliability is one of the most important parameters for the design and operation of high quality transmission equipment.

The same stringent design rules have been applied for the M5 channel translating equipment as for the earlier M3 and M4 equipments, for which excellent reliability figures have been achieved.

Reliability is dependent on the number of components used in the equipment. By using subgroup modulation with common filtering for the M5 channel to group translation, and in other respects applying a careful circuit design, it has been possible to keep down the number of components, which has created an even better basis for achieving high reliability.

The fact that the power developed per channel end is even lower than before has also made its contribution to the reliability. The development of power results in a rise in temperature, and bearing in mind that component life is dependent on temperature, it is desirable to keep this as low as possible. In the M5 channel translating equipment the power developed can be kept down to 0.2 W per channel end, which causes only a very small rise in temperature in the equipment.

The MTBF (Mean Time Between Failures) in the M5 channel translating equipment is therefore expected to be at least as high as in earlier equipment.

Translation

Only three types of units are used in the translation from channel to supergroup, namely the channel modem, group unit and group modem, see fig. 5 (block diagram) and fig. 6.

The channel modem contains all the equipment needed to convert three channels to a subgroup in the group band and vice versa. The channel modem also has built-in signalling equipment.

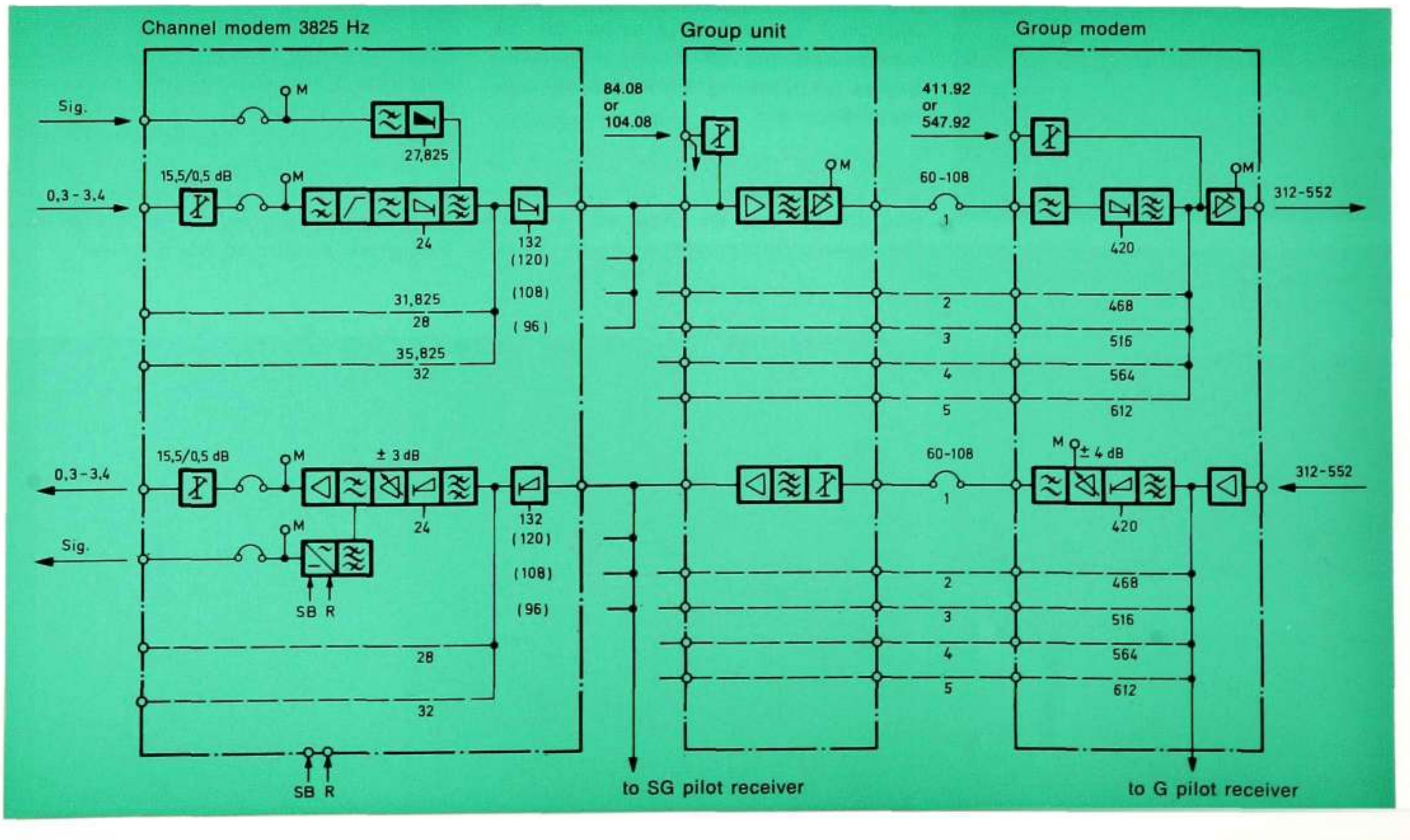
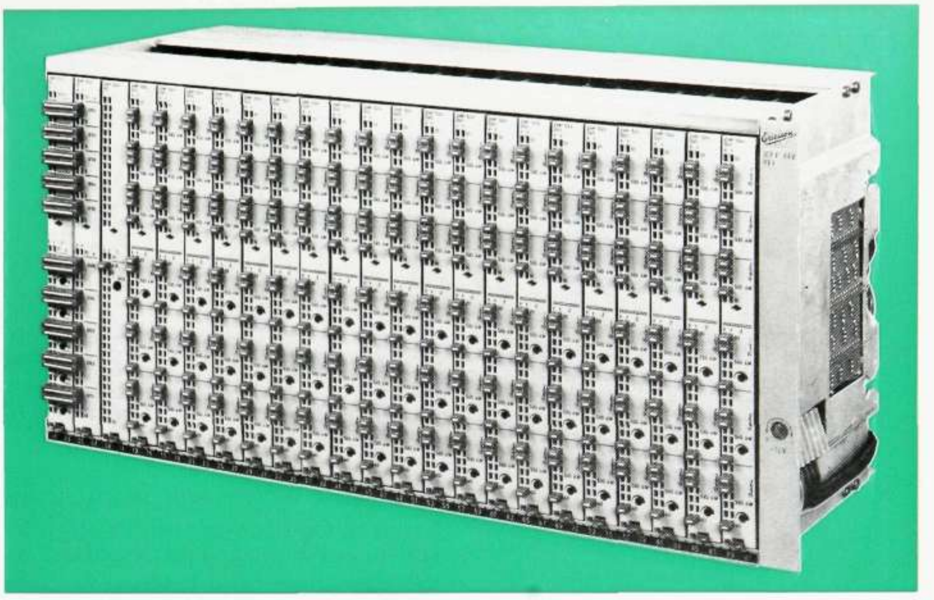


Fig. 5

Block diagram for channel and group translating equipment with out-band signalling

M Test point
Sig. Incoming and outgoing signal
SB Signalling blocking
R Release

Fig. 7
Channel and group translating shelf



The group unit carries out the filtering and the level and impedance matching required in order to obtain a group interface having the required performance characteristics. The unit is common for five groups.

The group modem is used to transfer the five groups to and from their positions in the supergroup band.

A single shelf, the channel and group translating shelf, contains all the translating and signalling equipment required to form a basic supergroup or alternatively five basic groups from 60 channels and vice versa, see fig. 7.

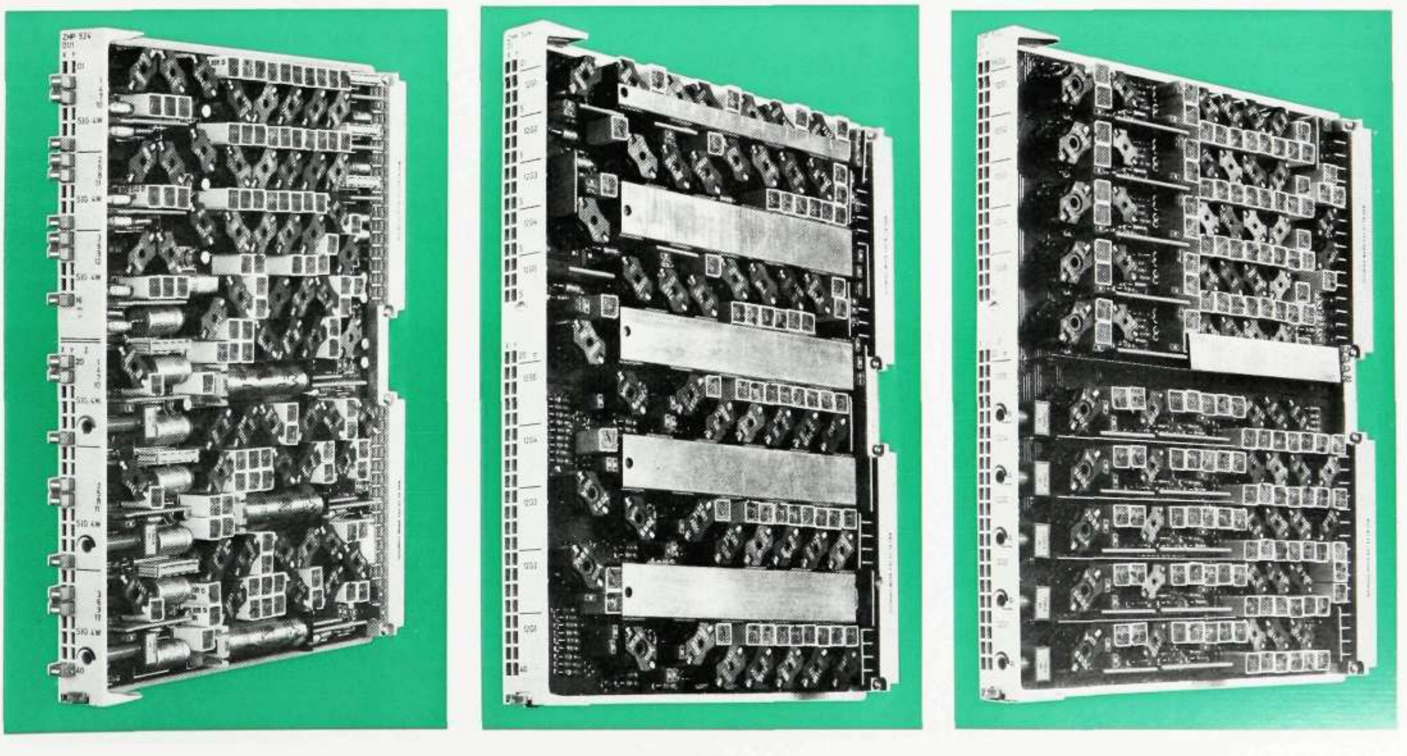
Active circuits

The number of active circuits in the equipment has purposely been minimized in order to limit the rise in temperature. As much of the gain as possible has been included in the common functions, which has meant that it has been possible to make both the channel and subgroup modulators passive. Amplifier circuits with low d.c. power dissipation are used wherever possible.

In the send direction there is only one amplifier that is channel-dependent. This is included in the high-pass filter and is also used as a limiter. The high output level from this amplifier makes possible a level arrangement that gives good isolation between the low-pass filter and the band-pass filter. The limiting curve is shown in fig. 8.

In the receive direction two amplifiers have been used for the channel-dependent gain because of the large difference between input and output levels.

Fig. 6
Channel modem 3825 Hz, group unit and group modem



The four subgroups are combined and separated in active combining and separating circuits, which also have an amplifying function.

Modulators and demodulators in the group-to-supergroup translation are active, and the common amplifiers for the supergroup also function as combining and separating circuits for the groups.

The thick-film hybrid technique is used for all active circuits.

Filters

In both the send and the receive paths the channel filtering is carried out in three different circuits. In the send path a high-pass filter, a low-pass filter and a band-pass filter are used, and in the receive path the filtering takes place in a band-pass filter, a low-pass filter and the output channel amplifier, which has a frequency dependent gain.

The LC technique, which permits the greatest flexibility in the filter design, is used for the low-pass and band-pass filters. The high-pass filter is an active filter and the attenuation function in the channel amplifier is provided by an RC correction circuit. The thick-film hybrid technique is used for these last two filters.

The band-pass filters are dimensioned so that they have a low sensitivity to variations of the component characteristics. The rounding that occurs at the edges of the pass-band because of the losses is equalized by the high-pass filter, low-pass filters and channel amplifier, which are all dimensioned so that they have a compensating effect.

Furthermore, through a combined optimization using Monte Carlo analysis, stochastic optimization, the different filter curves have been adapted to each other in the best possible way taking into consideration the deviations from the nominal values of the components, both those due to the manufacturing tolerances and those that arise as a result of aging and environmental conditions such as temperature and humidity.

The variation with frequency of the overall loss that is achieved is shown in the curve of fig. 9. It will be seen that the curve is well within the limits recommended by CCITT over the whole of the frequency band.

During the design stage particular efforts have been made to improve the attenuation distortion at the edges of the band, in relation to the CCITT recommended limit values. A low attenuation distortion at the edges of the band is desirable as this improves the transmission quality, particularly in the case of intercontinental calls with a large number of interconnected circuits.

The group delay distortion is shown in fig. 10. In this case also the results achieved are very good and the CCITT recommendations for public telephone circuits are met with good margins over the whole of the frequency band 300—3400 Hz. The group delay distortion is so low that no additional equalization

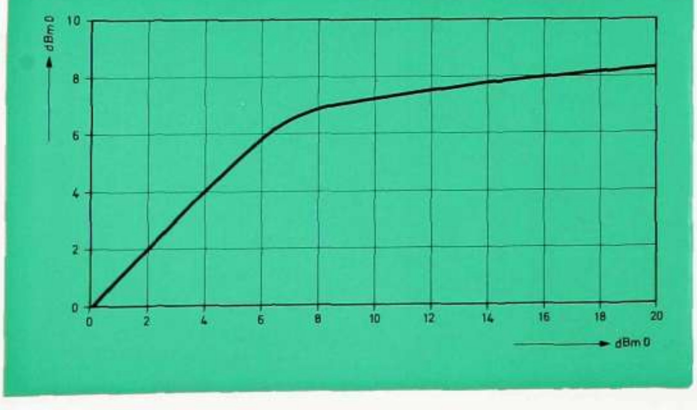


Fig. 8

Limiting curve for the channel translating equipment. Output level as a function of input level measured as r.m.s. value at the group output

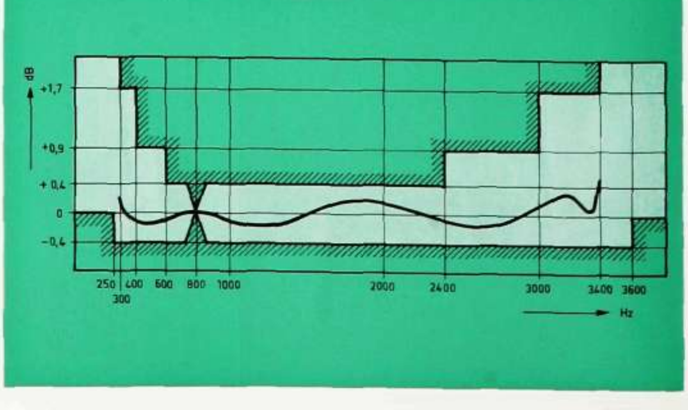


Fig. 9

Variation with frequency of the overall loss for 12 channels in tandem and looped at group frequencies (mean value per channel). Limits in accordance with CCITT Green Book, Vol. III, Rec. G 232 A

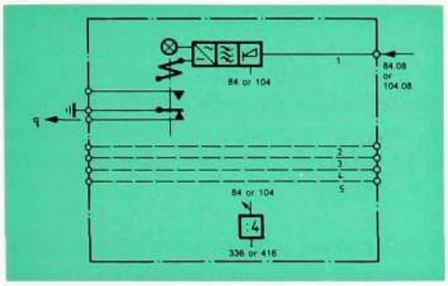


Fig. 12 a

Group pilot receiver, 84.08 or 104.08 kHz, for interruption control (R2)

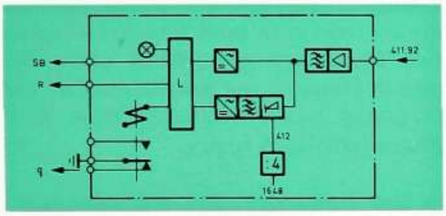


Fig. 12 b

Supergroup pilot receiver 411.92 kHz for interruption control (R2) and signalling blocking

q Interruption control
SB Signalling blocking
R Release
L Logic

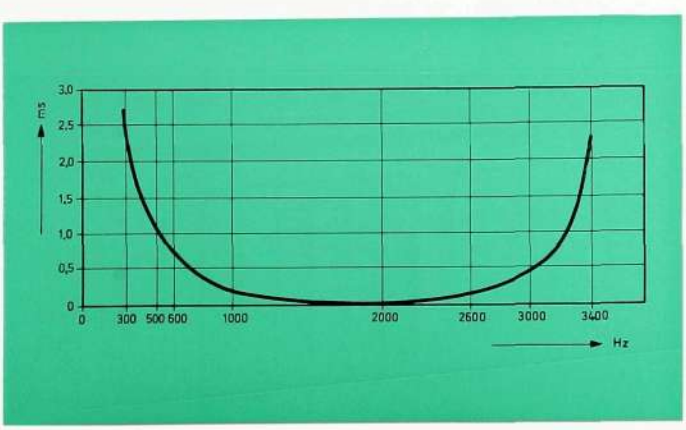


Fig 10

Group delay distortion curve for a channel looped at group frequencies. (Min. group delay 0.8 ms)

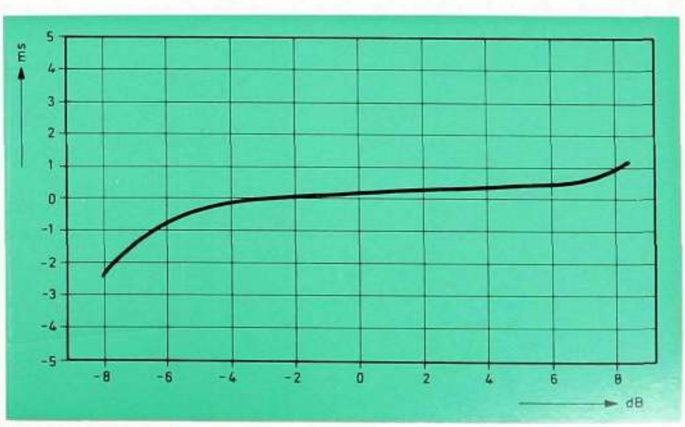


Fig. 11

Pulse distortion curve. Pulse ratio 50/50 ms, 0 dB → —6 or —18 dBm0 respectively

is normally required for a circuit set up in a carrier system to be used for transmitting data.

Modulators

Passive modulators with MOS-type field effect transistors are used for channel and subgroup modulation. This type of modulator is characterized by its low carrier power and low carrier leak.

An active double-balanced, monolithic modulator has been chosen for the group modulation.

Signalling

The same channel unit can be used for out-band signalling, 3825 Hz, either when working with discontinuous signalling (low or high level) or continuous signalling (low level), for example R2 signalling.

The signalling frequency is fed in at the subgroup stage, and with random phase, 0° or 180°. When keying the signalling tone, the flanks of the pulses are rounded off on a low frequency basis.

The incoming signalling tone is branched off to the signalling receiver circuits at speech frequency. Since the channel-dependent level regulation is common for both speech and signalling, the level of the signalling tone is also automatically adjusted when the channel level is set in connection with the normal circuit maintenance. In this way the prerequisites for good signalling reception are created.

The filter in the signalling receiver includes suppression for 3920 Hz, so that no extra pilot stop filter is required, irrespective which group or supergroup pilot that is used. The signalling receiver contains a correction circuit, which results in very little variation in pulse distortion over the level range, see fig. 11.

The signalling output can be either a reed relay or a transistor. Both outputs can function with either positive or negative voltages in the exchange. Extensive investigations show that a very high operational reliability is obtained irrespective of which type of output is chosen. The transistor output has the advantage that it has a lower power consumption.

An alternative version of the channel modem allows 2400 Hz in-band signalling. The channel modem can also be supplied without signalling equipment.

Interruption control

When out-band, tone-on-idle signalling, is used, an interruption in the transmission path can cause false signalling. In order to avoid this, pilot receivers are used for interruption control. These pilot receivers operate either on a group or a supergroup basis in accordance with the CCITT recommendations for the R2 system, see the block diagram of figs. 12 a and 12 b. Thus, when a group or supergroup interruption occurs, information on the interruption is sent to the exchange for further processing. With the aid of the

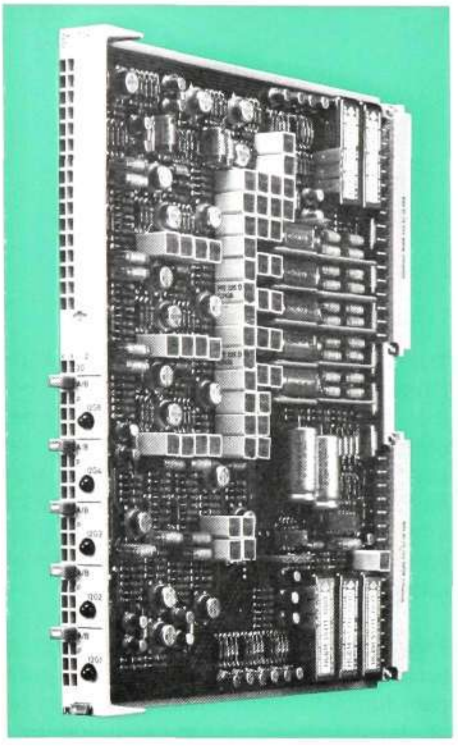


Fig. 13
Group pilot receiver 84.08 or 104.08 kHz for interruption control (R2)

supergroup pilot receiver, the signalling receivers can also be blocked in order to prevent false signals when the interruption occurs. An arrangement for disconnecting interrupted calls is also included.

Both types of pilot receivers are provided with standardized alarm circuits and also with separate alarm outputs for interruption indication.

The group pilot receiver module, fig. 13, has receivers for five groups and is included in the channel and group translating shelf as an alternative to the supergroup pilot receiver. The same group or supergroup pilot receiver is used irrespective of the pilot frequency. It is only the carrier that has to be changed.

Frequency generation

All frequencies required for channel to supergroup translation, signalling and pilot receiving are generated in the carrier generating shelf, see fig. 14. This shelf has space for two sets of generating equipment, each of which normally supplies five supergroups or twentyfive groups, and hence the whole shelf can supply ten supergroups or fifty groups, corresponding to 600 channels.

The basic frequency, 12 kHz or 124 kHz, and the pilot frequencies, 84.08 kHz or 104.08 kHz for the group, and 411.92 kHz or 547.92 kHz for the supergroup, are obtained from the central frequency generating equipment.

As can be seen from the block diagram of fig. 15, all frequencies are generated with the aid of three phase-locked oscillators, which are controlled by the incoming basic frequency. The required output frequencies are obtained by frequency division and in some cases by frequency division combined with modulation.

The solution with phase-locked oscillators and frequency dividers provides a simple design. In those cases where frequency division and modulation are used, the filter requirements are moderate, which gives simple and stable filters. Observation of the output levels is not required. Each output frequency is checked with a level monitor circuit, which is built into the respective frequency generating unit. The output frequencies are blocked if the incoming basic frequency fails or if phase locking is lost.

In the frequency dividers integrated circuits of CMOS-type are used which is advantageous from power consumption point of view.

The frequencies from the carrier generating shelf are distributed to the translating shelves via a distribution cable, which is connected to the relevant equipment in the carrier generation shelf. The distribution cable is placed in the right-hand upright of the bay, and is connected to the translating shelves concerned with plug and socket connections.

Interfaces

All the interfaces are strictly in accordance with CCITT recommendations. Over and above this, different

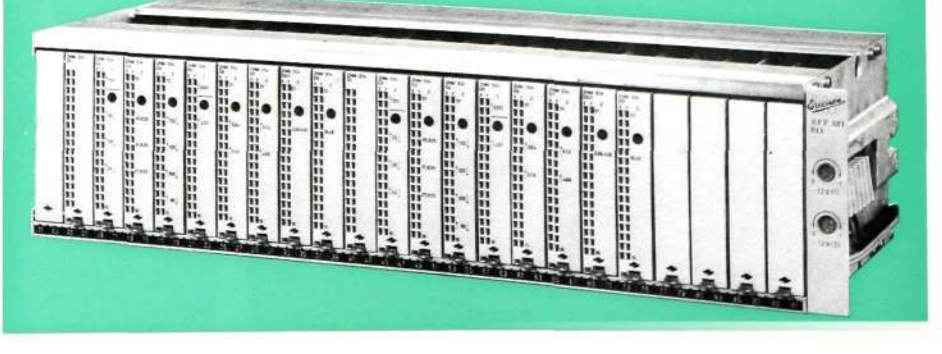


Fig. 14
Carrier generating shelf

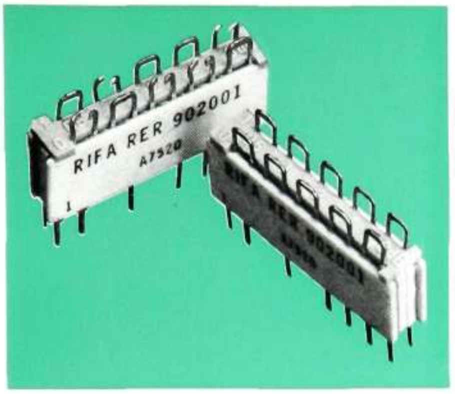


Fig. 16
Channel attenuators, at left showing straps cut

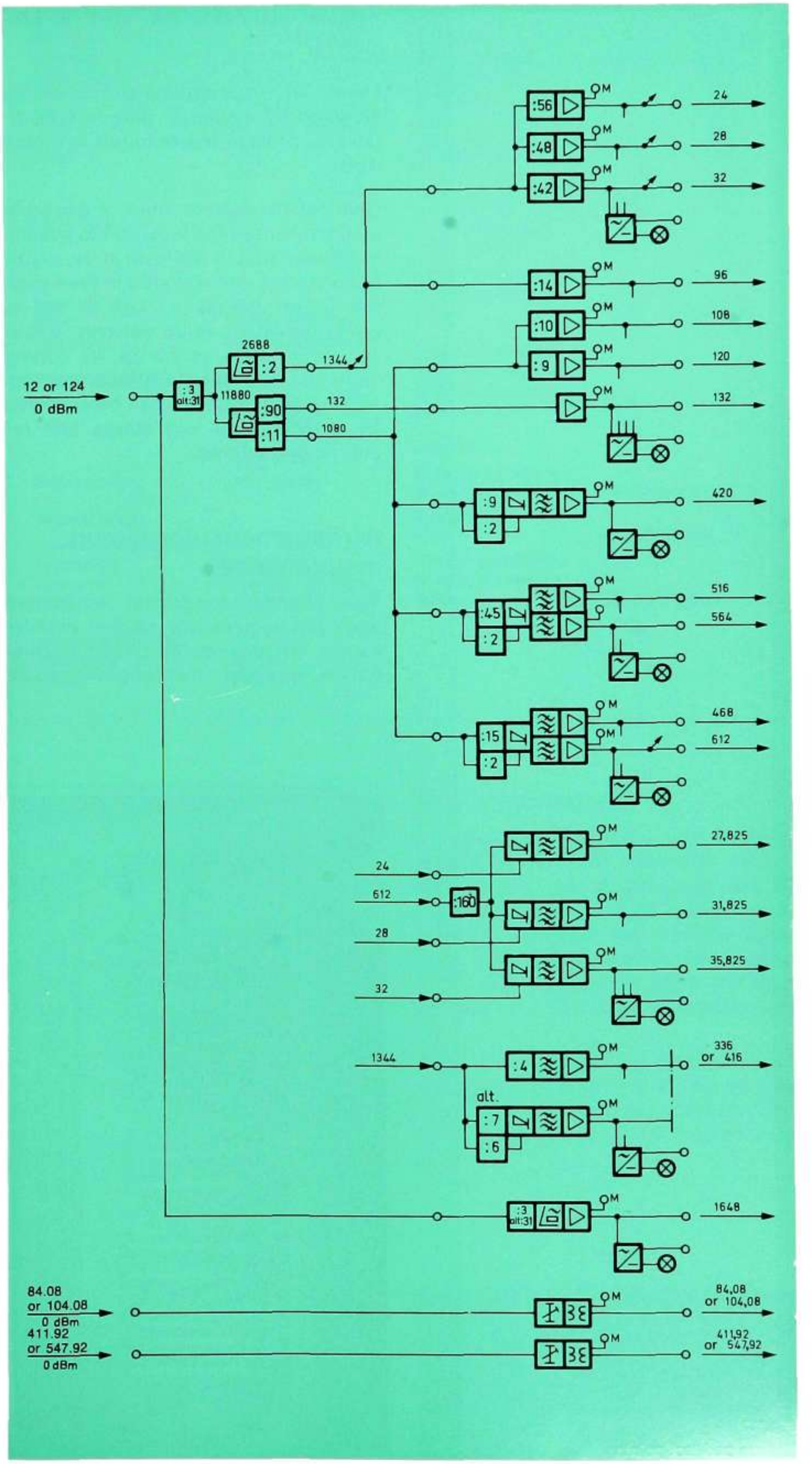


Fig. 15
Carrier generating equipment

national standards can also be provided for.

Levels and impedances can easily be selected by means of plug-in type U-links to provide the required interface data.

Channel attenuators, which are used to match the interface level on the speech frequency side to the level at the distribution frame, are included in the equipment. The attenuators can be set to any attenuation value between 0 and 15.5 dB in steps of 0.5 dB, by cutting open the appropriate straps, see fig. 16. The value chosen can be changed by soldering the cut straps and recutting as required.

Arrangements for circuit maintenance

The channel translating equipment does not require any routine maintenance. For the overall circuit maintenance, however, the following facilities have been included in the equipment.

Access points at the speech frequency and signalling interfaces as well as at the group interface are provided on the front of the units, and are made accessible by removing U-links in the respective interface.

Clearly marked test points, placed at important points in the transmission path, simplify the making of measurements, see fig. 17. Parallel type test points are used on the low frequency side. All other test points are short circuit proof. The test point level is standardized.

Level regulation devices in the form of cermet-type potentiometers, which have been shown to have a very high reliability, are included on the receive side in each group and in each channel, to provide compensation for residual level errors.

Pilot receivers can be included in the

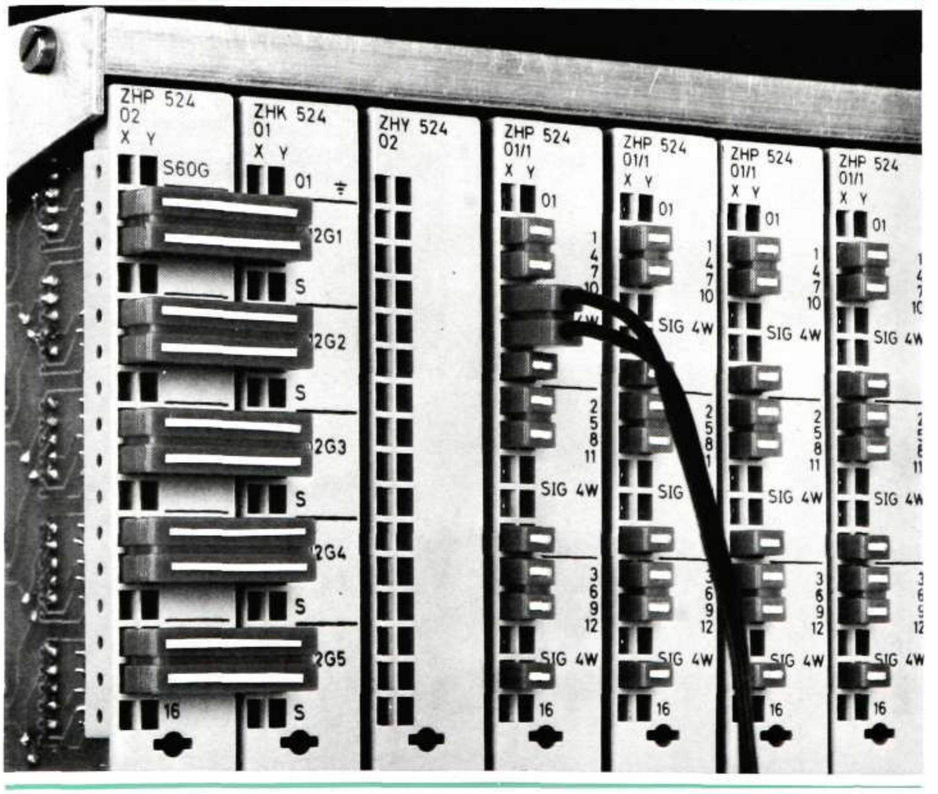


Fig. 17
Access and test points

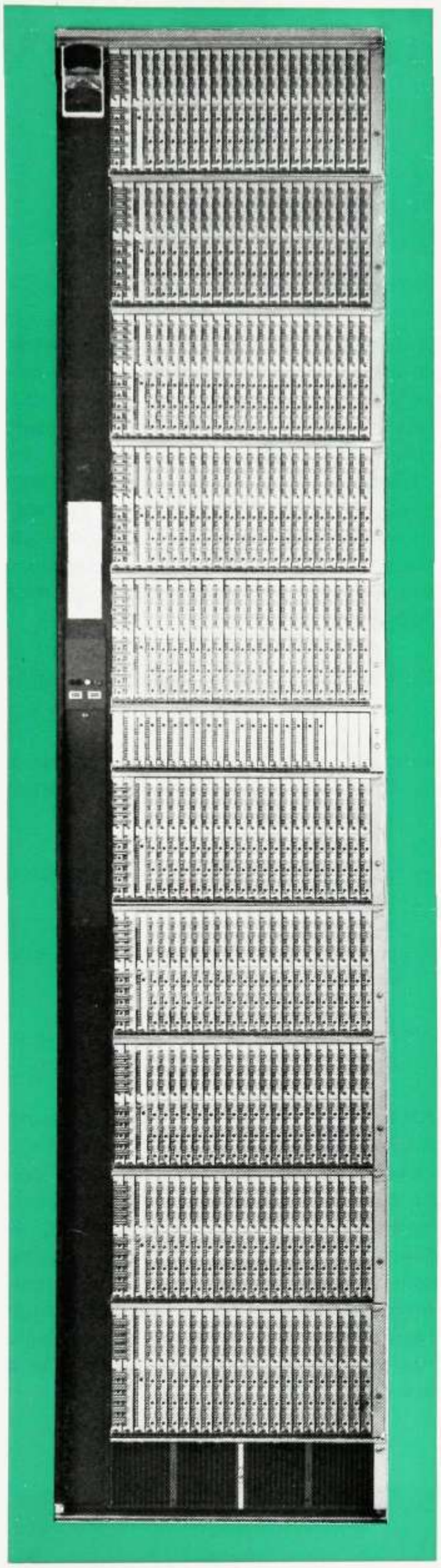


Fig. 18

Bay with channel translating equipment for 600 channels to 50 basic groups or 10 basic supergroups

Technical data

FREQUENCY RANGES

Nominal bandwidth per channel	4 kHz
Effectively transmitted frequency band	0.3—3.4 kHz
Nominal bandwidth per basic group	60—108 kHz
Nominal bandwidth per basic supergroup	312—552 kHz

NOMINAL LEVELS (dBr)

Channel			
Sending	min. —14	or	—16
Receiving	max. +4		+ 7

Group	Channel/ Group	Channel/ SG
Sending	—26	
	—36	—36
	—37	—37
Receiving	— 8	
	—23	—23
	—30	—30

Supergroup	
Sending	—35 or —36 dBr
Receiving	—23 or —30 dBr

NOMINAL IMPEDANCES

Channel	600 Ω bal.
Group	75 Ω unbal. or 150 Ω unbal.
Supergroup	75 Ω unbal.

SIGNALLING

Out-band signalling	
Frequency	3825 Hz
Low level	—18 or —20 dBm0
High level	— 5 or — 6 dBm0
In-band signalling	
Frequency	2400 Hz
Level	—6 dBm0

BASIC FREQUENCIES AND PILOTS

(supplied from an external source)	
Level/impedance	0 dBm/75 Ω
Basic frequency	12 or 124 kHz
Group reference pilot	84.08 or 104.08 kHz
SG reference pilot	411.92 or 547.92 kHz

POWER CONSUMPTION

(operating voltage 12 V d.c.)		
Channel and group translating shelf (excluding pilot receivers)	Channel/ Group	Channel/ SG
with reed relays in the signalling receiver output		
discontinuous signalling	12 W	15 W
semi-continuous signalling	20 W	23 W
with transistors in the signalling receiver output	11 W	14 W
Carrier generating shelf (supplying 600 channels excluding pilot receivers)	4 W	5 W

WEIGHTS

Channel and group translating shelf	28 kg approx.
Carrier generating shelf	8 kg approx.
Bay (fully equipped, excluding station cabling)	350 kg approx.

equipment for supervising the group or supergroup level.

Visual alarms ensure that a faulty function is quickly located. When pilot supervision is included, alarms are given if there is an interruption of the group or supergroup pilot. Alarms are also obtained if any of the carrier frequencies or the signalling frequency should fail. The frequency that has failed can easily be identified with the aid of the test points. The alarm circuits in the equipment can be connected individually and also jointly to the central alarm concentration in the station.

Bay applications

A completely equipped bay contains equipment for 600 channels, corresponding to 10 supergroups or 50 groups, see fig. 18. The equipment is arranged so that the common functions, carrier generation and power supply are provided in pairs and thus serve a maximum of 300 channels each.

Other bay applications can easily be arranged. Some examples that may be mentioned are multiplex bays for 120-channel systems and 480-channel systems.

References

1. Axelson, K., Harris, P.-O. and Storesund, E.: *M5 Construction Practice for Transmission Equipment.* Ericsson Rev. 52 (1975: 3/4, pp. 94—105).

Stored Program Controlled Transit Exchange ARE 13 with Control System ANA 302

Stig Ellstam and Bengt Olsson

The control system ANA 30 used in stored program controlled (SPC) ARE 11 local exchanges has been earlier described in Ericsson Review[1].
The present article describes the SPC system ARE 13 designed for national and international transit centres.
ARE 13 consists of a control system ANA 302 with a number of traffic control processors and a common operation and maintenance processor, and of a switching unit with a switching network made up of link-connected crossbar switches. There is a great resemblance between ANA 302 and ANA 301 used in ARE 11.
From the operation and maintenance points of view, among other purposes, therefore, it is suitable to use a combination of ARE 13 and ARE 11 for building up a telephone network.

UDC 621.395.722:
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8344

Since the installation of the first crossbar transit exchange of the LM Ericsson system ARM in 1950, the system has held a leading position. It is now one of the most widespread transit exchange systems in the world and is used in 56 countries on all continents.

LM Ericsson's crossbar transit exchanges have been continuously improved. A very important step has now been taken through the introduction of the SPC technique, with all its advantages, in the shape of ANA 302. The operation and maintenance functions of the new transit exchange system ARE 13 will thus meet up to the most modern requirements Direct or remote-controlled communication between operational and maintenance staff and ANA 302 via, for example, a teleprinter will be offered (fig. 1). This will comprise the transmission of data for changing of traffic routing, charging, signalling, traffic class and numbering; also for ordering of supervision, fault tracing, traffic measurement, statistics, etc. Other essential advantages of ANA 302 are:

- large analysis capacity and route sizes covering all requirements
- increased multiple and traffic handling capacity in relation to earlier crossbar systems
- great flexibility and easily handled software
- possibility of common channel signalling
- normal network management functions of an SPC system.

ANA 302 can also be used for raising the facility level of an existing ARM exchange to the ARE 13 level. This can be done without difficulty in continuous operation by insertion of ANA 302 in place of the corresponding existing equipment. It is thus possible with good economy to introduce the same high facility level in, for example, a whole region or a whole country where there are older ARM exchanges.

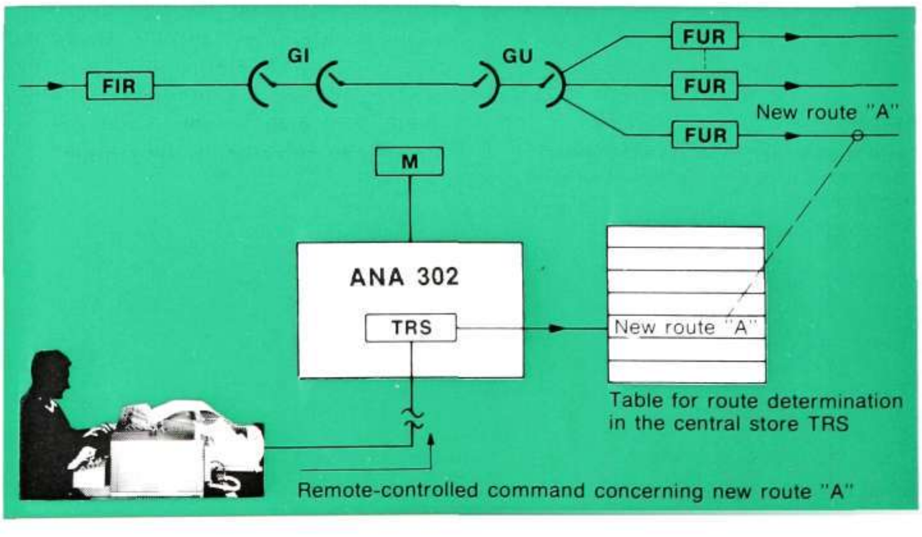

Fig. 1
Remote-controlled communication between operational and maintenance staff and ANA 302, exemplified by insertion of new route

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Telephone Exchange Division

Types of exchange and capacity

ARE 13 is a modern transit exchange system for national or international traffic or for a combination of both.

The final capacity of an exchange unit ARE 13 is 8000 multiple positions. In twin form the multiple capacity is $2 \times 8000 = 16{,}000$ and in triplet form $3 \times 8000 = 24{,}000$. An even larger capacity can be attained by suitable arrangements.

The exchange has a high traffic handling capacity owing to the large number of B-links, the speed of the markers, and the fact that four reselections can be made. The permissible load varies with the mean holding time per incoming circuit, the size of the exchange and the permissible internal congestion. For normal values of these parameters it is between 0.75 and 0.85 erl./circuit.

The national exchange is always 5-pole, while the international may be a combined 5- and 10-pole or exclusively 10-pole exchange.

Main principles

ARE 13 contains a control system ANA 302 with processors and a switching system with crossbar switches.

The advantages offered by the SPC technique have been fully utilized. ANA 302 executes all functions which can with advantage be electrically changed and/or centralized. Such functions are route analysis, route selection, tariff analysis, end-of-selection analysis, and determination of receiving and sending programs. ANA 302 also performs very qualified remote-controllable operational and maintenance functions.

Relay equipment has been used only in those units in the marker organization where advantages are gained with a retained facility level. The logic of these units, of course, lies in ANA 302. The processors can therefore be optimally utilized, since they are freed from routine work such as imaging of link states, hunting for a free circuit, etc. For this reason, among others, the programs can be processed in fixed time slots, which greatly simplifies the data processing unit.

Facilities

The advanced operation and maintenance functions are dealt with under a separate heading. The most important of the other facilities are listed below.

Capacity
An exchange unit ARE 13 can be extended from 200 to 8000 multiple positions. Two or three exchange units can be combined in twin or triplet form. The traffic control processors in one of the units can then directly control the central devices in the other two units. The system can thus be extended to 24,000 multiple positions with full availability between input and output sides. As already mentioned, a larger capacity can be attained if desired.

Circuit economy and transmission
A national or international exchange switches important calls on expensive circuits. Satisfactory transmission properties and optimal circuit utilization are therefore important. ARE 13 offers the following facilities in these respects:

The *route size*, in an exchange of maximum capacity, may be up to 50 % of the total number of outgoing circuits.

Up to eight *alternative routes* may be selected, but owing to the network structure only four are normally utilized.

Full availability with very low internal congestion is offered on all routes.

The *through-connection time* is 500 ms counted from the moment when the necessary number of digits has been received until the connection has been checked.

The connection and disconnection of the *pads* is controlled by the processors, so that the equipment can be optimally adapted to the national level.

Echo suppressors can either be connected direct to the repeaters and/or collected in a common group and connected through the selector stages. Connection and disconnection are controlled by ANA 302.

No intermediate distribution frame between incoming and outgoing selector stages

The links between the incoming and outgoing selector stages require no intermediate distribution frame. In the case of small and continuously growing ARE 13 exchanges, however, it may be advisable to use an intermediate distribution frame.

Signalling system

All existing signalling systems can be connected to ARE 13. The fact that different signalling systems can directly interwork with one another offers great flexibility, particularly in international traffic. Complicated translation equipment is avoided in this way. This applies also to the interworking between common channel and analog signalling systems. Thanks to the SPC technique, furthermore, existing signalling systems can be easily modified and new systems can be introduced.

Analysis capacity

The capacity for analysis of tariffs, routes, etc. is highly developed and fully adequate for all existing cases. Traffic routing facilities which allow optimal utilization of the junction network are thus available. Considerable operational advantages are obtained through the simplified handling and the possibility of quickly changing analysis data.

Charging

Multimetering and/or toll ticketing can be applied at option. For the latter purpose a new electronic system can be used.

Subscriber services

Subscribers connected to registerless rural exchanges, for example, can be offered SPC local exchange facilities if the exchanges are directly connected to ARE 13 (fig. 2). For this purpose ARE 13 can be equipped with subscriber

Fig. 2

Subscribers on registerless rural exchanges obtain the subscriber services of the SPC technique on connection to ARE 13, which is here exemplified by abbreviated dialling.

x = one digit or one code character

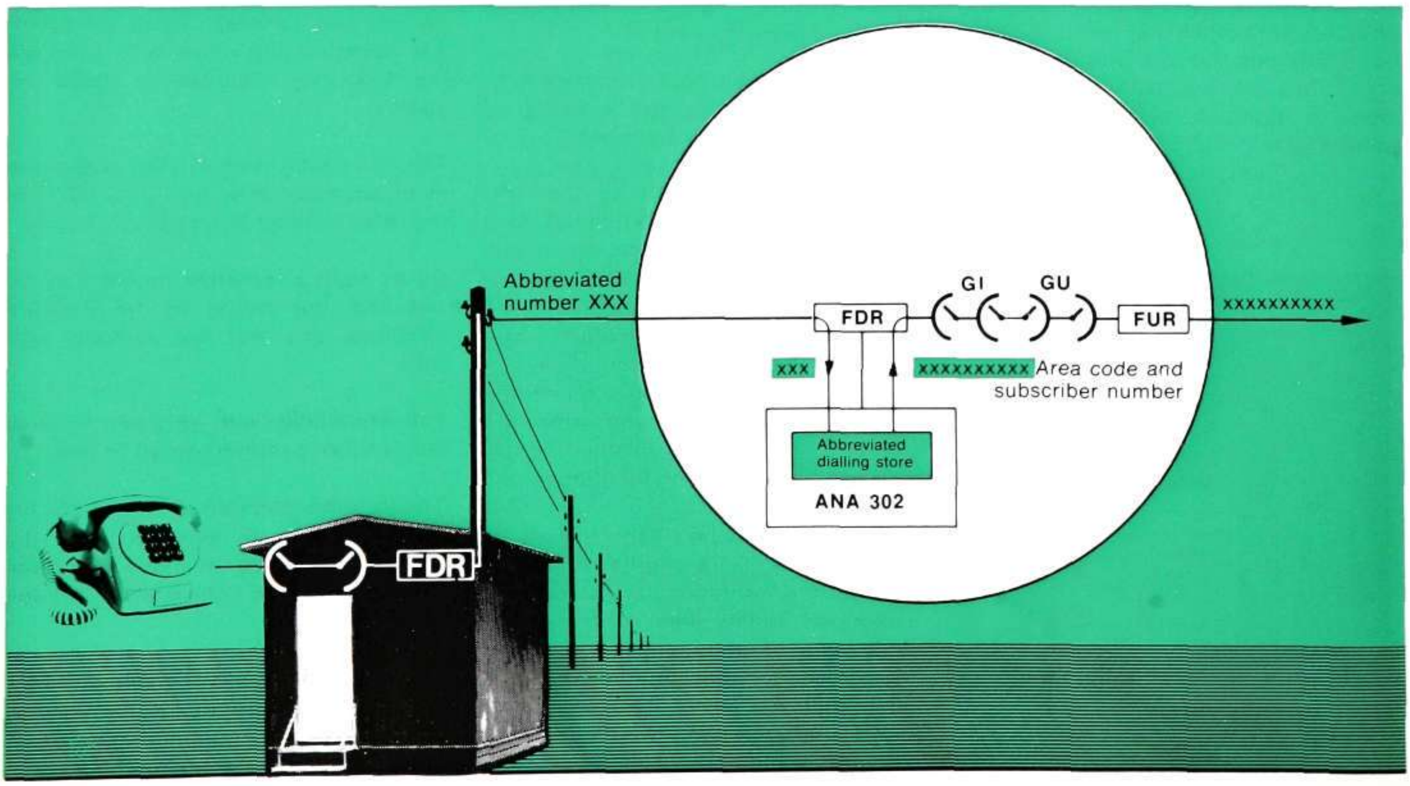
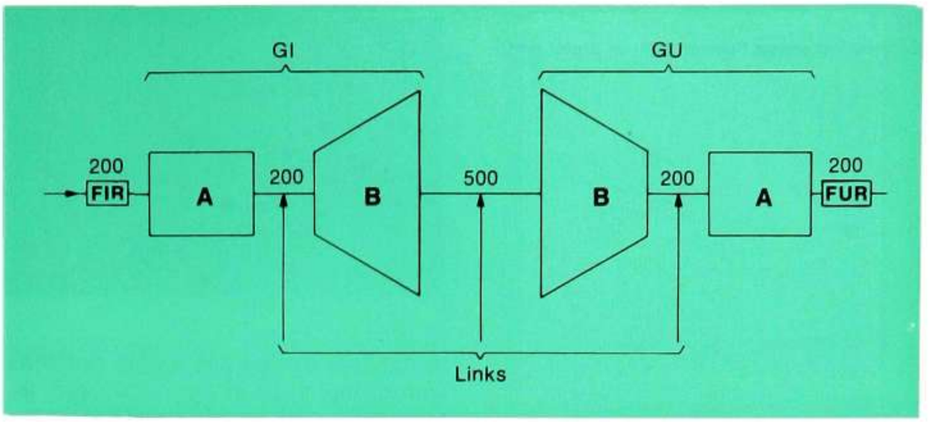


Fig. 4

Incoming stage GI and outgoing stage GU showing the degree of expansion and concentration



category and abbreviated dialling stores. For outgoing calls the rural exchange must be able to transmit the A-number to ARE 13.

Structure of the system

As already mentioned, ARE 13 consists of two sub-systems, a switching system and a control system (fig. 3).

SWITCHING SYSTEM

The switching system comprises a switching network with 4-wire through-connection of the speech wires and an efficient relay marker organization. The latter sets up the connection to an outlet selected by ANA 302.

Switching network

The switching network is made up of two identical crossbar switching stages, the incoming stage GI and the outgoing stage GU (fig. 4). Each of these stages consists of two partial stages, the A-stage and the B-stage. The two partial stages and the B-verticals in GI and GU are interconnected by means of links.

The incoming, outgoing and two-way junction circuits FIR, FUR and FDR are connected to the A-multiple. Normal connections are set up through GI and GU (fig. 4). If a connection is to be set up over a twin or triplet unit owing to route congestion in an incoming unit, it passes GI in the latter unit and GI + GU in the twin or triplet unit (fig. 5). When economically justified, a connection to the local network passes only through GI. If there are two-way circuits FDR, they are connected to a two-way stage GD (fig. 6).

Each A-stage has 200 multiple positions. Up to 20 incoming and 20 outgoing stages or 20 two-way stages can be connected to a single exchange. Thus 8000 one-way or 4000 two-way circuits, or a combination of the two, can be connected to a single exchange.

Fig. 3

ARE 13 consists of a crossbar switching system and a control system based on SPC technique

A SWITCHING SYSTEM

GI	Incoming switching stage
GU	Outgoing switching stage
FIR	Incoming junction circuit
FUR	Outgoing junction circuit
M	Marker
TB	Test block
RS	Finder

B CONTROL SYSTEM ANA 302

(a) Data processing part

TCP	Traffic control processor
CPU	Central processing unit
PRS	Program store
DAS	Data store
OMP	Operation and maintenance processor
TRS	Translation store
SCS	Subscriber category store
ADS	Abbreviated dialling store
MUX	Multiplexor
TT	*Toll ticketing equipment*

(b) Interface part

STU	Signal translation unit
KM	Code receiver
KS	Code sender
SS	Finder
Interface	Other interface equipment

(c) Input and output devices I/O

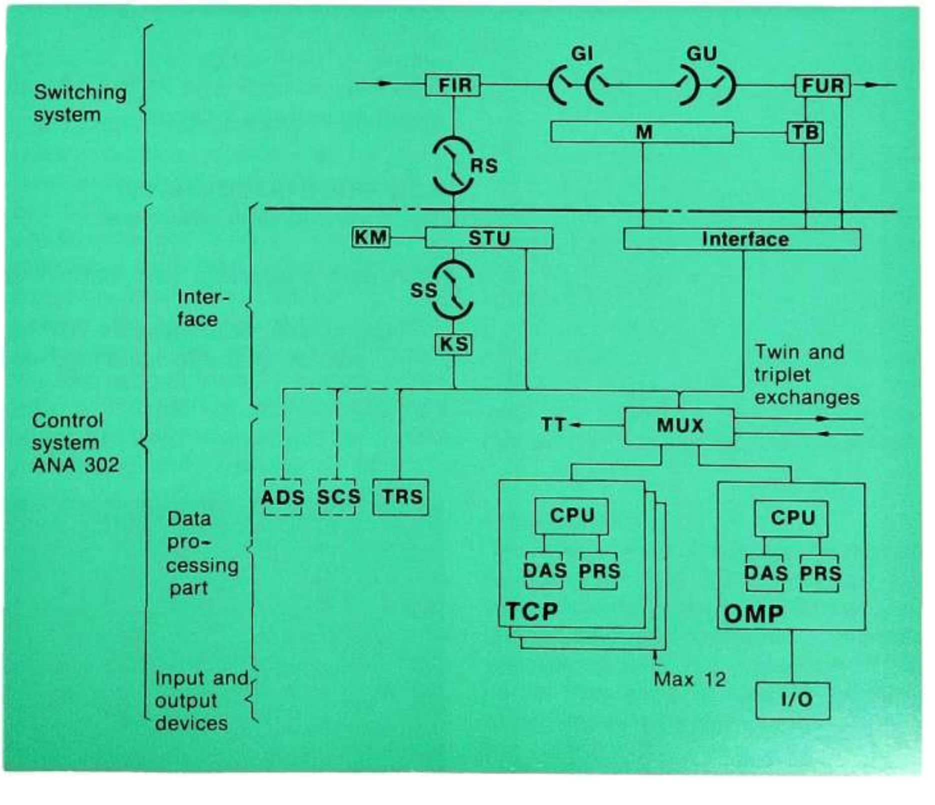
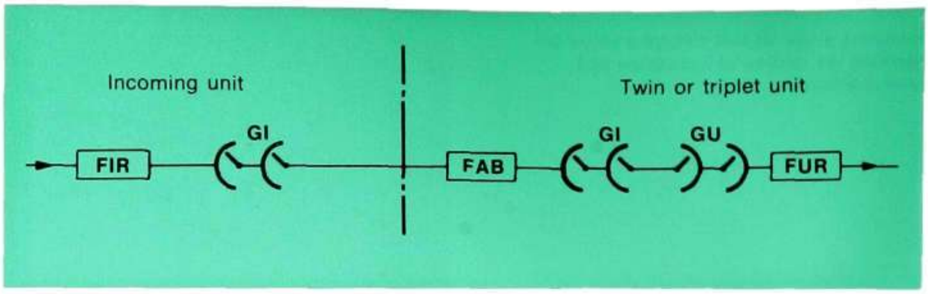


Fig. 5
Connection set up through twin or triplet unit



In national exchanges 5-pole switches with grouping as in fig. 7 are used. International exchanges normally utilize 10-pole switching stages in order to be able to cater for complicated signalling requirements of today and tomorrow with a grouping as in fig. 8.

For combined exchanges, and also for other purposes, both 5- and 10-pole switching stages may be used in the same international exchange unit ARE 13.

Marker organization
The marker organization is of a simpler type than the conventional form, since the necessary logic lies in ANA 302.

The *marker M* selects a free path through the switching network and sets up the connection. It receives the logic information from the data processing part, but a test block TB and the interface unit also participate as described below.

A *test block TB* is selected by TCP when the latter has determined the route and, via the interface part, established that a free circuit exists in the desired route. TB then selects a circuit in the route and gives TCP the necessary information. If required, for example in connection with automatic transmission tests with ATME, TB can select an individual circuit.

CONTROL SYSTEM ANA 302
The control system comprises:

— A *data processing part* containing

(a) a number of processors TCP for control of traffic handling, etc.

(b) a processor OMP for advanced operation and maintenance functions

(c) central stores TRS also SCS and ADS in the event of connection of registerless rural exchanges

(d) multiplexor MUX for connection of processors to the respective devices

— An *interface part* which translates the signalling between ANA 302 and the switching system

— *I/O devices* which, via OMP, transfer data between the operation and maintenance staff and ARE 13.

Data processing part
The intelligence of the system is concentrated in the data processing part.

The *processors TCP* and *OMP* are similar from the hardware point of view (fig. 9), but the software is entirely different since the two processors have different functions. The functions of OMP are dealt with under the heading "Operation and maintenance". The main functions of the traffic control processor TCP are

— to perform the logic functions comprising setting up of connections, charging, as well as the required exchange of information with exchanges further back and further forward in the chain.

— in the case of traffic to a twin or triplet unit, to control the entire setting up of the connection both in its own and in the twin or triplet unit.

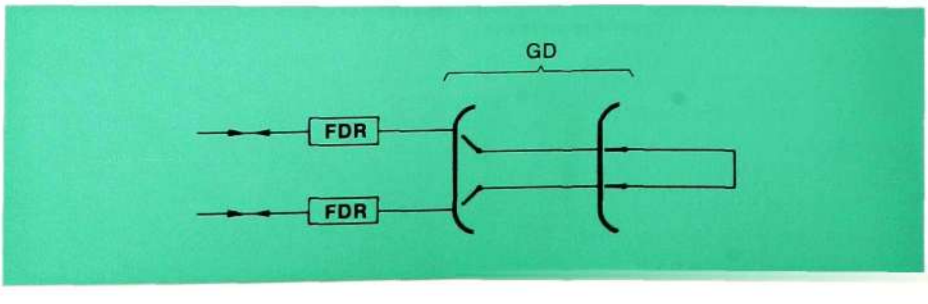


Fig. 6
Two-way circuits connected to two-way stage

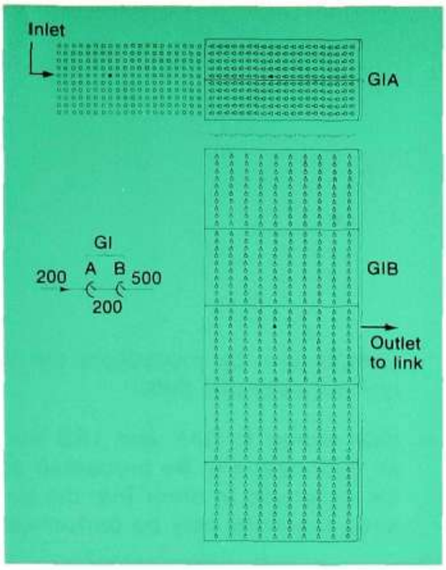
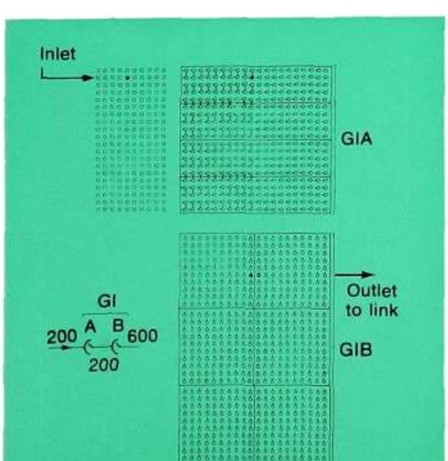


Fig. 7

Grouping plan for national exchange with 5-pole through-connection

Fig. 8

***Grouping plan for exchange with international* circuits and 10-pole through-connection**



— to interwork with the operation and maintenance processor OMP by transferring to it data concerning events in the traffic process such as call and seizure of devices, faults, etc. On order from OMP, TCP performs functions for fault tracing, testing and collection of statistical data.

As in other SPC systems, each processor consists of a program store PRS, a data store DAS and a central processing unit CPU.

The program store PRS for TCP stores mainly programs for the aforementioned functions, while PRS for OMP stores operation and maintenance programs. Most programs are identical for all exchanges, but some of course vary owing to market requirements. PRS is divided into pages, each containing a program of max. 256 words.

The data store DAS stores temporary data, which contain information about the different calls in progress and initiate various measures performed by the programs. These data consist of A-number, A-category, B-number etc., which are erased after the setting up of each call. DAS as well is divided into pages with 128 words on each page. Each page corresponds to a certain time slot in the primary interval.

The central processing unit CPU contains a number of functional units interconnected via an internal processor bus CPB. The functions of these units are summarized in fig. 9. CPU reads instructions from PRS and successively executes them. The instructions may consist, for example, of data transfer to and from other units. CPU converts the instructions from the program store into a number of microinstructions which are used internally in the central processing unit. Transfer of data between the modules of the central processing unit takes place on the bus system CPB. This ensures programmable and flexible interworking between these modules, which increases the adaptability to new requirements and simplifies routine testing and fault tracing.

There are three types of *central stores:*

— A duplicated translation store TRS

— A duplicated subscriber category store SCS

— An abbreviated dialling store ADS.

Of these stores the two latter are used only when registerless rural exchanges are directly connected to ARE 13 and SPC subscriber services shall be provided. The central stores utilize ferrite cores and retain stored information in the event of loss of voltage.

To simplify addressing and analysis TRS also contains a logic unit. TRS stores general analysis and exchange data which are dependent on the type of the exchange. It also contains B-number, route and tariff analysis data.

Traffic routing, signalling method, transmission class, charging etc. can be easily altered by changing the corresponding data in TRS. These changes can be quickly and conveniently carried out by an operator writing the relevant command on a teleprinter or a visual display.

In the same way changes of subscriber categories and abbreviated dialling numbers for rural subscribers can be made in SCS and ADS. The table in fig. 13 (page 126) contains some characteristic data for instructions and stores.

The *multiplexor MUX* is used for connection of units to one processor at a time. The processors interwork with the central stores and the interface part via a bus system. Each processor is connected by its own bus to a duplicated multiplexor MUX in each of the racks which contain units controlled by the processor. MUX ensures that only one processor at a time is connected to a unit in the rack in question.

Interface part

The interface part translates the signals between the data processing part and the switching system. It also performs certain functions controlled by the data processing part, e.g. reception of the voice frequency signals in an MFC signalling system and identification of the calling FIR.

The signal translation unit STU in the interface part connects code receivers KM and code sender KS to the speech wires. They are controlled by the data processing part and perform normal code sender and code receiver functions.

I/O devices

Up to four I/O devices can be connected for direct or remote-controlled communication with OMP. They may consist of teleprinters, display terminals, tape readers and tape punches. For remote-controlled communication, which can take place over a permanent or a switched connection, a modem is required.

Software

The software consists of

— programs stored in PRS which specify how the processors are to process available data

— data stored in DAS and TRS with all information to be processed by the programs in order that the desired functions may be performed.

Programs

There are normally about 30 programs for TCP (7.5 k) and about 40 for OMP (10 k). They consist of monitor programs *(control programs), traffic handling programs* and operation and maintenance programs. Examples of traffic handling programs are MFC reception, MFC transmission, and digit analysis.

Each program has well defined functions so that it is easy to introduce new functions and to change existing ones. The programs interwork with one another, however, and a program can at any time call another program for the execution of supplementary functions.

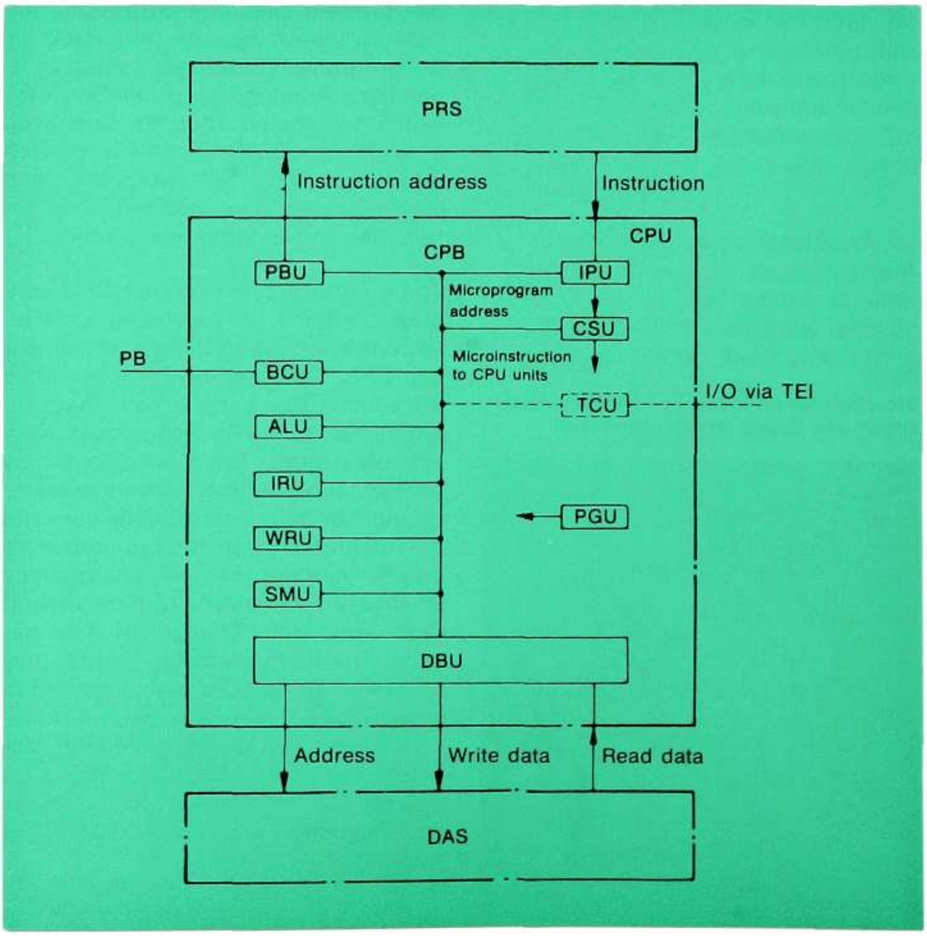


Fig. 9

Central processing unit CPU with its main functional units

- **PBU** Program store buffer unit containing program address registers
- **CPB** Internal processor bus
- **BCU** Bus control unit, for interworking between CPU and STU, KS, TRS etc.
- **ALU** Arithmetic and logic unit
- **IRU** Index register unit, modifies the data store address
- **WRU** Working register unit, stores temporary data during a time slot
- **SMU** System monitor unit, controls the connection of every program phase in the corresponding time slot
- **DBU** Data store buffer unit, transfers data in cooperation with DAS
- **IPU** Instruction pretranslation unit; translates, together with CSU, ordinary instructions into microinstructions
- **CSU** Control store unit, the microinstructions of which control the units of CPU
- **TCU** Terminal communication unit which exists only in OMP and interworks with the I/O devices
- **PGU** Pulse generator unit which generates clock pulses for synchronization of the work of the processor

A program is divided into phases, each of which is executed within a time slot in the primary interval. In some cases, however, phases in two separate programs are handled in the same time slot.

Program execution
The primary interval for TCP and OMP is 8 ms. TCP (fig. 10) will be described below, but the working mode of OMP is similar.

TCP's primary interval is divided into 61 time slots. The first 60 time slots are associated with the traffic handling and each signal translation unit STU is allotted its specific time slot. The last time slot is used for communication between TCP and OMP.

At each incoming call a signal translation unit STU is automatically connected to the FIR that has received the call. It serves as intermediary link for signalling on the line etc. STU is connected to TCP and extends the connection to KM and KS, the logic functions of which lie in TCP. Control of markers and test blocks engaged to set up the connection is done by TCP via the other interface equipment.

In DAS one page is associated with each time slot and the corresponding STU. One such page stores, among other items, the number and phase of the program to be handled in the respective time slot. The called program reads out the stored phase number from the page and the corresponding phase is handled in the time slot. In this way the respective phase for TCP or OMP is normally connected to its time slot and handled there. Certain phases do not occupy the entire time slot, so that a spare time is obtained (fig. 10).

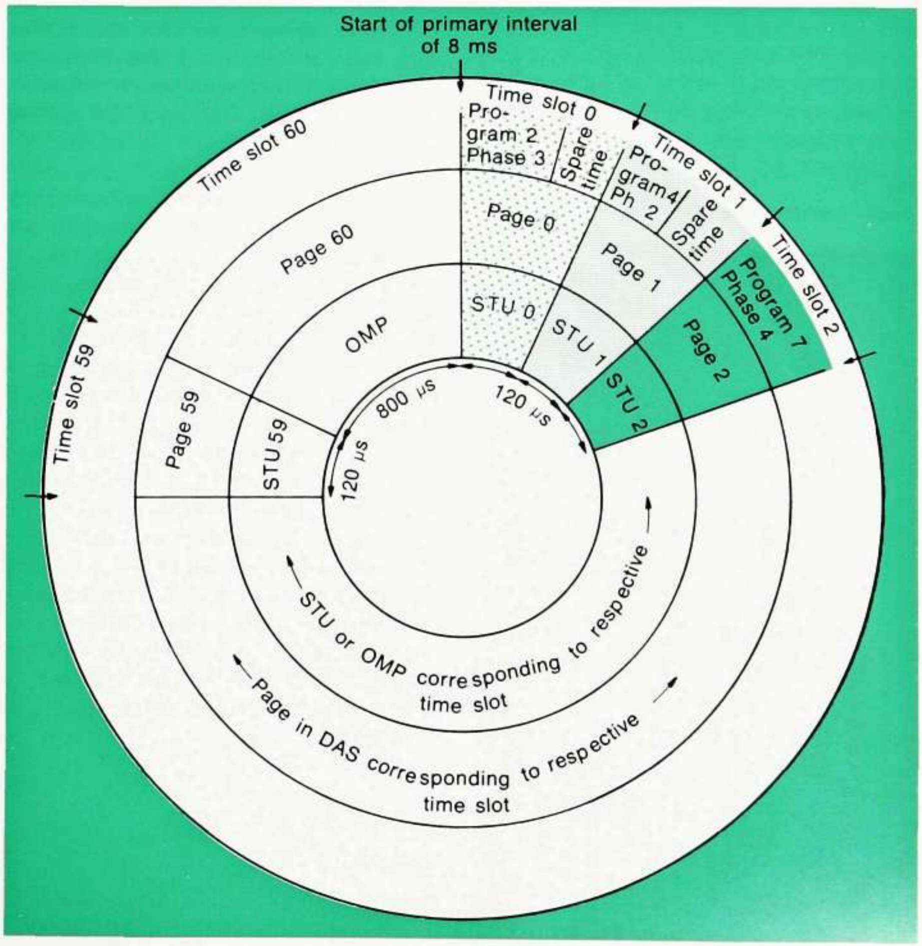


Fig. 10
Principle of program execution in fixed time slots recurring during each primary interval

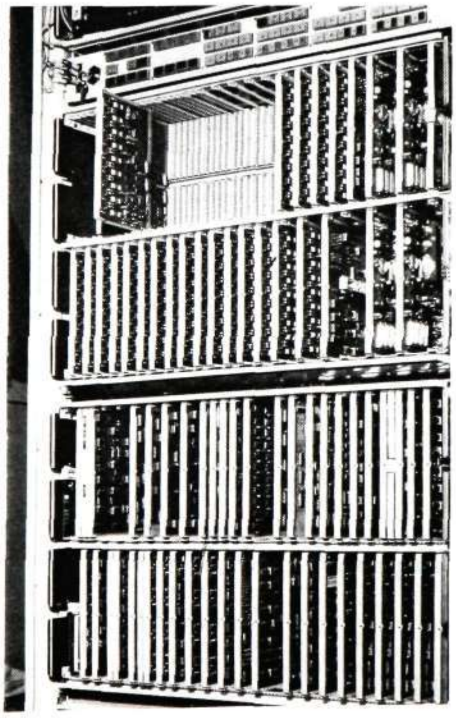
When all time slots within a primary interval have been executed, the monitor program switches to the next primary interval, and so on in an unbroken sequence. When, for example, the first phase of a program has been handled in a specific time slot, the subsequent phases are connected to the same time slot in the subsequent primary intervals until the necessary phases in the program have been executed. The next program in succession is then called.

Thanks to the philosophy of the SPC system ARE 13, it has been possible to use the principle of program execution in fixed time slots. This simplifies the monitor program, since it only needs to call the various program phases in permanently allotted time slots without taking priority levels in a complicated time pattern into consideration. The system is thus very easy to handle, to adapt to new requirements, to document, etc.

Interworking between TRS and TCP

The main principles of the B-number analysis are dealt with below. Other interwork between TRS and TCP utilizes similar principles.

Fig. 11
Traffic control processor TCP in ANA 302



The B-number analysis, which comprises varying numbers of digits depending on the phase concerned in the connection process, takes place roughly as follows. The analysis is done digit by digit and TCP calls TRS after reception of each new digit. A code word defining the area for B-number analysis is then transferred to TRS. TCP then sends information as to where the analysis is to start in this specific area and finally sends the digit concerned. By means of these data TRS addresses a word in the store and TCP reads data from it. These data may indicate either that the analysis is to continue with the next digit or that it is to be terminated, in which case data concerning the traffic route are read out by TCP.

Connection to twin or triplet unit

Even if the exchange is divided into three units with altogether $3 \times 8000 =$ 24,000 multiple positions, there is full availability on all routes. The number of circuits per route connected to each unit should correspond to the amount of traffic carried by the respective unit. The traffic rejected from an incoming unit owing to congestion is passed as overflow through a twin or triplet unit. This traffic generally constitutes less than 5 % of the total traffic.

Fig. 3 shows a complete unit for 8000 multiple positions. Fig. 12 shows only the equipment which takes part in the connection of the overflow traffic from an incoming unit via its twin or triplet unit to the desired outgoing route. It has first been established that no FUR in the desired route is free in the incoming unit. TCP then checks via a bus circuit that a free FUR exists in a twin or triplet unit. GI in the incoming unit is then connected to a junction relay set FAB, after which marker M in that exchange is released. Under the control of TCP in the incoming unit, GI and GU are then set up to the selected FUR on the desired route.

Reliability

Reliability is ensured primarily by

a) careful design, using reliable components with long life

b) a far-reaching modular structure

c) duplication of important central units.

A modified standby principle is adopted in order to attain optimal reliability in an economic way. The first processor TCP in a group of maximum six serves as standby for the remaining processors in the group. The first processor must have a given basic load to guarantee that it is always in working condition if, for example, another processor in the group should become faulty. The size of the basic load depends on the number of processors and must be selected so that, during the repair time, the first processor can be dispensed with. In the case of a fault in another TCP in the group the first processor interrupts its own work and takes over the entire work of the faulty processor.

If there is a fault in the first processor, it is automatically disconnected and an alarm is issued.

FIR and FUR in ARE 13 are supervised per route, and all other devices individually. Central devices are duplicated and, in the event of a fault in one of them, the processor automatically switches over to a correctly functioning device. All faults with associated data can, on request, be written on a teleprinter, which can be placed in the exchange or in a maintenance centre.

Operation and maintenance

The system meets the high requirements placed on operation and maintenance functions. It offers advanced supervisory, fault tracing, traffic measuring and statistical functions. Exchange data can be quickly and simply changed so as to adapt the exchange to new conditions without disturbance of operation. Operation and maintenance can be centralized to an operation and maintenance centre common to several exchanges and located separately or in one of the exchanges. The operation and maintenance functions can thus be remote-controlled and the data concerned read out from the centre.

Supervision

Supervision that the failure rate does not exceed an acceptable predetermined value takes place continuously. If the rate is exceeded an alarm is issued, which is divided into three classes according to the degree of urgency. The alarm can be transmitted to the operation and maintenance centre.

The main supervisory functions are the supervision of the failure rate per route and individual device, supervision of blocking per route and type of device, and supervision of call congestion per route. There is also a well developed internal supervisory procedure built into processors and central devices for, for example, parity check and routine testing.

Fault tracing

On receipt of an alarm the fault must be traced. The first measure is that the operator requests a printout of the cause of the alarm from OMP, indicating the identity of the faulty device and the type of fault. Depending on the information received, the operator then issues a command for the necessary

Fig. 12
Setting up of connection from the incoming unit through a twin or triplet unit

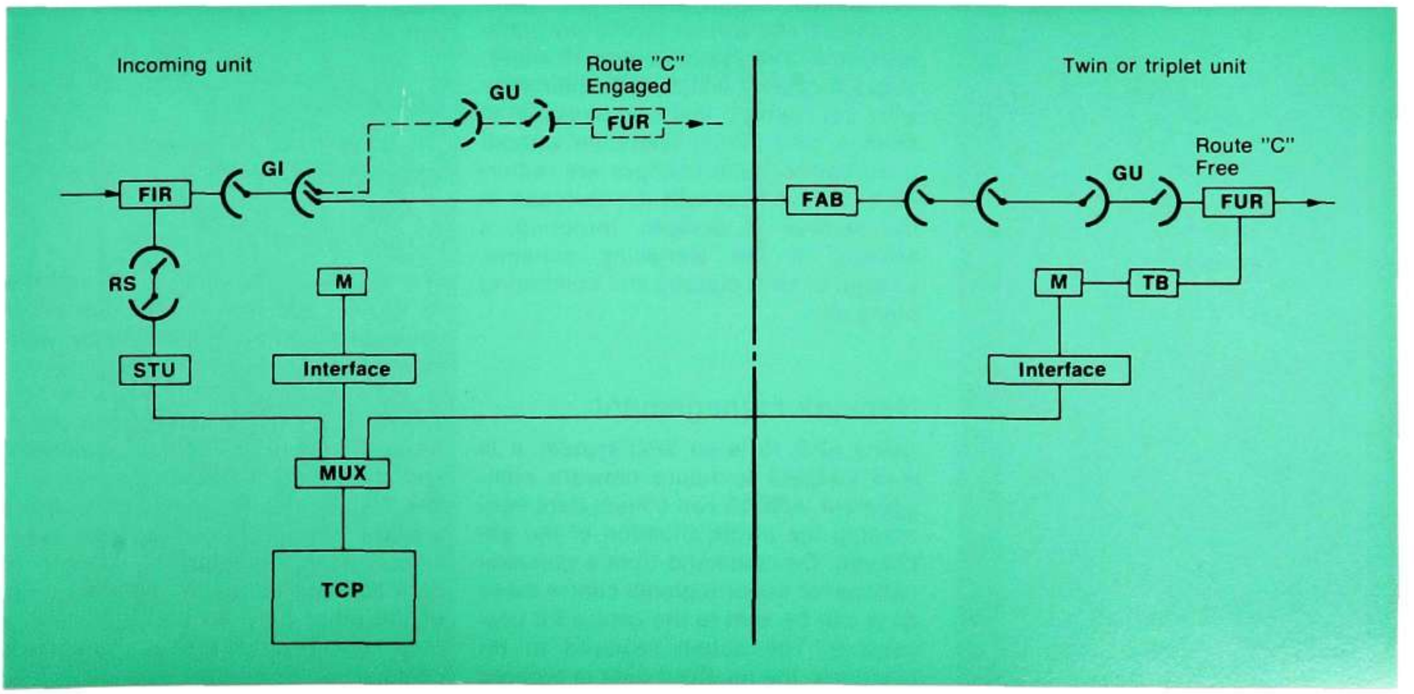


Fig. 13

Data for instructions and stores in ANA 302

Name	Word length in bits	Max. no. of pages	Words per page	Module
Instruction	16	—	—	—
Microinstruction	24	—	—	—
Program store PRS	16	64	256	2 pages
Data store DAS	8	64	128	8 pages
Central stores TRS, SCS and ADS	8	—	—	4096 words

action. The action may consist of remote blocking of a faulty device, output of switching data, initiation of test connections to specific devices, etc.

Traffic measurements

The measurements comprise recording of data of traffic intensity, occupation, call congestion, link congestion, and call dispersion. By measurement of the call dispersion it is easier, for example, to decide whether a new high-usage route to an exchange should be introduced or not.

Statistical functions

By means of statistics a long-term assessment can be made of the service quality of the switching and transmission network. For this purpose the operation and maintenance centre collects the necessary data from ANA 302.

The statistics also comprise data per type of device and network data. The latter provide valuable information concerning difficulties in the network and its exchanges.

Changes of exchange data

Exchange data can be easily changed so as to adapt the exchange to new conditions very quickly and with insignificant labour effort. This is done by an operator writing the necessary commands; alternatively the commands can be written from a programmed tape. The system contains supervisory functions which, in combination with duplication, make it possible to change data during operation without disturbance. Such changes are required in conjunction with an increase in the number of devices, rerouting, a change in the signalling scheme, change of tariff classes and numbering plans, etc.

Network management

Since ARE 13 is an SPC system, it is well adapted to future network management. ARE 13 can collect data concerning the traffic situation of the exchange. On command from a common national or major regional centre these data can be sent to the centre for processing. The action required in response to the received data is ordered from the centre by transmission of the relevant command to the exchanges concerned.

Conversion of ARM 20 to ARE 13

ARM 20 exchanges can be equipped with ANA 302 while in continuous operation and thus be converted to the facility level of ARE 13. The installation testing of ANA 302 is done with, among other means, a simulator before the equipment to be replaced is taken out of operation. If desired, ANA 302 can be set up separately from the remainder of the exchange.

The traffic is successively transferred to ANA 302 by connection of one signal translation unit STU at a time. The new equipment interworks with existing registers and with the cooperating control equipment.

Components in ANA 302

ANA 302 contains integrated circuits including LSI (Large Scale Integration), ferrite core stores and other types of modern semiconductor stores, discrete components and miniature relays (fig. 14). These components are mounted on printed circuit boards of two different sizes, the larger of which is shown in fig 15. The smaller board is half as large.

Some data

The table in fig. 13 presents some particular data for instructions and stores.

Power supply

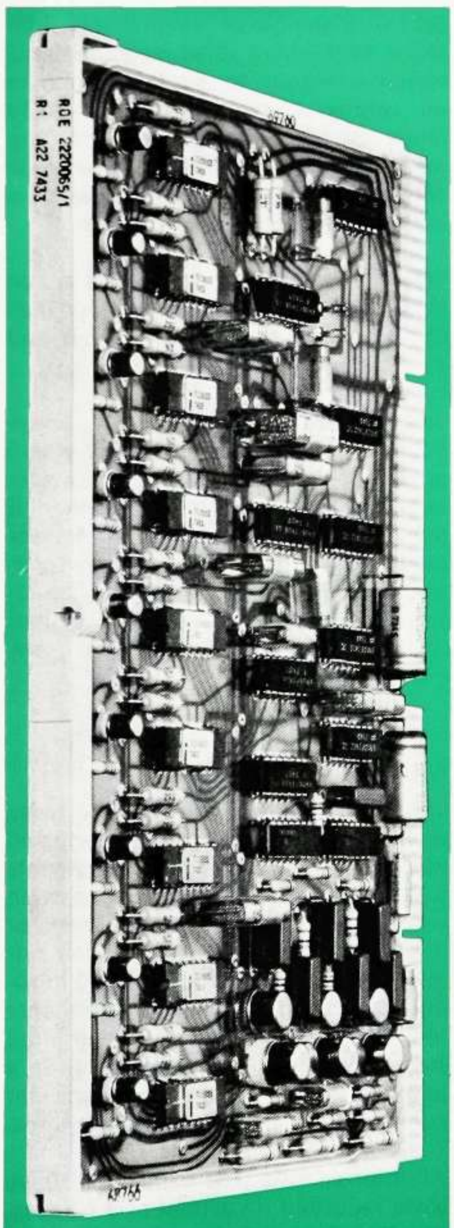
The main power supply plant delivers 48 V. ANA 302 requires various lower voltages which are generated by rack-mounted DC/DC converters.

The 48 V plant consists of two parts: one supplies the switching equipment and the other the DC/DC converters. The electrical components of ANA 302 are thereby protected against transients. The switching equipment of ANA 302 can utilize the standby units of the other part, so that the division does not result in any appreciable costs.

Fig. 14

Different types of miniature relays (top) and memory components (below) used in ARE 13

Fig. 15
Double-sided printed circuit board of the larger type in data store DAS



The DC/DC units are duplicated. If a fault arises in one unit, the other unit takes over the entire load.

The central 48 V power plant is designed in accordance with LM Ericsson's reliable system with series converters and thyristor rectifiers[2]. These are specially adapted for electronic equipment, since in all types of operation they have narrow voltage fluctuations. The voltage never falls below 47 V, which ensures small maintenance costs for ARE 13 and optimal reliability. These power plants can therefore advantageously be used for unattended exchanges, as has been successfully done for a large number of telecommunication plants.

Summary

ARE 13 is an SPC system and offers the many advantages of such systems. This applies especially to the operation and maintenance functions, which offer two-way communication between operators in the operation and maintenance centre and ANA 302 via a teleprinter or other I/O device. From the teleprinter the operator can order the necessary changes of data for rerouting, alteration of the signalling scheme, tariff classes, numbering plan, etc. In the other direction different types of fault printout etc. can be obtained. A great reduction of staff is thereby possible.

In the triplet form of the exchange the capacity is 24,000 multiple positions and a connection is always controlled by the processor in the incoming unit alone. The final capacity can be raised still further through suitable arrangements. Since ANA 302 can also be used for converting an existing ARM 20 exchange into ARE 13, a whole region or national network previously containing ARM 20 exchanges can obtain the same level of facilities. Rural exchanges of type ARK can also be connected to ARE 13, thus raising the level of facilities for rural subscribers to that of SPC exchanges. If the network contains ARF exchanges, these can be converted into SPC ARE 11 exchanges. If the local network is extended by ARE 11 exchanges, an altogether uniform and standardized system is obtained, from the international down to the rural exchanges.

Since the processors in ANA 302 perform only those functions which gain from data processing, they are not burdened with a mass of unnecessary routine work. ANA 302 has therefore a simple structure with limited program volume and program execution divided into time slots. The system is therefore easy to handle and changes and additions can easily be made.

ARE 13 also offers the property of electrically changeable stores characteristic of SPC systems. Data can be transferred for change of routing, charging, signalling, traffic class, numbering, etc.

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Survey of the Quality of the Swedish Wideband Network with Respect to Data Transmission over Group Links

Branko Tigerman

On behalf of, and in cooperation with the Swedish Telecommunications Administration, LM Ericsson have carried out measurements on a number of group links in the carrier network in order to investigate the possibility of using such links for the future data network. This article gives just a brief account of the test methods used and the results obtained.
A more detailed report will be given in the Swedish Telecommunications Administration's journal TELE.

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Group links in existing and future carrier systems will be used in the Swedish public data network for transmission of data in the basic group band between concentrators and data exchanges in Stockholm, Gothenburg and Malmö.

By group link is meant a transmission path, with the associated equipment, for the transmission of a normal 48 kHz group band terminating in a group distribution field, to which various types of terminal equipment can be connected.

The transmission quality of the group links is determined partly by steady state characteristics and partly by disturbances that occur at random. The effect of the steady state characteristics, amplitude and group delay distortion, can be reduced by using only the groups situated in the middle of the supergroup, i.e. groups no. 2, 3 and 4.

The disturbances that occur with random distribution in time, such as short interruptions, phase jitter and impulsive noise, affect the data transmission by causing bit and block errors in the transmitted data flow.

It would of course have been fairly simple to determine the suitability of the link for data transmission by measuring only the bit and block error rate. However, such measurements do not give any information about the cause of the errors and thus provide no information for combating faults. Furthermore the results apply only for the type of data modem used.

In order to obtain more exact information about the group links, certain measurements and investigations have been carried out of, for example, the occurrence of short interruptions, phase jitter, impulsive noise and error rate*. The aim has been to determine the existing conditions without analysing either the origin or cause of the disturbances or finding methods of eliminating them. The measurements were carried out on links that were selected and connected up by the Swedish Telecommunications Administration.

During a period of roughly one year (April 1973—May 1974) measurements were carried out for over 13,500 hours on various routes with a combined length of approximately 7500 km. The measuring time per link varied between 160 and 1600 hours. The link lengths varied between 180 and 1060 km.

The measurements were carried out on both transistorised and valve coaxial cable systems for 12 and 60 MHz and on radio relay systems.

The results of the measurements have been published in a test report, which gives a detailed account of the measuring methods and results obtained. It must be pointed out, however, that any conclusions regarding transmission media and system type can only be related to the tested links, as the number of links was too limited to permit any generalisations.

Measuring methods

Measuring methods for various types of disturbances were developed, and measuring equipment and instruments were purchased or built in cooperation with the Development Department of the Swedish Telecommunications Administration. It was necessary to introduce certain definitions and concepts in order to make it possible to carry out the measurements at all, as there is a lack of CCITT recommendations for such measurements on basic groups.

All interruptions that exceeded 10 μs were recorded (in a total of 9 classes, of which 8 were between 10 μs and 1

* The first three phenomena mentioned were measured, registered and analysed by LM Ericsson (the System Department of the Long Distance Division) in cooperation with the Central Administration of Telecommunications (the Plant Engineering and Development Departments). The error rate measurements were carried out by the Administration's Development Department and the results were processed by LM Ericsson.

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Long Distance Division
System Development Department

minute). A phase jitter disturbance was recorded every time the amplitude exceeded 10°, 20° and 30° respectively. For impulsive noise the level limits were set to −16, −10 and −4 dBm0. The measurements and recordings were carried out continuously. However, the readings of the recorded values took place at different intervals for the various phenomena. Thus short interruptions were automatically recorded whenever they occurred (with a time resolution of 1 minute) and every tenth minute respectively (for the shortest interruptions, of 10—50 μs). The recorded number of seconds disturbed by phase jitter was photographed automatically once every hour, whereas the number of phase jitter disturbances was read and recorded manually twice a day. The recorders for impulsive noise were photographed automatically once every hour. During the measurements of bit and block error rates the recorded values were written out automatically every fifth minute if any errors had occurred.

In order to simplify the checking and supervision of the continuous recordings, the measurements were carried out on loop-connected systems, i.e. the transmitter and the receiver were situated at the same place. Any influence on the test results caused by this arrangement is so small that it may be neglected.

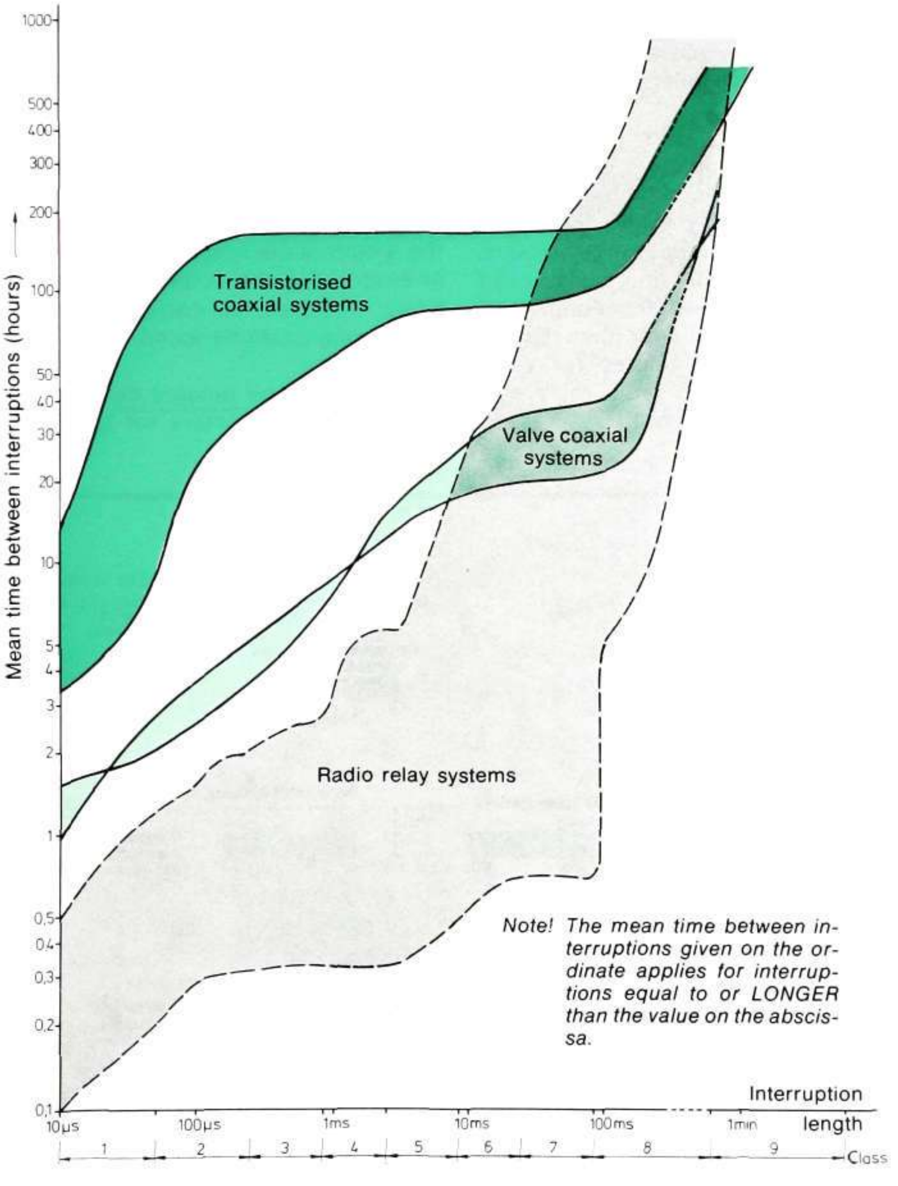
All the measurements with the exception of those on the 60 MHz system were carried out either from the Stockholm repeater station or from the Telecommunications Administration's premises at Farsta in south Stockholm. The measurements on the 60 MHz coaxial system were carried out from the Örebro repeater station.

Results of the measurements

The measurements were carried out on group links in supergroups that had no other form of traffic. Groups no. 2, 3 and 4 were used.

The occurrence of short interruptions was measured on three transistorised coaxial systems, two coaxial systems equipped with valves and five radio relay systems. The existence of phase jitter and impulsive noise was measured on two transistorised and two valve coaxial systems and four radio relay systems. Error rate measurements were carried out on one transistorised and one valve coaxial system and on one radio relay system.

Fig. 1
Mean time between interruptions as a function of the interruption length



In spite of the fact that each of the measured phenomena has its own "parameters" that can be presented as the test results, certain points are common to all measurements. Thus the occurrence can be given as a function of time or the distribution over the 24 hours of the day and a cumulative occurrence can be given as a function of a suitable parameter such as the percentage of undisturbed time units, the number of disturbances per time unit etc.

Short interruptions

A brief account will be given here of some of the more important results for the various phenomena. For short interruptions the mean time between interruptions (MTBI) for the different types of systems and as a function of the interruption length (cumulative) are shown in fig. 1.

A more detailed analysis of the number of interruptions in single interruption classes usually shows that MTBI tends to rise with longer interruptions. It was also found that on transistorised coaxial systems 63—100 per cent of all interruptions are shorter than 50 μs. The corresponding figures for valve coaxial systems and radio relay systems are 30—65 per cent.

The mean values of some interruption parameters for different links, in the form of discrete points on a logarithmic scale, are given in fig. 2.

The recording method used also made it easy to calculate the percentage of hours free from interruptions during the test period, see fig. 3.

The study of the interruption sequence as a function of time (recording with transient recorder) shows that the interruptions often occur in series and disturbance periods, which for some minutes can be more or less continuous. The interruptions themselves can be "clean" or contain short or long transition periods, which makes if difficult to confine the concept interruption. Moreover interruptions of different lengths can occur during the same interruption sequence.

It may be mentioned that attempts were made to find a connection between the number of interruptions and the length of the route and the number of modems in the connection respectively. However, no correlation worth mentioning could be found.

It should also be pointed out that the interruption parameters for the radio

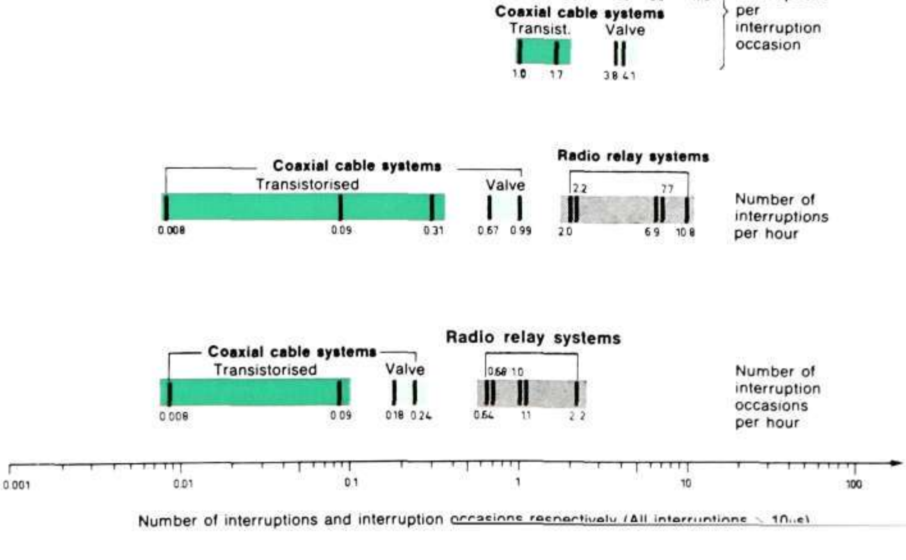


Fig. 2

The number of interruptions and interruption occasions for different transmission media. The mean values for the various measuring periods are given as lines with numerical values

Fig. 3
The number of interruption-free hours as a function of the interruption length

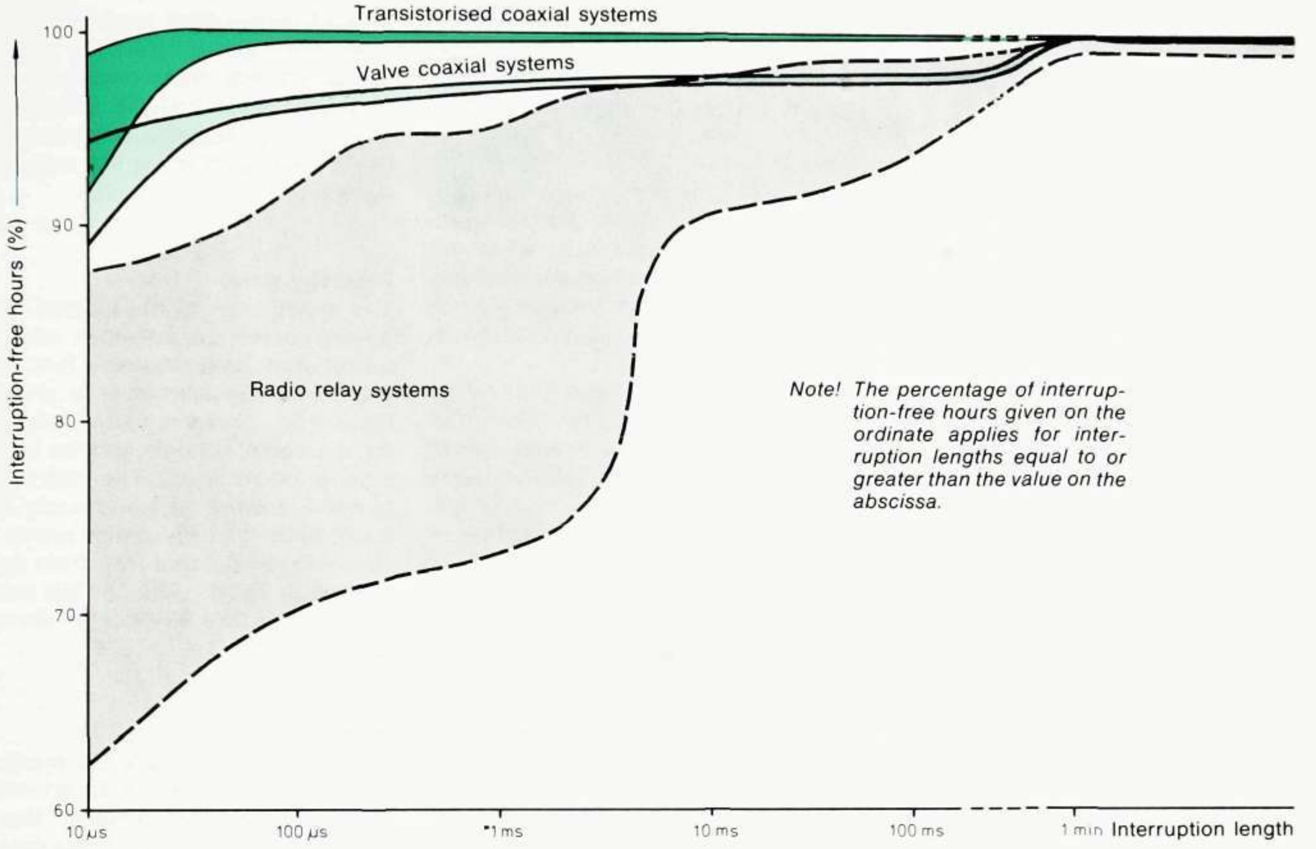
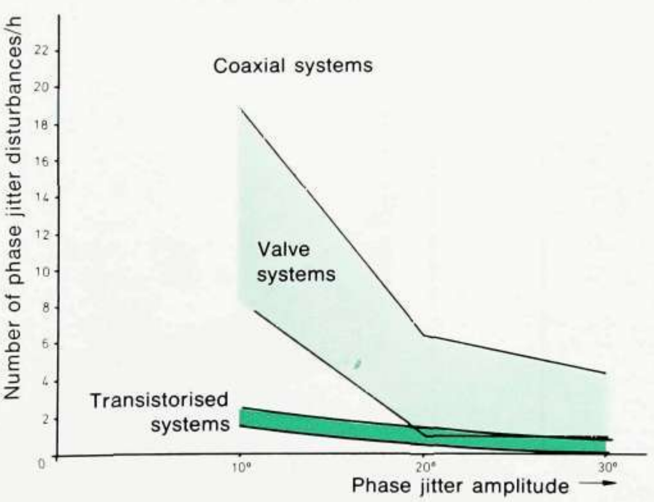
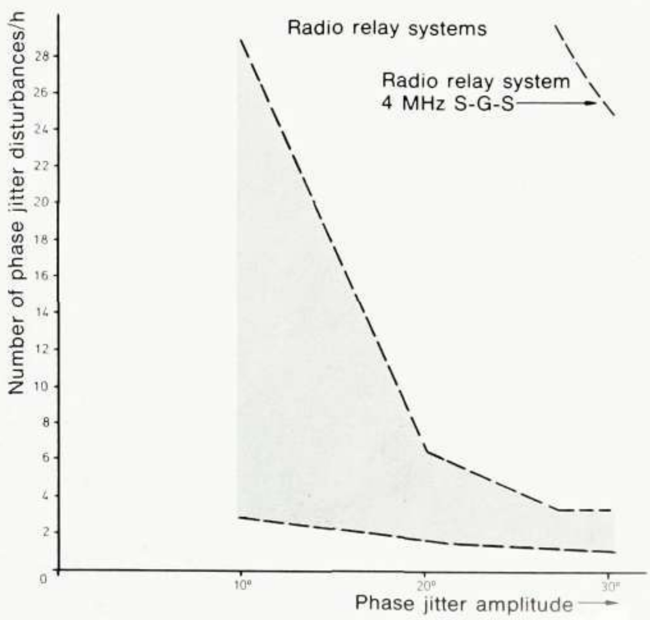


Fig. 4
The number of phase jitter disturbances per hour as a function of the phase jitter amplitude





relay systems can be affected by the setting of the noise threshold for the changeover from the working to the standby system.

Phase jitter

When measuring phase jitter the absolute number of phase jitter disturbances and their duration were recorded, and also the number of phase jitter disturbances per hour as a function of the phase jitter amplitude, fig. 4.

The duration of the phase jitter deviations as a function of the phase jitter amplitude shows the same tendency as the number of phase jitter disturbances. The absolute values vary between 0.1 and 2.2 ms/h for amplitudes $> 10^\circ$ and between 0 and 0.3 ms/h for amplitudes $> 30^\circ$. The mean values for single phase disturbances vary between 40 and 180 μs for different links.

The number of disturbed seconds per hour as a function of the phase jitter amplitude is given in fig. 5.

An analysis of the mean values obtained shows that during each disturbed second (phase jitter amplitude $> 10^\circ$) there are approximately 1—3 disturbances on the transistorised coaxial systems, about 2.5—3.5 disturbances on the valve coaxial systems and about 3—13 disturbances on the radio relay systems.

Impulsive noise

The mean value of the number of impulsive noise disturbances per hour for different links and as a function of the impulsive noise level is shown in fig. 6. The spread is particularly large for the cable systems and for low impulsive noise level. The radio relay systems, however, are practically equal for all three impulsive noise levels. The percentage of hours free from impulsive noise is 28—78% for the coaxial systems but only 6—14% for the radio relay systems.

Error rate

The error rates have been measured on data connections with data modems connected to group links on the test routes.

Fig. 5
The number of disturbed seconds per hour as a function of the phase jitter amplitude

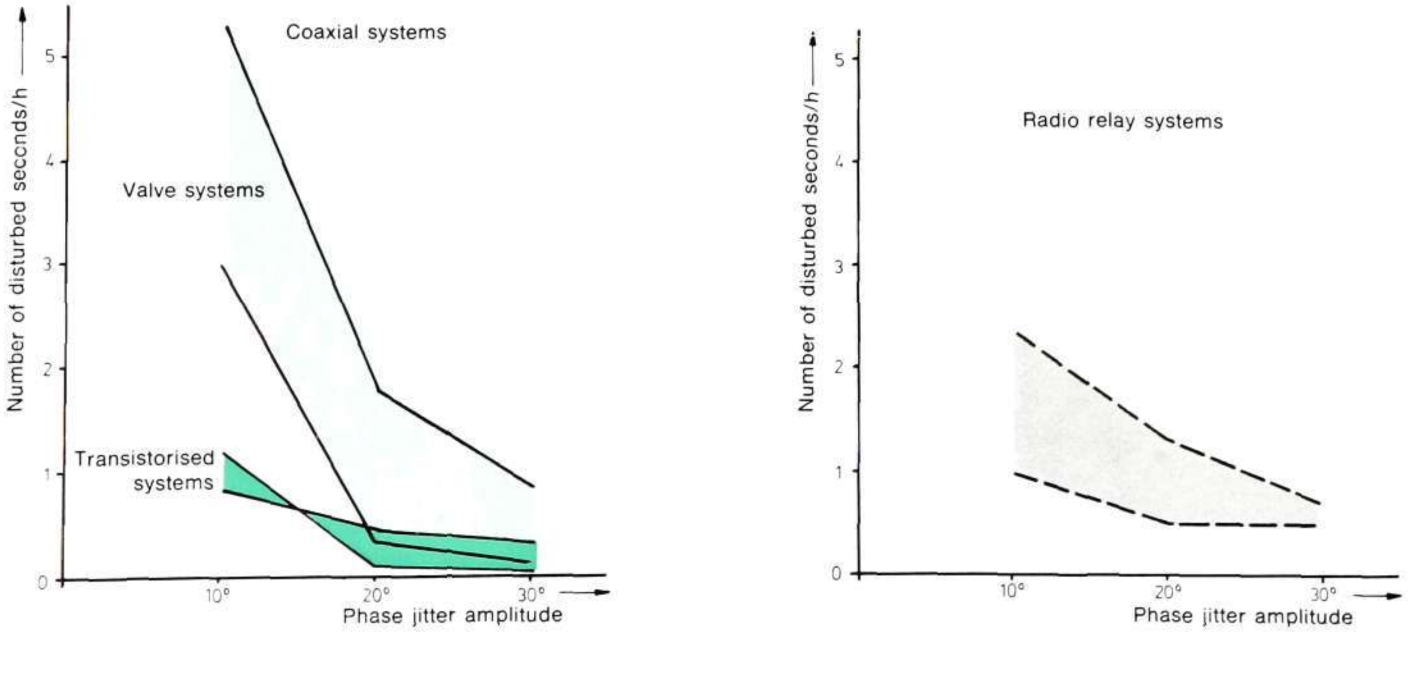


Table 1
Error rates for group links with data modems

ERROR RATE PARAMETERS	COAXIAL SYSTEMS Transistorised	Valve	RADIO RELAY SYSTEMS
Bit errors (during the test period)	1×10^{-9}—2×10^{-8} (6.6×10^{-9})*	5×10^{-9}—5×10^{-7} (1.5×10^{-7})	1.5×10^{-7}—2.5×10^{-5} (4.9×10^{-4})
Block errors (during the test period)	1.5×10^{-7}—1×10^{-6} (5.7×10^{-7})	3×10^{-7}—2.4×10^{-5} (5.8×10^{-6})	2×10^{-6}—6.5×10^{-4} (1.5×10^{-4})
Number of disturbed 5-minute intervals per hour	0.04—0.17	0.13—1.3	0.4—5
Percentage of disturbance-free 5-minute intervals	99%	97%	81%
Distribution over the 24 hours of the day	Fairly even	Maximum 0800—1700 hours	Falling tendency 0700—2400 hours
Test time	332 hours	353 hours	350 hours
Length of the test routes	962 km	935 km	961 km
Number of links measured	1	1	1

* *Mean value*

The most important parameters are given in table 1.

Comments on the test results

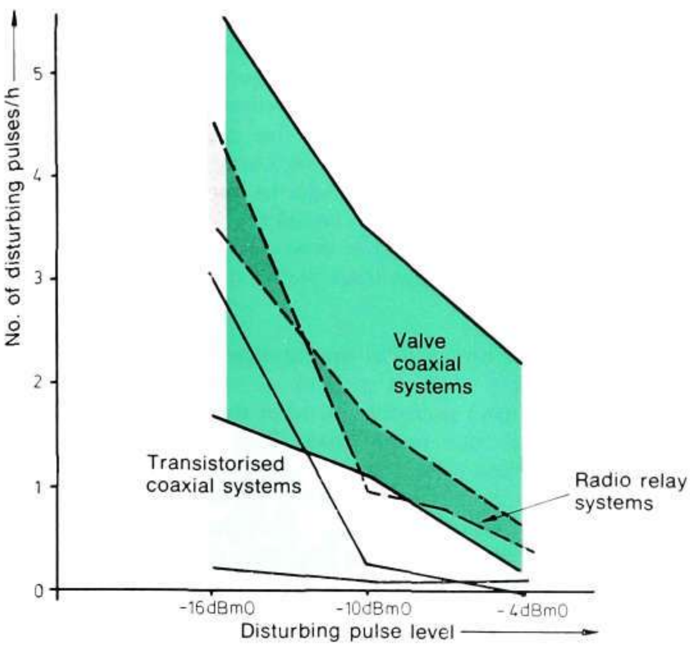
Comparisons between the different links are based on mean values for various parameters, since their distribution function is not known. Brief comments on the measured links are given below.

Transistorised coaxial cable systems
The transistorised systems on coaxial cables show fairly long mean time between interruptions, i.e. a small number of interruptions per hour with many interruption-free hours. Most interruptions are short and usually occur as single phenomena. Only on one of the links were there more interruptions during working days than during non-working days.

The occurrence of phase jitter is characterised by a small number of disturbed seconds per hour, with few phase jitter disturbances per disturbed second for all phase jitter amplitudes $> 10^\circ$. The number of phase jitter disturbances per hour is also small, and the phase deviations are of short duration. The variations during the 24 hours of the day are small. As regards larger phase jitter amplitudes one of the two systems (60 MHz) shows a considerably larger number of hours free from phase jitter than the other links.

The two transistorised systems that were measured differ greatly as re-

Fig. 6
The mean value of the number of disturbing pulses per hour for different links and as a function of the disturbing pulse level



gards the number of disturbing pulses that exceed −16 dBm0 (0.3 and 3.1 disturbing pulses/h respectively). However, fewer disturbing pulses occur than in the case of the radio relay systems. As regards high disturbing pulse levels the transistorised systems are considerably better than the other systems (a single disturbing pulse > −4 dBm0 in the 60 MHz system).

The transistorised systems had the same percentage of hours free from disturbing pulses as the valve systems, which was much greater than that obtained with the radio relay systems. The variations in the number of disturbing pulses during different days are quite small.

The error rate measurements show only a few bit and block errors, with fairly small variations during the different days of the test period. Compared with the other systems the transistorised systems show the greatest number of error-free hours, mainly during the day. Of the total number of 5-minute intervals recorded, 99 per cent were free from errors.

Coaxial cable systems equipped with valves

The mean time between interruptions for the valve systems on coaxial cables is shorter than that for the transistorised systems, which means a greater number of interruptions per hour. In this case also, the number of interruption-free hours was fairly high. The tendency for short interruptions is less pronounced than in the case of the transistorised systems, but at the same time the mean number of interruptions per interruption occasion is greater. There are more interruptions during working days than during non-working days.

For phase jitter amplitudes > 10° the links show a greater number of disturbed seconds per hour than three of the four radio links. The number of phase jitter disturbances per disturbed second is greater than for the transistorised systems, but considerably less than for three of the four radio relay systems. The number of phase jitter disturbances per hour is greater than in the case of the transistorised systems. The duration per disturbance is shorter than for the radio relay systems. The distribution over the 24 hours of the day varies, but shows no definite tendency.

The number of hours free from phase jitter is of the same magnitude as for the other systems.

As regards impulsive noise disturbances there is a great difference between the two valve systems measured, and the difference is consistent, i.e. it exists at all disturbing pulse levels. The percentage of hours free from disturbing pulses is greater than for three of the four radio relay systems. The distribution over the 24 hours of the day shows a somewhat irregular tendency.

The valve systems show a greater number of bit and block errors and also greater variations than the transistorised systems. The number of error-free hours is also less, although the number of error-free 5-minute intervals is 97 per cent of the total recorded. The maximum error rate occurs during the daytime.

The radio relay systems

The mean time between interruptions is considerably shorter for radio relay systems than for cable systems, and the number of interruption-free hours is also less. However, there is a considerable improvement in the case of interruptions that are longer than about 3 ms. On average there are more interruptions per interruption occasion. As far as could be seen there is no tendency towards more interruptions during working days than non-working days.

The phase jitter measurements showed that for phase jitter amplitudes > 10° there are more disturbed seconds than on transistorised links. Owing to a "bad" link the spread of the number of phase jitter disturbances is large. Two of the four radio relay systems are of the same class as the valve coaxial systems, and one is even considerably better. However, the duration of the phase jitter disturbances and also the number of disturbances per disturbed second are greater than for the coaxial systems. The day variations are somewhat larger than for the coaxial systems, but the number of hours free from phase jitter disturbances is of the same magnitude as in the case of the coaxial systems.

As regards the number of disturbing pulses all four radio relay systems show a surprising similarity at all three pulse levels. The radio relay systems are not quite as good as three of the four cable systems, but at high levels the difference is insignificant. The percentage of hours free from disturbing pulses is lower than in the case of the cable systems, and for higher pulse levels the spread between the different radio link systems increases. The distribution over the 24 hours of the day shows fairly large variations.

The radio relay systems have higher bit and block error rates and greater variations than the cable systems. There were no error-free hours during the test period and only 81 per cent of the recorded 5-minute intervals were free from errors. The distribution over the 24 hours of the day showed a continuously falling tendency from early morning to late evening.

Summary

Measurements of short interruptions, phase jitter, impulsive noise and error rate have been carried out on certain groups in the Swedish Telecommunications Administration's carrier network in order to investigate their suitability for high-speed data transmission.

To summarize the measured data recorded, processed and analysed during the course of a year, the following can be said regarding the links measured in their "existing condition".

The transistorised coaxial systems definitely show the best characteristics with regard to all disturbance parameters and are considered to be the most suitable for data transmission.

The coaxial systems equipped with valves are not quite as good as the transistorised systems. They are of roughly the same quality as the radio relay systems as regards phase jitter and impulsive noise, but better than the radio relay systems as regards short interruptions and error rate.

There are more interruptions and bit and block errors on the tested routes that contain radio relay systems than on coaxial cable routes, and this may put certain limitations on their use for data transmission. However, the reason for this may be that the changeover noise level is set too low, and in certain cases a simple adjustment can give an improvement. Phase jitter disturbances and impulsive noise are of the same order of magnitude as for coaxial systems equipped with valves.

ERICALL CONTACTOR – a New Generation of Wireless Paging Systems

Dag Åkerberg

A new generation of wireless paging systems—ERICALL CONTACTOR— has been developed by Svenska Radio AB (SRA). Transmission takes place using amplitude-modulated radio signals in the frequency band 25—44 MHz. The heart of the system is a specially developed digital decoder which is included in each pocket receiver. The digital decoder, together with a fixed equipment of modular design, has given the ERICALL CONTACTOR many valuable system characteristics.

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A distinction is made between *local* paging systems and *city-wide or country-wide* systems.

Local paging systems* form part of the internal communication system for a company or an administration. The systems can vary in size from five to over 1000 receivers, i.e. from small offices that require only one control unit with transmitter, to large industries, fire brigades and hospitals, with several transmitters, many simultaneous calls, several control positions, connection to a PABX or PAX and/or intercom exchange, automatically released alarm calls, group calls, different characters for the various receiver alarm signals, function supervision, charging rack, absence indication etc. Moreover it must be possible to provide local systems with facilities for sending speech messages to the pocket receiver and it must also be possible to supplement the pocket receiver with a transmitter for acknowledgement or talk back.

City-wide or country-wide systems offer quite another, and relatively uncomplicated form of service. The fixed equipment for such a system is expensive, and in Europe the transmission network is often owned by the country's Telecommunications Administration. Paging can take place from each telephone that is connected to the public telephone network. The paging service is available to the public. Receivers are either leased or bought. Very often the receivers are unable to send speech, only bleep signals, in certain cases with different signal characters. Answers cannot be given by radio, the person who is paged having to ring a telephone number or carry out some other predetermined action. These systems with large coverage constitute a complement to the local systems in cases where staff operate outside the local organization, for example in the case of service staff who operate over the whole of a town.

ERICALL CONTACTOR is a paging system for local use. However, the digital decoder can, in principle, be used for very large systems, since it can quite easily be arranged to differentiate between 16 million codes.

The basic design of the CONTACTOR system

A local system must be able to satisfy widely diverging customer requirements, yet at the same time it must be possible to manufacture economically through long production series of standard equipment. Furthermore, in order to be competitive the system

* Svenska Radio AB have marketed local paging systems of their own manufacture since 1961.

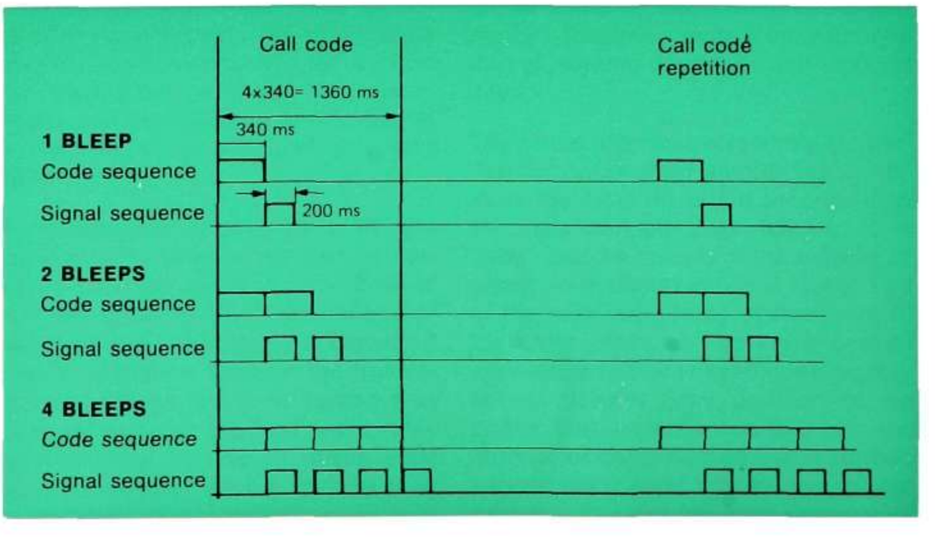

Fig. 1

Receiver signal characters

The signal characters are controlled by an encoder, which means that a short 200 ms bleep is heard in the receiver each time the code is sent out. A call code can consist of 1, 2, 3 or 4 bleep signals at the receiver. The call code is repeated a number of times, the number of repetitions being determined from the control unit. Each receiver can be coded for an arbitrary A code and an arbitrary B code. Which of the two codes has been received can be decided by optical indication, which makes possible a maximum of eight different signal characters, four for the A code and four for the B code.

DAG ÅKERBERG
Svenska Radio AB

must be designed so that a simple and small system does not have to bear the costs of facilities that are not utilized. These requirements are fulfilled in the following way.

By developing a digital decoder in low voltage C-MOS technique it has been possible to make all the receivers the same from the point of view of manufacture. The individual receiver identity is obtained through an inexpensive plug-in type code key, in which certain contact wires are burnt off.

The time sequence of the call signal from the receiver is controlled by an encoder. This means that the receiver is of simple design and that a standard receiver can be used for both simple and complicated systems. The increased complexity is placed in the fixed equipment. Each time the correct code is received, the receiver gives one bleep. In order to obtain the different signal characters, the fixed equipment, encoder, repeats the code in accordance with defined patterns, see fig. 1.

The standard receiver can be equipped with a talk-back transmitter by replacing the attachment clip with a thicker clip which contains the transmitter.

The fixed equipment is centred around a control unit EC 100/110 or a system encoder EC 200. EC 100/110, fig. 2, is a simple and inexpensive equipment, which covers most requirements. EC 110 is an "all in one" system, which requires very little installation work. The transmitter and the aerial are built into the control unit. A maximum of 100 persons can be called. The control unit can be provided with extra facilities, fig. 3. EC 100 has the same functions as EC 110, but it uses a separate transmitter and aerial, which increases the range.

The system encoder EC 200 is used for large systems and is able to satisfy a great variety of customer requirements. EC 200 is a modular system which can be built out for up to 16 terminals. By terminals is meant control units, PABXs or PAXs, intercom exchanges, contacts for the automatic release of preset alarm codes etc.

The cost difference between EC 100 and the simplest versions of EC 200 is held at the right level by the modular design and through the use of the bus technique with as much as possible of the electronics decentralized to the terminal boards.

Fig. 2
Control unit EC 110

The unit is connected by means of a mains plug to 220 V. At the rear there is a fixture for the whip aerial. Up to 100 persons can be paged with three different signal characters

Fig. 4

The central unit in the EC 200 system

The central unit contains a power unit and space for eight plug-in printed board assemblies. Up to 16 terminals can be connected to the EC 200 system: control units, exchanges, alarms. The simplest version with only one terminal requires only two printed board assemblies. In principle an extra printed board assembly is required for each extra terminal. The code system is so rapid that calling from all 16 terminals can take place at the same time without blocking in the form of busy markings. All board positions are identical, and hence it has been possible to connect all board contacts to a connection board with printed wiring. When more than eight board positions are required, the connection bords of several units are connected in parallel. EC 200 is a very flexible system that is able to meet the most diverging customer requirements

Due to the use of the bus system the board frames will be identical, irrespective of the complexity of the particular system, fig. 4. The board frames do not include cable arms and they can be manufactured rationally in long production series.

Development of the decoder

The earlier SRA paging system used call codes consisting of two or three consecutive tones. The decoder in the receiver was designed around a number of frequency selective circuits, LC circuits or frequency reed relays.

The work on the specification of the CONTACTOR system coincided with the development of the low current, low voltage C-MOS process for the manufacture of integrated logic circuits for wrist watches.

Investigations showed that a digital decoder in the C-MOS technique could give advantages as regards manufacture, storage, operational reliability, system facilities, speed and limited current consumption. SRA developed the digital circuit solution for the decoder, and the semiconductor manufacturer provided the manufacturing process. The circuit solutions are different for a decoder for systems for country-wide coverage and for local systems. Systems for country-wide coverage require a larger number of codes and greater speed, and they can also bear a higher cost than local systems, where the receiver price competition is intense. The major part of the work consisted of selecting a combination of code format and circuit solution that made possible a sufficiently reliable code transmission without making the circuit solution unnecessarily complicated. The development phases were as follows:

October 1970: Two different proposals for relatively simple decoders were sent to the semiconductor manufacturer with an invitation to tender.

February 1971: Offer received. Price satisfactory.

June 1971: A working decoder, more complex than those in the tender, has been connected up with standard C-MOS circuits. Field trials show that there is far too great a risk of false calls.

December 1971: New code format selected and an even more complicated decoder produced. Field trials and laboratory investigations demonstrate a high functional reliability. New invitation to tender.

March 1972: New offer received.

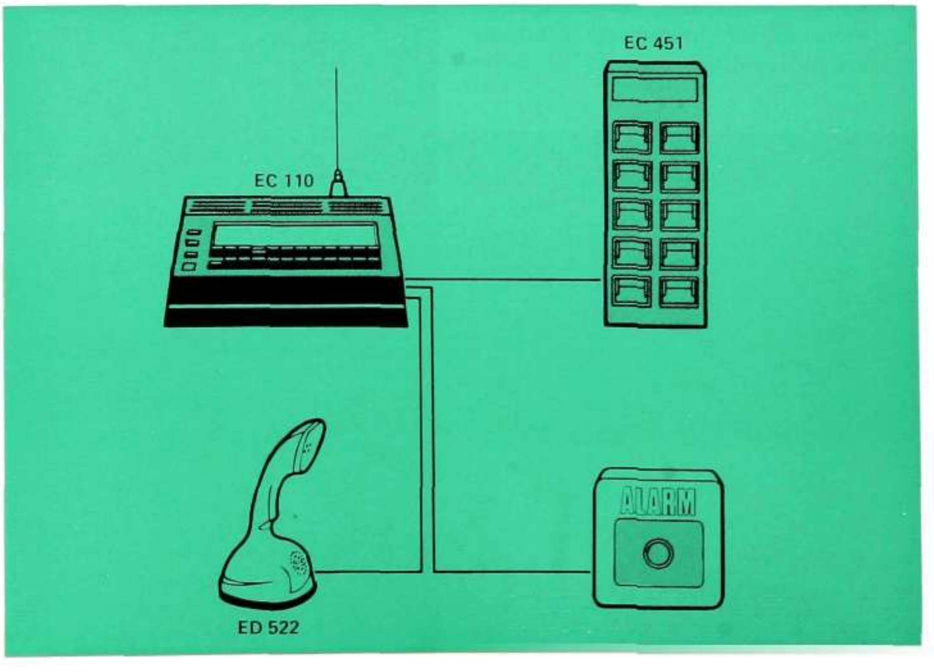

Fig. 3

Control unit EC 110—an inexpensive all-in-one system, which only needs to be connected to a 220 V mains wall socket

The figure shows various extension facilities, such as absence indication via charging unit EC 451, automatic release of a preset alarm code, and one-way or two-way speech connection with the pocket receivers

April 1972: SRA order development of 50 prototypes.

June 1972: Final specification and test data drawn up. Complete model produced.

April 1973: 50 prototypes obtained and evaluated. Operate extremely satisfactorily.

August 1973: SRA order series production quantities.

August 1974: Series delivery of the decoder commences.

February 1975: The first ERICALL CONTACTOR system delivered to a customer.

Code format

The code format selected is shown in fig. 5. The code consists of a start bit and 12 code number bits. The decoder is able to receive two different codes, an A-code and a B-code. In order to be able to differentiate between the A and B codes, the lengths of their start bits are different. The code number bits consist of binary ones or zeros, in what is known as biphase code. Both ones and zeros have a flank in the centre of the bit. The one has a negative flank and the zero has a positive flank. Fig. 5 shows the call code A 064 in BCD coded form, which is standard. The 12 code number bits give 1000 combinations with BCD coding and 4096 combinations with binary coding. Before the code can modulate the transmitter carrier it is first converted into tone frequencies, the high level being represented by frequency f 1 and the low level by frequency f 2. In fig. 5 this is indicated by the black and white fields.

A further four frequency pairs f 1/f 2 can be obtained, giving a total of 5,000 call codes of each type A and B with BCD coding, and 20,480 with binary coding. The number of codes is so large that there is no necessity for adjacent systems to use the same call code.

Decoder

The decoder contains more than 600 transistor functions and can be divided up into the following functional blocks:

Level detector, pulse shaper, clock oscillator, time counter with control

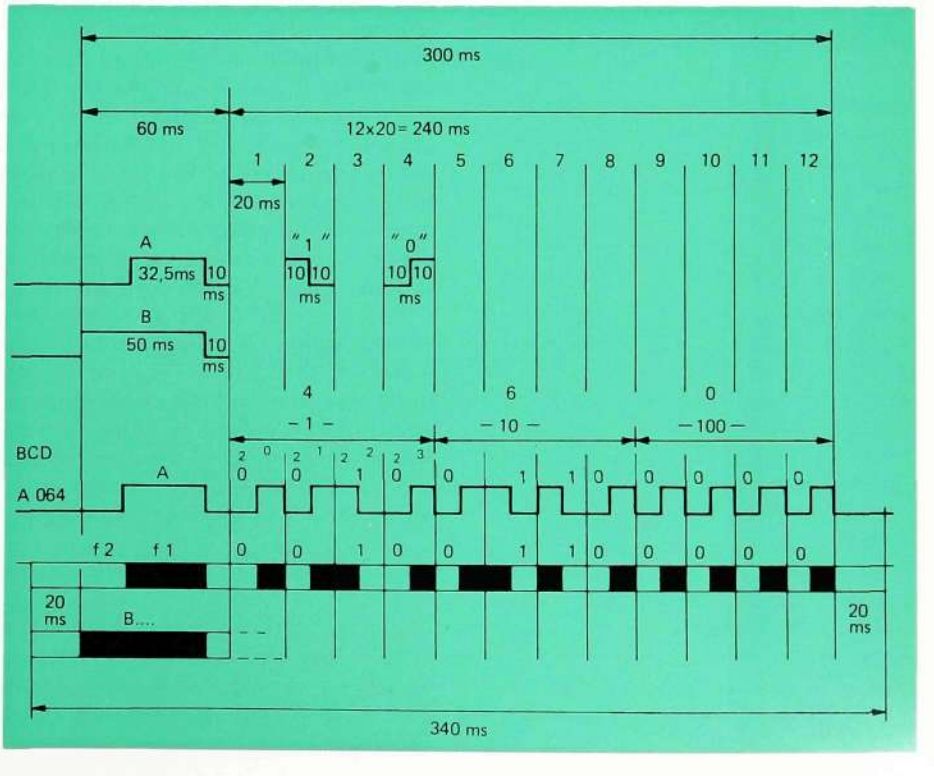

Fig. 5

Code format

The code is of 300 ms duration. The code repetition time is 340 ms, which means a maximum of 177 codes per minute. The first 60 ms of the code are used for a start bit, which can have two different lengths. This is used to differentiate between the two different types of codes, the A and B codes. Each receiver is programmed for an arbitrary A code and an arbitrary B code. The numbers of the codes are determined by 12 binary code number bits, each of 20 ms duration. The twelfth bit is the most significant. The binary code consists of what is called biphase code. The figure gives an example showing the call code A 064 in the BCD coded version. The two rows at the bottom show the tone-carried code. High level corresponds to frequency f 1 and low level to frequency f 2

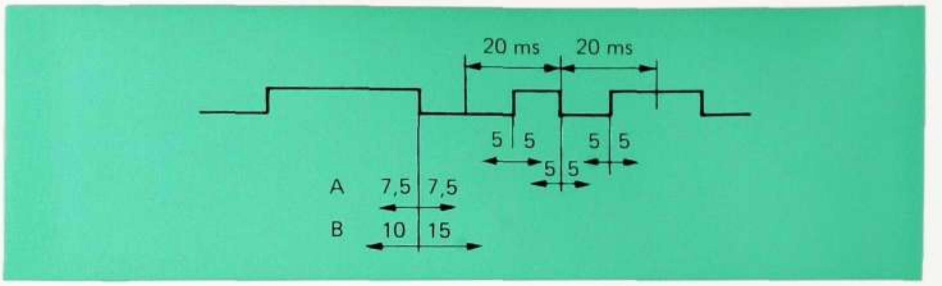

Fig. 6

Permissible deviation from the nominal code. The duration of the start bit may vary by ±7.5 ms for the A code and +15 ms and —10 ms for the B code. The flanks of the code number bits must not vary by more than ± 5 ms

circuits, memory for detecting the start pulse, memory for type of start pulse (A or B code), bit counter which counts the bits that are detected as correct, output and input stages to the code key, signal time circuit, which determines the length of the signal that is given when the correct code has been received, and signal circuits for audible and optical indication.

The level detector and pulse shaper are designed in such a way that the receiver can be subjected to impulsive noise with relatively long pulses without the code being recorded as defective.

The clock oscillator, together with the time counter and control circuits, constitutes the time reference for the decoder. The decoder measures the time between the flanks on the incoming code. Figure 6 shows the permissible time deviation from the nominal code. Thus for a pulse to be detected as a start pulse it must be between 25 and 65 ms, otherwise the decoder will be cleared. If the start pulse is between 25 and 40 ms it is detected as an A start pulse and if it is between 40 and 65 ms it is detected as a B start pulse. If a correct start pulse is received, the decoder continues to check the following code number bits in accordance with the code strapped in the code key for the A and B codes respectively. Each code key can be strapped for one arbitrary A code and one arbitrary B code. The flanks of the code number bits must lie correct within ±5 ms, otherwise the decoder is cleared. The clock oscillator has a stability of ±1.5% over the temperature range −10° C to +55° C and with a feeding voltage within the range 2.2 V to 3.0 V. A stability of ±20% is required in order to be able to detect the code correctly, and thus the margin is good. The external components of the pulse shaper are not critical either, and can be allowed to vary by as much as ±20%.

The signal duration is normally 200 ms.

The signal circuits have a tone signal output, and two outputs for lamp or light emitting diodes to indicate whether it is an A-code or a B-code that is received.

Safety against interference

Noise interference at the sensitivity limit

The sensitivity of the receiver is better than 30 μV/m. Measurements of the risk of false calls have been carried out with a code in which the last code number bit was in error, i.e. it was only necessary for the noise to convert this last bit in the code in order that the false call would be accepted as the correct code. No false calls could be obtained above and below the sensitivity limit.

It was only just on the lower edge of the sensitivity limit, where about 50% of all correct calls are lost, that 0.1—0.2% false calls were obtained. The average risk is insignificant that the receiver in a local system will be exactly on the lower edge of the sensitivity limit when a call comes in. A figure of 1 in 10^6 as the practical risk for false calls would be no exaggeration.

Measurements have also been carried out with codes in which all the code number bits have been correct, but the A bit has been replaced by the B bit and vice versa. The A code can never give rise to a false B code. The B code, on the other hand, can give rise to a false A code, but only just on the lower edge of the sensitivity limit. The practical risk that a B code will be mistaken for an A code is less than 1 in 10^4. The risk can be avoided entirely if the number of the B code is separated from that of the A code. The B code is normally used for group calls or automatic alarm calls, and is not used very frequently.

The only result of a false call being received will be that a single 200 ms bleep will be heard, since the sending out of alarms is controlled by the encoder. A single bleep cannot be mistaken for paging.

Impulsive noise

Impulsive noise cannot cause false calls, it can only suppress real calls. The design of the pulse shaper in the decoder is such that the sensitivity to impulsive noise is very low.

Interference from adjacent paging systems using the same radio frequency

Owing to the large number of codes

Fig. 7

Receiver EC 400/410. The receiver has an attractive design and can be supplied in four different colours, black, yellow, green and beige. At the top can be seen the listening button and the lamp cap.
The size of the receiver is 16.5 (28) × 55 × 93 mm and its weight 104—112 grammes

Fig. 8

The receiver EC 400/410 with talk-back transmitter. The unit consists of a standard receiver with the clip replaced by the talk-back transmitter

available there is no risk that adjacent systems must be allocated the same code numbers.

The start bit ensures that code number bit no. 1 is always received as no. 1 and, for example, bit no. 5 as bit no. 5. This eliminates the risk of false calls through mixing of the codes, i.e. the possibility that a part of a code from one system and a part of a code from another system could simulate a real code.

Due to the accurate time supervision and the fact that each bit consists of both a high and a low level, neither tone codes from other systems nor beat tones obtained through transmitter interference can cause false calls. The only result of these forms of interference is that whole bits may have either high or low level.

Adjacent paging systems using the same radio frequency can, however, give rise to blocking of transmitted calls if the field strength is sufficiently high. Blocking will not occur if the field strength of own system is 6 dB higher than that of the adjacent system. Blocking manifests itself in the form of lost calls or limping signal characters, since the signal character is controlled by the encoder. Owing to the fact that the system is a local one, the field strength is, in general, automatically higher than that of any adjacent system. The best remedy for blocking between systems that are very close to each other is radio frequency separation, which is possible in most countries, and/or to place the aerials as low as possible.

Receiver

Attractive design — four different colours

The small pocket receiver has an attractive design and can be supplied in any of four different colours; black, green, yellow and beige, fig. 7. The standard version includes facilities for speech reception. A receiver with extra high audio output can be supplied for use in noisy environments. An auxiliary unit can be provided which contains lamps or light emitting diodes for giving an optical signal. The receiver can very easily be equipped with a talk-back transmitter which is mounted in place of the clip on the front of the receiver, fig. 8. The receiver can also be provided with small sub-units for special functions, which for example make possible a receiver-controlled alerting signal or talk-back transmission only after the code call has been received.

Two versions of the radio part

There are two versions of the receiver, EC 400 and EC 410, which have different radio parts. The EC 400 is a relatively wideband superregenerative receiver and EC 410 is a narrow-band superheterodyne receiver. EC 400 costs less than EC 410. In most cases the wideband reception is not a disadvantage, since in the local system the field strength of the system is usually greater than that of any other system in the vicinity. Both the receivers have the same size and facilities, and have a guaranteed sensitivity of better than 30 μV/m.

Specially manufactured integrated circuits

Apart from the previously described decoder, the receiver contains another specially manufactured integrated circuit, which was designed by SRA and manufactured by AB Rifa. The circuit is a linear LF circuit and contains a voltage regulator, limiter for the code signal and speech and tone signal amplifiers.

The temperature compensated regulator gives the receiver constant performance characteristics and data for different types of batteries, for the whole of the battery life. Mercury batteries, chargeable NiCd accumulators or carbon-zinc batteries may be used.

The limiter, which has a large gain and a well defined duty cycle, feeds a filter, the output signal from which is detected by the level detector in the decoder. For signals into the limiter from the radio system of between 1 and 40 mV, the output signal from the filter, relative the threshold of the level detector, varies by only ±1.5 dB for feeding voltages between 2.2 V and 3.0 V and for temperatures in the range —10° C to +55° C. The threshold value is —8 dB referred to the filter peak voltage above earth.

The speech amplifier is connected in when the listening button is depressed.

The speech signal from the radio system is amplified by about 30 dB before it is fed to the audible indicator device at a level of approximately 10 mW. The tone amplifier amplifies the 3.2 kHz signal from the tone signal output of the decoder. The strength of the tone signal is 68 dBA (71 phone) at a distance of 300 mm and 87 dBA (92 phone) in the case of the receiver with the higher audio output level.

Operating time of 2500 hours

The current consumption of the EC 400 receiver is only 240 μA and that of the EC 410 receiver is 650 μA, not including the alerting signal. When an alerting signal is given the tone signal draws 20 mA, tone and lamp 90 mA, tone and light emitting diode a maximum of 50 mA and speech 15 mA.

If each receiver (EC 400) is used for 10 hours every day, and on average gets five calls with 10 bleeps per call, the energy consumption for tones and lamps will be only 10 per cent of the consumption in the standby condition. It is, however, possible that the high lamp currents reduce the energy content of the batteries by more than the actual energy output. Practical tests are being carried out. Theoretically, the mercury batteries should last 3200 hours with tone signalling. SRA give 2500 hours, i.e. one working year based on a normal working day. For EC 410 the operating time given is 1000 hours.

Easily replaced code key

The code key consists of a connector and a variable printed conductive pattern. Each code key can be programmed for one A code out of a possible 4096 combinations, and one B code, also out of a possible 4096 combinations. The code key can very easily be moved or exchanged, fig. 9. This means that, for example, the make up of groups can easily be changed and if a receiver should need to be repaired the code key can be moved to a spare receiver while the repairs are being carried out. The spare receiver then automatically gets the correct identity. A marking label (not shown in figs. 9 and 10) with the numbers of the A and B codes is fixed on a transparent label holder on the code key, and thus goes with the code key when it is changed or moved to another receiver.

Simple mechanical design

The receiver is built up on a printed board and has no wire connections at all except the connecting wires for the audible indication device (fig. 9). The receiver is held together by a single screw. At the bottom of the receiver there are four metal contact strips for external connection to the charging voltage of the charging rack and the absence indication. The item, series and code numbers can be seen through a window in the case, fig. 10.

Control unit EC 110 — an inexpensive all-in-one system

EC 110 is a small and straightforward

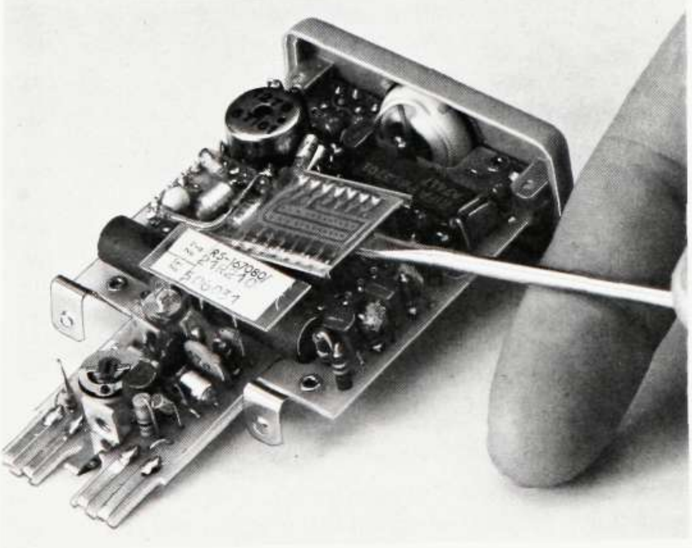

Fig. 9

Receiver EC 400

The electronic circuits in the receiver are robustly built up on a printed board assembly. The receiver contains two specially manufactured integrated circuits, the LF circuit from AB Rifa and the decoder circuit. The decoder circuit has 28 legs and is placed on its back on the main board with the legs sticking up through a sub-board on which the remaining components in the decoder are mounted. The figure shows the removal of the code key. The code key is secured direct on the legs of the decoder, with the sub-board lying in between

Fig. 10

Receiver EC 400/410

The receiver is held together by a single screw through the battery cover. The batteries are fitted in a special compartment in the sleeve shaped cover. When changing batteries the cover is prevented from sliding off the printed board assemblies by the catch that can be seen in the cut-out between the protruding terminal strips

system (fig. 2). A total of 100 A codes and 100 B codes can be selected from the keyboard. The 100 codes are selected from among a possible 8000, so that the risk of code interference between different systems is negligible. Three different signal characters cover most of the signal identification requirements.

The call is reset automatically after 1 to 11 preset repetitions of the call code. It can also be reset manually by the operator.

Full flexibility for group calls, without extra equipment

The B codes are normally used for group calls, since each receiver in the standard version is able to receive an arbitrary A code and an arbitrary B code. Thus EC 110 allows up to 100 groups with an arbitrary number of participants in each group.

Speech

One-way speech from the control unit to the receivers is made possible by the addition of a plug-in board and a microphone in the control unit. When two-way speech facilities are required between the control unit and the receivers, the receivers are equipped with talk-back transmitters, and a talk-back receiver ED 500 is connected to the control unit, together with an "Ericofon" hand microtelephone.

Speech between receivers

If the system is equipped for two-way speech, the operator can, when necessary, connect the control unit for relay traffic without having to use extra equipment. This makes possible speech between two receivers that are equipped with talk-back transmitters. A lamp in the control unit blinks as long as the conversation continues. Facilities are also provided for monitoring such calls.

Automatic alarm calls

By the addition of a plug-in board a call code can be preset for automatic release of an alarm. This call does not interfere with the calls sent out from the keyboard, the two types of calls being sent out alternately. However, alarm calls have priority over speech transmission.

Absence indication

The charging rack, the primary task of which is to hold the accumulators charged, can also be used for absence indication. A called receiver which is placed in the charging rack causes the control unit calling signal lamp to blink, and in this way indicates absence. The indication is given by means of different lamps, depending on whether the absence indication is in response to a call from the keyboard or an alarm call. The receivers can be placed in any one of the charging racks.

EC 100 for large areas

If the paging system is to cover a large area, the EC 100 system is to be preferred. The system has the same facilities as EC 110 but it has a separate transmitter and an outdoor aerial.

System encoder EC 200 — a modular system for up to 20,000 receivers and 16 terminals

The basic version of EC 200 is extremely simple, but thanks to the modular design the system can be extended for up to 20,000 receivers, with simultaneous calling from a maximum of 16 terminals, and it can be adapted to meet widely divergent paging requirements. The normal capacity of the system comprises 1000 receivers. The terminals may consist of control units, alarm contacts, PABXs, PAXs and intercom exchanges.

Examples of the number of terminals

A paging system EC 200 can have two control units, be connected to an intercom exchange and have three automatic relay contacts for production supervision, which together constitute six terminals.

Basic design and function

The system has a central unit (fig. 4), which can be equipped with a number of boards depending on the system requirements. The rear edge contacts on the board are connected to the common bus for the central unit. The respective terminals and any peripheral equipment are connected to the front edges of the boards. The connections are made via a plug-in type terminal strip, fig. 11.

Each system has a *sequence giver board,* which can be said to constitute the coordinator for the system. All codes are sent by or via the sequence giver to the transmitter(s). The sequence giver contains oscillators that determine the duration of the code bits and the frequencies f 1 and f 2 of the tone-carried code (fig. 5).

The terminals have separate types of *number giver boards* (there are three number givers per board for the alarm contacts).

The number giver boards collect information from the respective terminal and convert it to a suitable form. They then pass on the information to the sequence giver when the sequence giver requests this. The number givers also contain memories for absence indication and acknowledgements, and provide the respective terminal with lamp indications and tone information. Number givers that require priority during speech can easily be strapped for this.

Fig. 12 shows, in principle, how different number givers are scanned by the sequence giver. The rotating arrow in the middle symbolises the sequence giver that scans the different number givers. The panels in the outer circle symbolise the positions for the 16 number givers, of which six are occupied. Terminals 1 and 6 are alarm contacts, 2 and 3 are multiwire control units, 4 an intercom exchange and 5 a telephone exchange.

The sequence giver stops for a certain time at each terminal (number giver) that has start information, and leaves out the remainder. Fig. 12 indicates that only 1, 4 and 6 are scanned, so that the passage time for the remainder is 0 seconds. The time that the sequence giver stops at each terminal depends on the signal character that the terminal has selected on that occasion. One or two bleeps takes 0.68 seconds, three or four bleeps 1.36 seconds. Each time the sequence giver passes the same terminal the signal sequence is repeated in the called receiver. The number of times that the scanning is to be repeated, before automatic scanning is stopped, can be set up individually for each terminal by strapping on the number giver boards. Stop can also be ordered manually from the terminal.

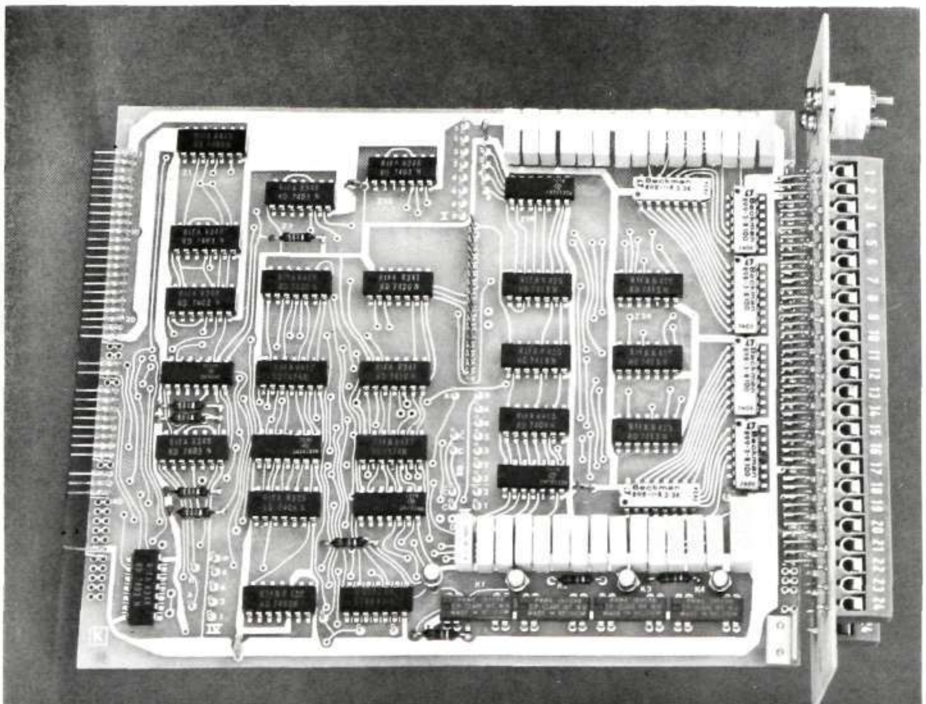

Fig. 11

Number giver board EC 264 for a PABX, PAX or intercom exchange connection

The row of contacts to the left are connected to the central unit bus. The contact row to the right is provided with a removable screw-type terminal block for connection to the exchange

Fig. 12 indicates that terminal 1 sends 4 bleeps without automatic cut-off, terminal 4 sends 2 bleeps with cut-off after three times and terminal 6 sends 1 bleep six times.

In order that the time between repetitions of the call code should not vary too much, since this is dependent on the number of terminals that are busy at the same time, any desired number of the most frequently used number givers can, if necessary, be included in an "inner loop". The sequence giver then stops at each number giver position in this inner loop for at least 0.68 seconds even if there is no start information and even if the number giver is missing. With, for example, four number givers in the inner loop the cycle time will be 3—4 seconds. If any of the less frequently used terminals that are not included in the inner ring must be scanned, the cycle time will be extended somewhat.

Simultaneous calls from 16 terminals without busy marking

The system normally has 3—5 terminals. This gives a cycle time of 3—5 seconds and a mean access time of about 2 seconds. Even in cases where a system has 16 terminals it is unusual for more than three or four to be in use at the same time. In such cases most of the terminals usually consist of alarm contacts that are not used very often. However, if all 16 terminals are used frequently, the sequence giver can very easily be changed so that each terminal does not require more time than the signal sequence needs, that is to say 1 bleep 340 ms, 2 bleeps 680 ms and so on. If the short signal characters are selected for terminals that are used most often, it is possible to reduce the average time per terminal to less than 0.6 seconds. For the case when all 16 terminals are calling at the same time this will give a cycle time of 10 seconds and a mean access time of 5 seconds.

The system is so fast that there is no necessity for a priority system or busy indications.

Control unit EC 281/282

Externally, and also from the point of view of the user, these control units are similar to control unit EC 100. As in that unit the EC 281/282 units have full flexibility as regards group calls and they can be equipped for absence

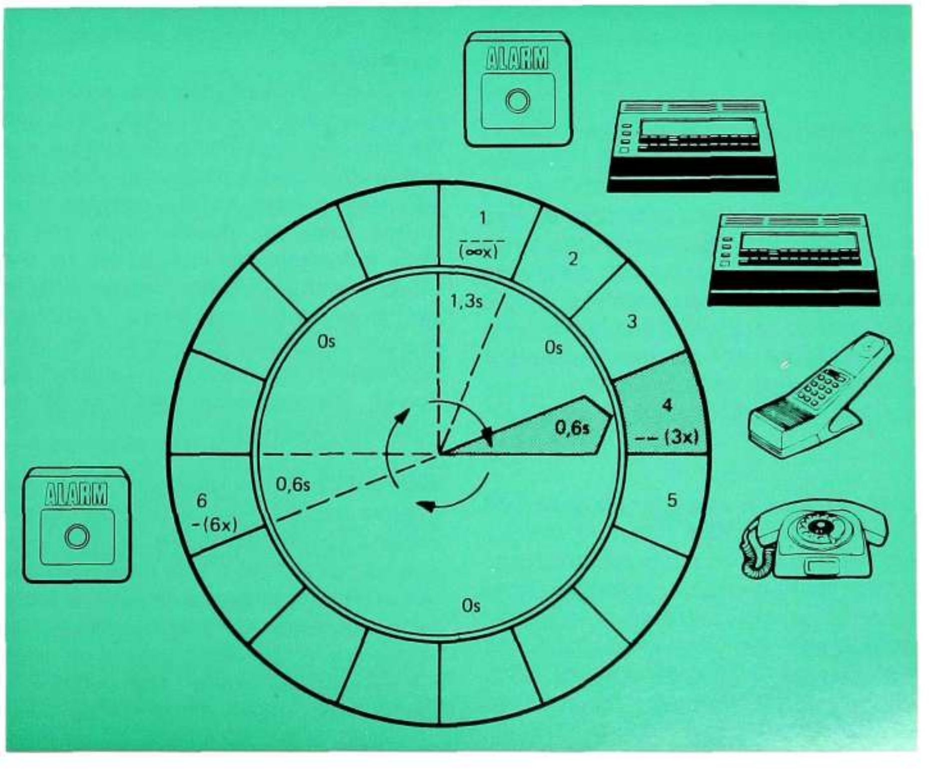

Fig. 12

Diagram showing the principle of scanning different terminals in the EC 200 system

The arrow in the middle symbolises the sequence giver and the panels in the outer ring symbolise the 16 number givers, of which six are occupied

indication, one-way or two-way speech, tone acknowledgement and relay traffic switching.

EC 281 permits the calling of up to 100 receivers with three different signal characters, whereas with EC 282 a total of 1000 persons can be called with five different signal characters. Any of the eight possible signal characters may be used.

A multiwire cable is used for connecting the number giver to the control unit, and the length of the cable can be a maximum of 750 metres. If the distance needs to be greater than this, a type of number giver can be used, to which a normal telephone set can be connected as the control unit. The connection is then via 2-wire. (Not to be confused with the exchange connection.)

Alarm contacts
Alarm contacts are connected on a 2-wire basis to an alarm number giver. The contacts release a preset code having an arbitrary signal character (one of eight possible). The contacts can have a make or break function. Calling continues until the contacts return to their normal positions.

PABX, PAX or intercom exchange connection
If a PABX, PAX or intercom exchange is connected as a terminal, calls can be initiated from each telephone set connected to the exchange. The person paged goes to the nearest telephone, dials an identity digit, and is then automatically connected to the telephone that initiated the call. This is the most usual procedure. Facilities are also available for one-way or two-way speech via radio to the pocket receiver. The exchange can also be an intercom exchange.

The exchange connection does not present any problem as long as the exchange is only expected to deal with one call at a time. If it is necessary for the exchange to deal with several calls simultaneously, the paging unit in the exchange is provided with memories for several call codes. The content of the memories can either be sent out cyclically from the exchange through one single terminal connected to one single number giver, or the exchange is also provided with a terminal for each memory, in which the code information is available the whole time, and in which each terminal and thus each memory in the exchange is connected to its own number giver. In the former case the cyclic reading of the memories is controlled either by an internal clock in the exchange or by means of stepping pulses from the paging equipment.

The exchange connection board in EC 200 is prepared for adaption to all the described versions, but only the version with a terminal (number giver) per call possibility enables the EC 200 system to utilize its full capacity without priority arrangements and busy indications.

Speech and talk-back transmission from all terminals without risk of confusion
When it is desired to transmit speech from, for example, a control unit to a pocket receiver, it is first necessary to send a call code with a special character, which indicates in the pocket receiver that speech is to follow. As soon as the control unit starts to send this special code the speech channel is booked and no other control unit can break in by beginning to send the code for a succeeding speech message. Since the speech channel is booked, the talk-back channel for tone acknowledgement or talk-back is connected direct to the control unit in question. The outgoing speech channel is connected up when the Ericofon is lifted up or the call counter for the number giver has gone out. The conversation may now continue for a limited time but the call is cleared automatically after a warning tone lasting five seconds.

During the paging that precedes the speech a warning lamp is lit in all control units. This makes it possible to complete all code calls in progress before the Ericofon is lifted and all code sending is interrupted. (If necessary, code sending from certain number givers, for example alarm, can be given priority over speech.) Since all code sending must cease during speech via radio, speech traffic reduces the traffic considerably in large systems. Consequently, in principle, speech should not take place via the paging system but rather via a communication medium that has a high speech channel capacity, such as a PABX, PAX or intercom exchange.

Test board
A special test board is connected to a control receiver. The test board checks that codes are sent out and that the transmitters are operating.

Transmitter

Apart from the 0.5 W transmitter built into control unit EC 110, there are also separate 0.5 W and 5 W transmitters. A 50 W power stage is also available for those cases where such high power is permitted.

Several transmitters can be installed if it is found that one does not provide sufficient coverage. Calls must then be sent out alternately over the different transmitters in order to avoid interference between the standard transmitters. This may reduce the calling speed, and this procedure is unsuitable in connection with speech transmission, since it is not possible to know which transmitter the person paged happens to be near. Consequently SRA have developed a 5 W transmitter which is synchronized through phase locking with a low frequency reference frequency. Such transmitters can transmit simultaneously without risk of interference.

Other equipment

The list below includes some of the additional equipment for the ERICALL CONTACTOR:
— charging rack for 10 receivers
— charging unit for 1 receiver
— talk-back receiver with and without tone selective opening
— talk-back transmitter for tone, speech or tone and speech.

Summary

ERICALL CONTACTOR is a wireless paging system for local use in the frequency range 25—44 MHz.

The heart of the system is a specially developed low-current digital decoder, which is included in each pocket reiver.

The pocket receiver contains two specially developed integrated circuits, which has considerably reduced the number of components. The small number of components, together with the fact that there are no stringent tolerance requirements for the components, guarantees high reliability.

The identity of each receiver is determined by a plug-in type code key, which when necessary can be moved to another receiver or replaced.

The receivers have an attractive design and can be supplied in four different colours.

When optical indication is included, the receivers can differentiate between up to eight different signal characters.

On the "fixed side" two systems are offered, the control unit EC 100/110 and the system encoder EC 200.

The control unit EC 100/110 is a straightforward and inexpensive fixed equipment which covers most requirements.

In the basic version the system encoder EC 200 is a straightforward system, which thanks to its modular design can be extended and adapted to meet most paging requirements. When fully extended, the system can serve up to 20,000 receivers. Calling can take place simultaneously from up to 16 terminals (calling positions). The terminals can consist of control units, alarm contacts, PABXs or PAXs and intercom exchanges.

Full flexibility for group calls is standard for both EC 100/110 and EC 200. Moreover the systems can be provided with peripheral equipment that permits absence indication via the charging rack, one-way and/or two-way speech, tone acknowledgement or talk-back and speech connection between two pocket receivers (relay traffic).

Characteristics of Voice-Switched Loudspeaking Telephones

Olle Larsson

The article is a revised version of a paper read at the 7th Symposium on Human Factors, held in Montreal during September 1974, at which, among other things, the effect of room acoustics on the characteristics of voice-switched loudspeaking telephones was discussed and also the choice of frequency response curves and levels for sending and receiving.*

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Summary

Study of human behaviour during conversation tests with loudspeaking telephones, discussions and comparisons with investigations published earlier, lead to the following conclusions regarding these telephone sets.

a) Loudspeaking telephones designed using advanced modern techniques can give a transmission quality at least as good as that of normal handset telephones. For extremely adverse room acoustic conditions such as echoing rooms or very high room noise, there are, however, certain fundamental physical limitations. In order to obtain a guaranteed good transmission quality a disciplined use of the telephone set is also necessary, for example correct speaking distance. The speaking distance that is recommended (1/2 m approx.) is the distance that the user himself chooses spontaneously in conversation tests.

b) The acoustic voice level is 4—5 dB higher when using a voice-switched loudspeaking telephone than when using a telephone with the normal handset.

c) Methods for measuring levels and intelligibility which have been developed for measuring handset telephones cannot be used without modification for measuring loudspeaking telephones. One of the reasons for this is the difference in the behaviour of the user, who, for example, unconsciously speaks louder when using a loudspeaking telephone than when using a handset telephone. Another reason is that intelligibility tests are often simplified and do not simulate the true conditions of a normal conversation.

d) With short lines a sending reference equivalent (SRE) of about +15 dB with a loudspeaking telephone gives the same output level as a handset telephone with SRE ≈ +5 dB, i.e. the same output level as most handset telephones have.

Characteristics of the loudspeaking telephone

During discussions about the characteristics that a loudspeaking telephone should have, extremely divergent views are often put forward as to which characteristics are most important. Debaters often come with very detailed requirements, but the following important fundamental factors are often forgotten:

The construction and characteristics of a loudspeaking telephone are always a compromise between the ideal characteristics and the basic physical laws, between available techniques and costs. They are also dependent on the relation environment-individual.

The following requirements have occasionally been put forward by prospective users: "The instrument must be in one unit and stand on a table. The user must be able to move freely in the room, for example with his back to the telephone, and the transmission quality must be just as good as with a handset telephone. It is the engineer's job to achieve this." Have such requirements any realistic foundation? Can such a telephone set be designed? Today it is perhaps perfectly possible to solve the technical problems involved. The cost of such a telephone set would, however, be very high and it is doubtful whether there would be more than a small demand for such a set. It is therefore more appropriate to design a telephone set at a reasonable cost, an instrument that can be an aid in connection with normal office work. It is then important that the user is instructed in how the instrument is to be used and at the same time is given the correct reasons for this. The user must also be instructed about the limitations of the set in, for example, environments prone to echoes and with high room noise levels, and he should also be told the reason for these limitations.

* By voice-switched loudspeaking telephone is meant a telephone set that automatically opens the sending channel when sending and introduces attenuation in the receiving channel. When receiving speech the sending channel is attenuated in a corresponding way.

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When discussing transmission quality of loudspeaker telephones, the handset telephone should always constitute the reference. The reason for this is quite naturally that for many years to come the most common type of instrument will be the present handset telephone. Furthermore this instrument is in use throughout the world and its characteristics are well known. Consequently loudspeaking telephones must be given such characteristics that they can work well together with the handset telephone. For example, the two types must have equivalent sending characteristics.

For several reasons the requirements of handset telephones cannot be applied direct for loudspeaking telephones. Some of the reasons for this are that:

— the acoustic speech levels (voice levels) are different for the two types of instruments

— in the case of loudspeaking telephones an increase in the talking distance creates problems in the form of a poorer signal/noise ratio and more pronounced reverberations, and therefore influences the design of the sending channel

— during normal conversation handset telephones do not give the same sending level to the line as during internationally recommended reference equivalent measurements.

Consequently it appears to be realistic to specify the characteristics for a loudspeaking telephone on the basis of the functional characteristics that are wanted in practice. Instead of directly applying the handset telephone requirements for loudspeaking telephones, as very often happens today, the loudspeaking telephone should be treated quite separately and have its own specification and requirements.

In the following parts of this article some special problems of loudspeaking telephony are discussed on the basis of conversation tests carried out at LM Ericsson's telephone laboratory. A comparison is also made with other published investigations.

The influence of room acoustics

Signal/noise ratio when sending
Owing to the long distance between the talker and the microphone in the case of the loudspeaking telephone (Lst), the sending sensitivity, measured as a line voltage for a certain sound pressure, needs to be in the region of 25 dB higher than in the case of a handset telephone (Ht). If the microphones for both Lst and Ht are non-directional, i.e. pick up sound from all directions, the noise is amplified by about 25 dB more in Lst. Consequently we obtain a 25 dB worsening of the signal/noise ratio and as a result even a low room noise level, which is not heard in Ht, is clearly audible in Lst.

One way of improving the signal/noise ratio is to use a direction-sensitive microphone. However, this limits the usefulness of the loudspeaking telephone because the speaker must always be in the correct direction in relation to the instrument. The idea behind the loudspeaking telephone is that several persons sitting round the instrument should be able to take part in a telephone conversation. Thus the directional microphone does not have only advantages compared with the non-directional one.

Reverberations
Despite certain problems with signal/noise ratio it is, however, reverberations that cause the greatest quality deterioriation of speech from a sending loudspeaking telephone. M. B. Gardner[1] has described the importance of room acoustics for speech quality. Gardner found that even in a room with good acoustic properties the distance between the speaker and the microphone must be less than 25—50 cm if reverberations are not to be perceptible. When designing a loudspeaking telephone, efforts are made to place the microphone so that reverberations are minimized, but no significant improvement is obtained in this way.

Why, for that matter, should there be a problem with reverberations in the case of Lst and not with Ht? In the previous part of the article the difference in signal/noise ratio was discussed, and the reasoning used there applies here also. The direct sound represents the signal and the reverberations the noise. When two people are holding a conversation face to face in the same room there is seldom any reverberation problem. The reason for this is quite simply that with the help of our two ears we can detect and hear the signal we want to hear, and we do this without thinking about how we do it.

The problem of reverberations is not unique for loudspeaking telephony. Anyone who has attempted to make a recording using a non-directional microphone is bound to be aware of this problem. The difficulties encountered when recording are usually overcome by using one or more of the following aids: Short distance between speaker and microphone, microphone with very marked directional properties, multichannel recordings using several microphones at the same time and at short distances, and also studios with good acoustic properties. However, none of these remedies have a direkt application in the case of loudspeaking telephones for office use.

Research work is going on at Bell Labs with centre clipping and the use of several microphones in order to reduce reverberations[2]. However, at present the electric circuits required are far too advanced for these methods to be economically applicable in a normal loudspeaking telephone for office use.

Frequency response

Sending

Is there any reason for choosing a different frequency response curve for Lst than for Ht? The difference in the previously discussed speaking distance results in a greater dependence on room noise and room acoustic conditions, and this dependence must therefore have a certain influence on the choice of frequency response curve.

The most usual types of noise seem to come from traffic and ventilation systems[3]. These types of noise have a frequency characteristic which approximates very closely to the Hoth spectrum. Modern office rooms are often constructed with hard walls and without soft carpets on the floor. Consequently there is often a very long reverberation time at low frequencies. For this reason an improvement in quality can be obtained by suppressing frequencies under approximately 300 Hz[4].

Another question that arises is: What levels shall be used for the different frequencies in the telephony band of 300—3400 Hz, i.e. what frequency response curve should be used? In-

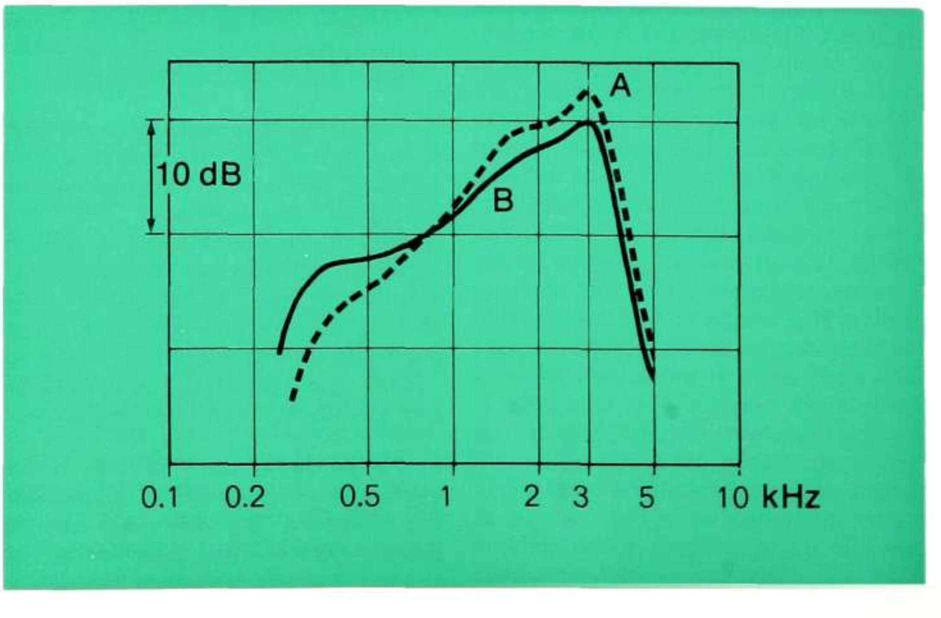


Fig. 1

Frequency response curves for sending from a loudspeaking telephone. Curve A rises by about 6 dB per octave and curve B by about 3.5 dB per octave

vestigations reported by N. Gleiss of the Swedish Telecommunications Administration show that with a short speaking distance for sending (in principle Ht), and listening in a receiver with a flat frequency response, a flat response curve or one that increases slightly towards the higher frequencies is preferred[5].

It can be shown theoretically that with the type of room noise usually encountered, the intelligibility can be improved by emphasising the higher frequencies. However, the signal/noise ratio is not improved by emphasising a particular frequency band, because the frequency characteristics of the noise and speech are very similar. If the high frequencies are emphasised too much, there is a risk that the speech will sound shrill and unnatural.

The following listening tests were carried out at LM Ericsson's telephone laboratory in order to obtain additional data required for new designs of Lst.

Two sending frequency response curves were compared, see fig. 1. The reverberation time in the sending room (ordinary office room) was 0.5 s. The room noise level was 35 dB(A). Recordings of Lst transmission with five female and five male speakers were used. The listening tests were carried out using a handset telephone with a flat frequency response over the frequency band 200—3400 Hz. The listening level was 80 dB [mean value of dB(A) and dB(B)], i.e. the preferred listening level when listening with one ear to a telephone receiver[6]. Ten male and ten female listeners took part in the listening tests. No voice switching was used during the test. Despite the fact that a 2×2 km local cable was included, the steeper curve A was judged to give too shrill a sound and curve B was judged to be considerably better (95 % confidence level).

Some time later another investigation was carried out in the Swedish Telecommunications Administration Laboratory. The report of the investigation, which took place during April 1974, has not yet been published. Naturalness and intelligibility were investigated and the tests were carried out in two rooms with different reverberation times, and two different sending frequency response curves were used. A loudspeaker with band limiting and with a flat frequency response over the band 200—3400 Hz was used for listening. One of the sending frequency curves was flat (frequency independent) and the other increased approximately 6 dB per octave from 200 Hz to 3400 Hz with a sharp cut-off at 3400 Hz. Tape recordings were made via a condenser microphone and with a speaking distance of one metre. The recordings and listening tests were carried out both in an anechoic room and in a room with reverberations. In the latter room the reverberation time varied almost linearly with frequency from 2 seconds at 150 Hz to 1 second at 3400 Hz. No voice switching or cable attenuation was included, table 1.

As regards naturalness the flat curve was judged to be the best in all the tests. Intelligibility appeared to be affected only to a very slight degree by the frequency response curve. It was only when recording in the room with reverberations that there was any increase in intelligibility with a 6 dB/octave rising frequency response curve.

In principle the Telecommunications Administration investigation gave the

Table 1
Speech investigation carried out by the Central Laboratory of the Swedish Telecommunications Administration

SENDING		RECEIVING	
Frequency response curve	Room type	Frequency response curve	Room type
flat	anechoic	flat	anechoic
flat	anechoic	flat	reverberations
6 dB/octave	anechoic	flat	anechoic
6 dB/octave	anechoic	flat	reverberations
flat	reverberations	flat	anechoic
flat	reverberations	flat	reverberations
6 dB/octave	reverberations	flat	anechoic
6 dB/octave	reverberations	flat	reverberations

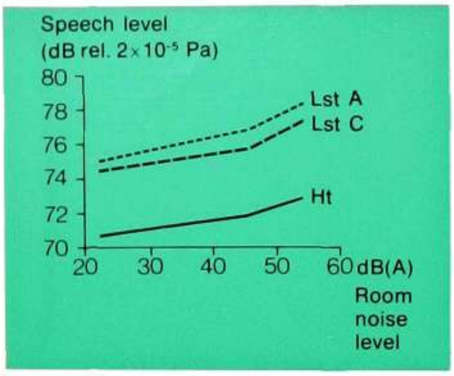


Fig. 3

Speech levels for connections Lst A—Ht, Lst C—Ht and Ht—Ht, measured in accordance with fig. 2.

Speaking distance is shown in fig. 8

The standard deviation was 2—3 dB

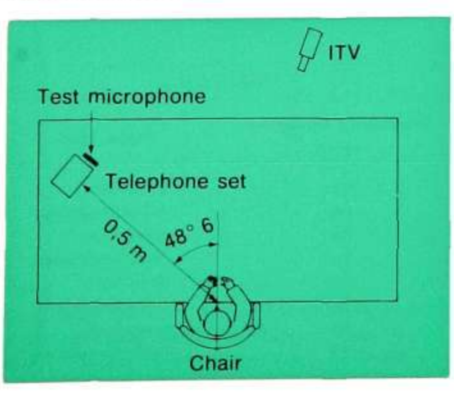
Lst A ERICOVOX DBE 100 (Manufactured during the period 1958—1975 with small modifications)

Lst C ERICOVOX DBE 200 (Ready for production 1975/76. Combined handset and loudspeaking telephone)

Fig. 2

Conversation tests carried out by the Swedish Telecommunications Administration and LM Ericsson

In the LM Ericsson tests those taking part in the tests were office staff without any particular interest in telephone sets. A furniture catalogue was available to stimulate conversation. As a result there was no difficulty in getting a flowing conversation



same result as the LM Ericsson investigation. This means that the sending frequency response curve should rise towards the higher frequencies in order to compensate for the capacitive attenuation of the most usual local cable line lengths.

Speech levels and sending sensitivity

What is the difference in the behaviour of a user of Lst compared with a user of Ht? How loud does he speak? It is necessary to know this when determining a suitable sending sensitivity, so that a suitable level is obtained on the line.

The quantity used nowadays is the sending reference equivalent (SRE), both for handset and loudspeaking telephones. We know, however, from previous investigations[7, 8] that people speak louder when using a loudspeaking telephone. We also know, from work in CCITT SG XII, that in the case of an Ht conversation the handset is not used in such a way that the SRE value adequately describes what output levels are obtained in practice.

One way of tackling the problem is to give up the present methods of measuring and specifying data entirely, and instead attempt to specify what we really want to achieve. For example, it is the aim that the listening quality in Ht shall be equally good irrespective of whether Lst or Ht is used for sending. One of the main factors affecting quality is the level. Consequently we should try to find a way of specifying the level so that in practice we get the same level when sending from an Lst as we do when sending from an Ht.

Conversation tests

In order to obtain more information about speech levels and output levels a so-called free conversation test was carried out in LM Ericsson's telephone laboratory.

Some tests were made at the same time at the Central Laboratory of the Swedish Telecommunications Administration. The tests included three different types of voice-switched loudspeaking telephones and a standard telephone set, fig. 2.

The following types of connections were included in the tests: Ht—Ht, Lst—Lst and Ht—Lst. Room noise and line loss were also varied. During the tests the acoustic speaking level was measured near the surface of the table at the telephone sets. The positions of the measuring points were selected (fig. 2), among other things because many loudspeaking telephones have their microphones near this measuring position. Furthermore the point was suitable for comparing speaking distances. The difference in the shapes of the instruments was judged to have a negligible effect on the measured results. The electrical levels on the line and the speaking distance were also measured. A VU-meter was used for all level readings. The VU-meter reads 0 dB with 775 mV across 600 ohms and a sinusoidal signal. The speaking distance was measured with the aid of ITV (internal television).

Acoustic speech levels

Fig. 3 shows acoustic speech levels for Lst and Ht as a function of room noise. The curves are mean values for line losses of 0, 15 and 30 dB. In that part of the trials where Lst and Ht were used

Telephone set	Sending (SRE)	Receiving (REE)	Side tone (SiRE)
Ht (LME test)	+2	−4	10
Ht (Adm. test)	+0	−2	10
Lst A	+14.5	manually adjustable in two steps	controlled attenuation
Lst B	+15	— ,, —	— ,, —
Lst C	+15 [with 45 dB(A) room noise]	preferred listening level = 68 dB(A+B) / 2	— ,, —
	Women	Men	
LME test	12	12	
Adm. test	6	6	
Room noise	Hoth weighting		

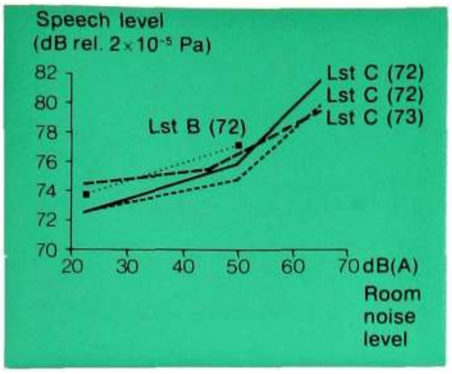


Fig. 4

Speech levels for loudspeaking telephones on different test occasions

Lst B WEGEPHONE

in the same test series, the participants spoke 4—5 dB louder when using Lst.

The difference Lst—Ht is somewhat greater than what has been shown by W. Heberle[8] but agrees very well with the findings of D. L. Richards[7], and also with the calculations made by the Central Laboratory of the Swedish Telecommunications Administration.

M. B. Gardner[9] found earlier that users spoke louder in a loudspeaking system than when carrying on a face-to-face conversation, even if the system gain was zero (Gardner does not show any comparison with Ht).

With Ht—Ht there is often a sense of more intimate contact, so that there may even be a tendency to speak quieter than when conversing face to face.

The fact that people speak louder in a loudspeaking system than when conversing face to face may perhaps be explained by the fact that with Lst there is no visual contact.

The LM Ericsson tests included voice-switched attenuation, i.e. with a signal on the send side, attenuation was introduced in the receiving channel, and with speech signals on the receiving channel attenuation was introduced into the sending channel. The amount of attenuation was between 30 and 60 dB. With lower voice-switched attenuation, and hence greater feedback from the subscriber at the other end, the level difference Lst—Ht will perhaps be somewhat less.

In connection with the tests, the side tone reference equivalent (SiRE) for Ht was +10 dB, and hence it was considered that the side tone did not reduce the speech level by more than 1 dB compared with what is obtained with higher SiRE[10].

Fig. 4 shows the acoustic speech levels on different test occasions with different test participants, and in certain tests the Ht—Ht connection has not been included. Hence the results are not intended to be compared with those for Ht, but constitute a measure of the reproducibility of the absolute levels obtained with Lst.

In the tests carried out by the Telecommunications Administration women spoke, on average, 4 dB lower than men. The corresponding difference in the LM Ericsson tests was 2—3 dB. M. B. Gardner[9] mentions a figure of about 3 dB difference.

Output levels

Fig. 5 shows the output levels obtained in connection with the LM Ericsson tests, given as a function of room noise. The curves represent the mean values for line losses of 0, 15 and 30 dB. The mean values were used since the output level varied very little with line loss for the particular total reference equivalent interval, which was also to be expected[11].

Fig. 6 shows the output level as a function of the overall reference equivalent (ORE) for Ht, with a room noise level of 45 dB (A). The LM Ericsson results, as well as the results from other investigations, are shown in the figure.

From fig. 6 it can also be seen that the loudspeaking telephones A and C with a SRE of +15 dB, measured at a distance in accordance with fig. 7, give the same output level out on the line as

Fig. 5

Output level from Lst for a connection Lst—Ht compared with Ht—Ht

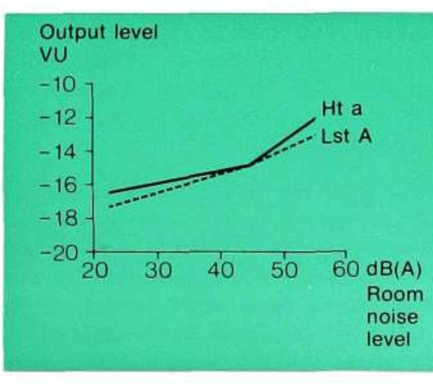


Fig. 6

Output levels in VU transformed to corresponding values for 45 dB(A) room noise by using the values from ref. 11. Line noise is assumed to be negligible

		Type of telephone set	SRE dB	Measuring year
— — —	Lst A	LME ERICOVOX DBE 100	+14.5	1973
- - - - -	Lst C	LME ERICOVOX DBE 200	+15.0	1973
———	Ht a	LME DIALOG	+ 2.0	1973
□	Ht b	Bell 500	+ 7.0	Ref. 12
○	Ht c	LME ERICOFON	+ 6.0	1972
■	Ht d	BPO 706	0.0	Ref. 13
●	Ht d'	BPO 706	0.0	1973

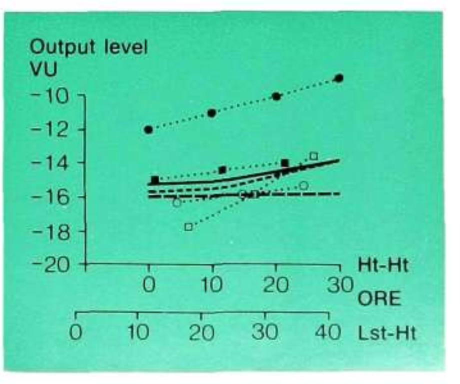


Fig. 7

Measuring distance recommended by CCITT SG XII for testing with loudspeaking telephones

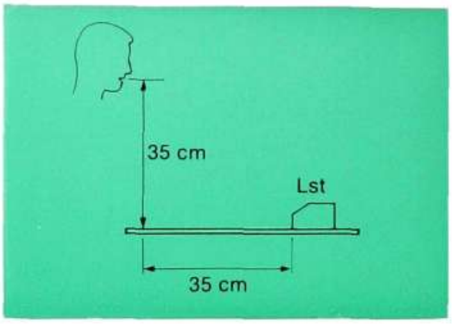
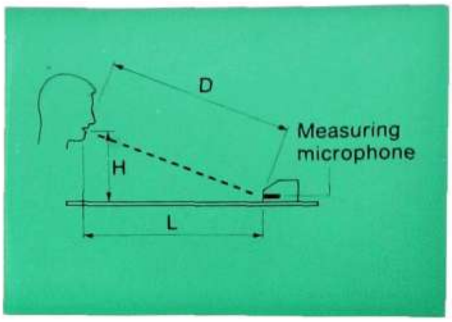


Fig. 8

Measured speaking distance used for the laboratory tests carried out by LM Ericsson

m Mean value in cm
s Standard deviation in cm

TYPE OF INSTRUMENT	H		L		D
	m	s	m	s	m
Ht a	28	3	52	8	57
Lst A	27	3	48	7	53
Lst C	27	3	49	7	54



handset telephones with SREs between +2 and +7 dB.

One reference[13] gives a higher output level from a standard telephone set than that obtained in the LM Ericsson tests. Is this because people in some countries speak louder than people in other countries when using the telephone? If so, the difference can be because users are accustomed to different room noise levels, different line losses and maybe different line noise levels and adapt their way of speaking accordingly.

The difference in SREs for Lst and Ht for the same output level is partly due to the high speech level when using Lst (4—5 dB). The difference is, however, also influenced by the fact that the microphone is held further away from the mouth during a normal telephone conversation than in the case of reference equivalent measurements[16]. The remaining difference may perhaps be due to the side tone with Ht. A certain difference can also be expected because VU (volume units) are compared with measured values (SRE) based on loudness.

In practice, different handsets can give different output levels even if the SRE is the same[14]. In fig. 6 a number of different types of handsets are represented, so that the magnitude of the difference between SRE for Lst and SRE for Ht should apply generally.

Output levels around —16 VU, which are near the values in fig. 6, have also been measured in the network of the Swedish Telecommunications Administration with normal operating conditions. (SRE +1 for the telephone sets in question[15].)

D. L. Richards[16] proposes that SRE for Lst should be +15 dB. In the LM Ericsson tests the loudspeaking telephones with SRE +15 dB gave an output level of —16 VU, which thus lends support to this proposal.

From the above it is clear that the SRE that applies for Ht must not be demanded for Lst. An SRE of +15 dB for voice-switched Lst appears to give the same output level as Ht with an SRE around +5 dB, i.e. as in the most common types of instruments. Consequently Lst with an SRE of +15 dB should work quite well together with Ht in most telephone networks.

Speaker-microphone distance

CCITT SG XII has provisonally recommended a measuring distance in accordance with fig. 7. When arranging the LM Ericsson tests it was found that this distance was impractical, since 35 cm did not leave room in the horizontal plane for a normal desk blotter. The height of 35 cm was not in agreement with the height of the chair relative the height of the table that the persons taking part in the test usually used. (An investigation carried out later indicated that these persons "normally" had their chairs 7 cm too low relative the height of the table from an ergonomic point of view.) For the purpose of the tests the telephone sets were placed at a horizontal distance of 50 cm in order to leave room for a desk blotter. The participants were then free to choose their own talking distance (no special instructions). The speaking distances measured are shown in fig. 8.

Since the test participants were able to select the talking distance themselves without restriction, and even so the talking distances did not exceed 50—60 cm, it appears to be both practical and suitable from a room acoustics point of view to recommend a horizontal distance of about 50 cm (L in fig. 8). This then gives a 55—60 cm speaking distance.

Receiving levels

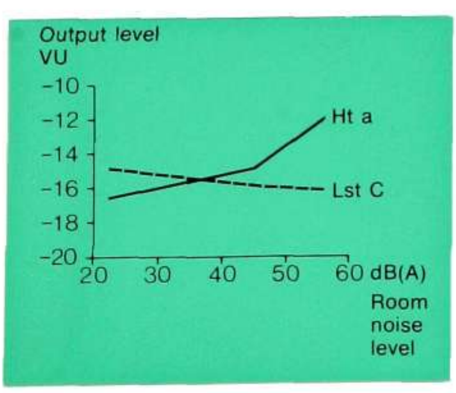
For receiving speech signals the loudspeaking telephone should be designed so that the preferred listening level is obtained. A suitable choice of listening level is discussed in detail by N. Gleiss[6] and will therefore not be discussed further here.

The influence of room noise on voice switching

In a voice-switched loudspeaking telephone without special protection circuits the background noise can be sufficient to put the instrument in the sending condition even when there is no speech signal on the microphone

Fig. 9

Output level for Lst and Ht in connection with Ht (Standard deviation for Vu $\simeq$ 2—3 dB)

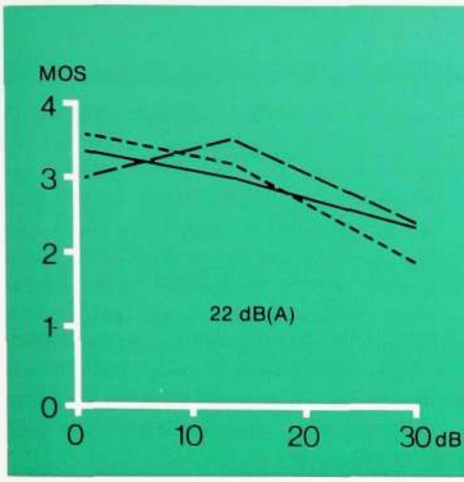


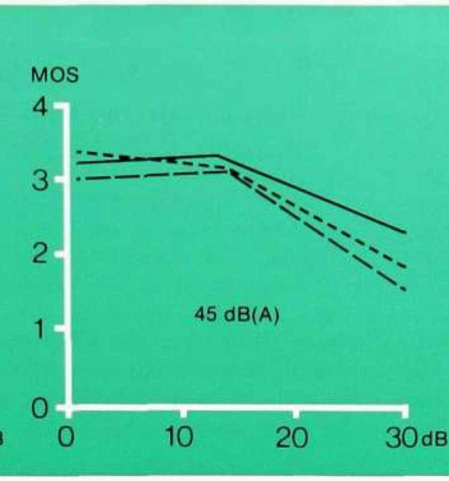
Figs. 10—18

Mean Opinion Score (MOS) as a function of line loss with different values of room noise

———	Handset telephone Ht a
— — —	Loudspeaking telephone Lst C
- - - - -	Loudspeaking telephone Lst A

4 = excellent
3 = good
2 = fair
1 = poor
0 = bad





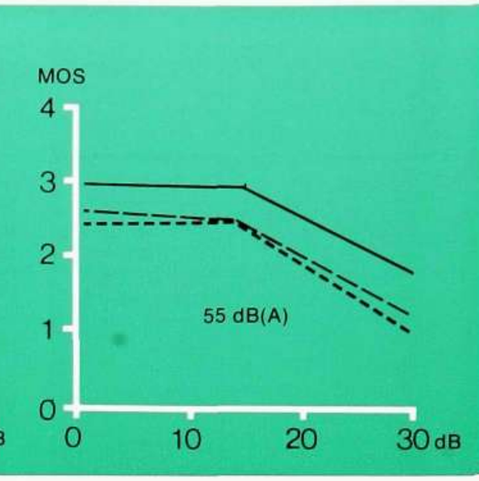
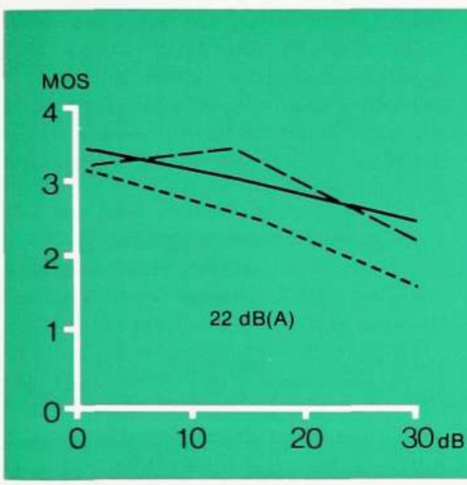


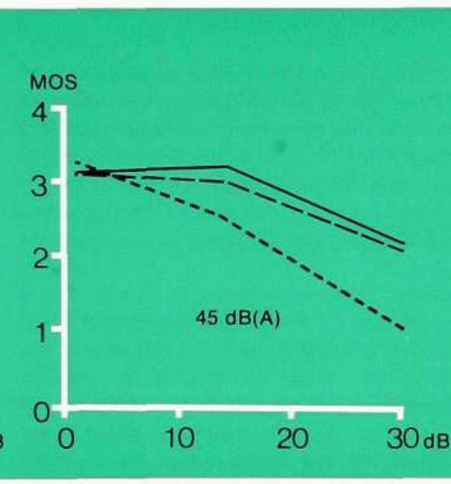
Fig. 10

Sending from Lst and Ht assessed at Ht on connections Lst—Ht and Ht—Ht

Fig. 11

Fig. 12





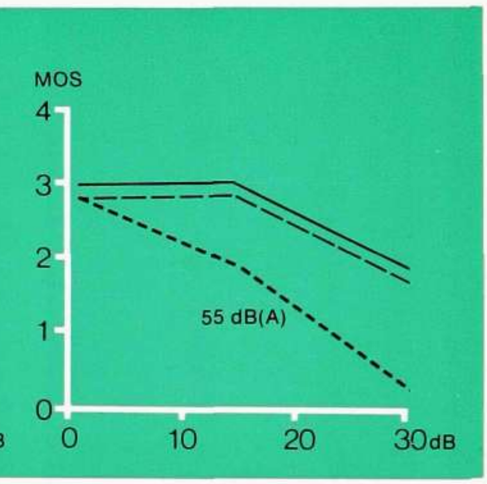
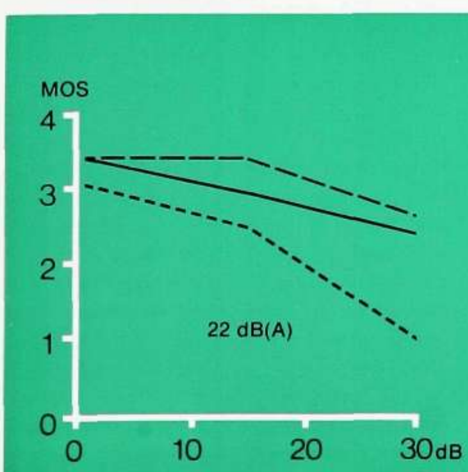


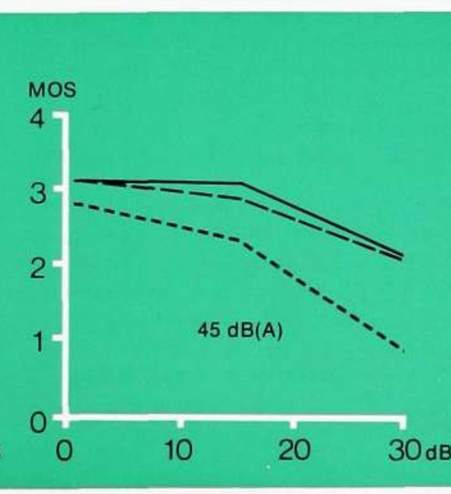
Fig. 13

Receiving in Lst and Ht assessed in Lst and Ht respectively on connections Lst—Ht and Ht—Ht

Fig. 14

Fig. 15





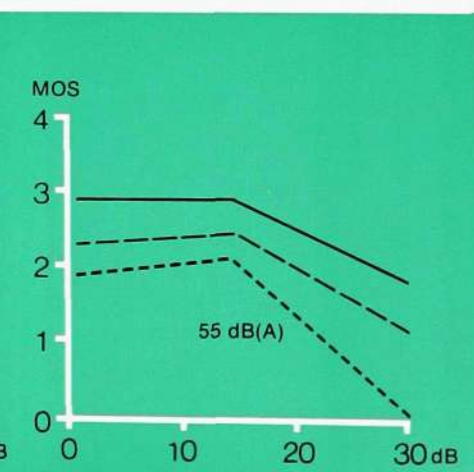


Fig. 16

Quality of the connection for Ht—Ht and Lst—Lst

Fig. 17

Fig. 18

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This will result in a considerable deterioration of the quality of the speech that is received by the loudspeaking telephone. If a Lst is designed to give the required output level at relatively low noise levels, it is possible to reduce the adverse effect of the room noise on the speech control by arranging the circuit so that the gain is reduced linearly with increase of the user's speaking level. Fig. 9 shows the line level for a Lst using such a circuit.

Transmission quality of loudspeaking telephones

In the free conversation tests discussed earlier one Lst (Lst C) had the following characteristics:

An SRE of +15 dB with 45 dB(A) room noise gave an outgoing line level of —16 VU. Automatic level control (AGC) held the received level from the loudspeaker at the preferred level of 68 dB [mean value of dB(A) and dB(B)] when listening to the loudspeaker with both ears.

In order to obtain this preferred level with high signal levels, automatic attenuation was introduced in the receiving channel. The attenuation introduced in the sending channel is reduced by the same value as it is increased in the receiving channel. The instrument was also provided with a noise sensing circuit with characteristics in accordance with fig. 9. The controlled attenuation varied between 30 and 50 dB. The transmission quality was assessed relative to a MOS scale (Mean Opinion Score)[18, 19]. The assessment of the transmission quality is shown in figs. 10—18. The values for both Lst A and C and for Ht a are given.

From figs. 10—18 it can be seen that loudspeaking telephone type C is judged to give the same good speech quality as an ordinary handset telephone even with relatively large line losses. The only exception is at the highest room noise level, when the poorer signal/noise ratio of the Lst has a negative effect on the quality.

Measuring methods

Intelligibility tests, such as for example AEN measurements, have often been used in telephony. Certain telephone administrations also specify the lowest permissible level of intelligibility for loudspeaking telephones. J. Barnes has shown that intelligibility tests can be very useful in connection with development work[17]. However, when measuring with loudspeaking telephones, certain measuring methods for intelligibility can give a false picture if the results are compared directly with the corresponding results for handset telephones.

A comparison has been made between the results of intelligibility tests and MOS assessment. In the intelligibility tests, which were carried out with 45 dB(A) room noise, CV syllables were used both in individual words and words included in carrier phrases. If the voice switching makes a new start for each word, as in the tests with individual words, the initial consonant will be lost.

Connection	Intelligibility with carrier phrase	without carrier phrase
Lst—Ht	94.7%	85.3%
Ht—Ht	98.3%	95.3%

A free conversation test over the same connections gave the following values:

Connection	MOS
Lst—Ht	3.2
Ht—Ht	3.3

In the conversation test the loudspeaking telephone was judged to have almost the same quality as the handset telephone, whereas it was assessed as being quite clearly inferior in the intelligibility test using individual words. It would appear that, when carrying out intelligibility tests using voice switching, the characteristics measured give poorer results than are normally obtained in practice. The explanation is quite obviously that normal conversation does not consist of individual words but of whole sentences. Consequently the results of intelligibility tests must be used with the greatest caution when applied for loudspeaking telephones. The test that best simulates practical use appears to be the conversation test with quality assessment

WORLDWIDE NEWS

New training program for Quality Control

A training program, called QT 74, has been introduced by LM Ericsson's quality control organization. QT stands for Quality Training and 74 for the year the project began.

QT 74 offers improved training facilities at several different levels in the Group's quality control.

As a first step, a training program for prospective inspectors has been prepared, the aim of which is to familiarise them with their future duties as quickly and efficiently as possible. The program provides a broad general knowledge of products and a general knowledge of measuring techniques.

Training has been divided up into so-called product packages, in which each product has its own program. Such a product package has now been completed and has been introduced in three of the parent company's Swedish factories.

This product package deals with the most common types of relays, and the training program for these will later on be used as a model for other product packages within, for example, the rapidly expanding electronics sector.

A QT 74 training program comprises six different phases. Each part is started and terminated by an instructor, but otherwise the pupils study by themselves with the aid of recorded tapes, compendiums and video programs.

The program phases are as follows:

- Phase 1 is in the form of a general survey of the subject of quality control and is aimed at giving the pupils an idea of how the control organization functions, what thinking in terms of quality means for LM Ericsson, and so on.
- Phase 2 comprises the basic information about the product, i.e. the main constituent parts, function and range of use.
- Phase 3 is devoted to the study of the product down to the very smallest detail, and the pupils learn how to carry out a complete visual inspection of the whole product.
- Phase 4 is the measuring part, which deals with measuring devices and measuring instruments used within the company.
- Phase 5 deals with the measurable characteristics of the product.
- Phase 6 is devoted to training the pupils in measurement and inspection of the product in preparation for the actual inspection work they will be carrying out.

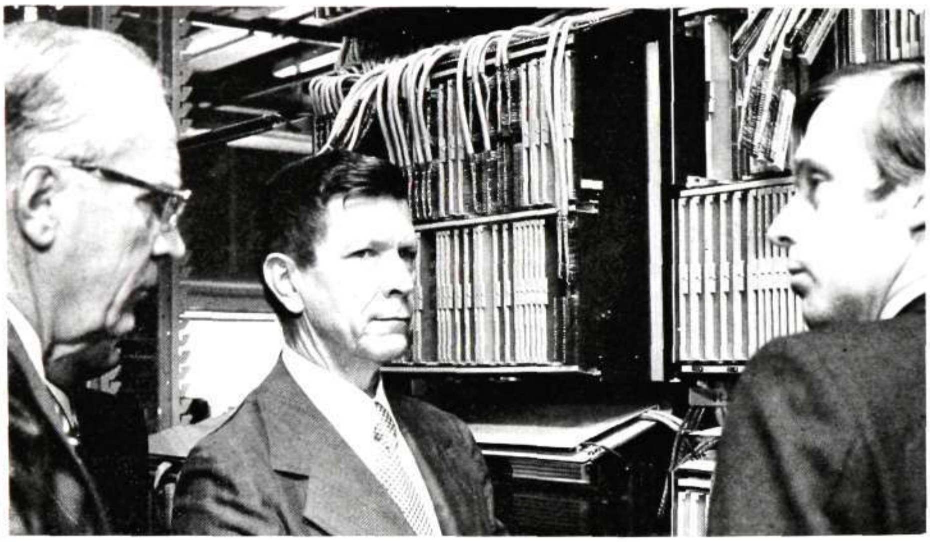
The need of a quick and uniform training in quality control is naturally greatest in countries where new factories are started, but even in established factories such a training can be appropriate in order to facilitate internal staff transfers, increase the knowledge of employees and improve the quality of the products.

One of the inspectors at the main factory during advanced training in accordance with QT 74

Deputy for LME's President appointed

At the Board meeting of Telefonaktiebolaget LM Ericsson, held on 6th June, Vice President Fred Sundkvist was appointed Deputy to the company President, Björn Lundvall. This is a newly created appointment within the company. At the annual general meeting Fred Sundkvist was also appointed deputy member of the company's Board of Directors.

Fred Sundkvist is a qualified engineer, having taken his degree at the Royal Institute of Technology in Stockholm. He began his career with LM Ericsson in 1949 in what was then the equivalent of the present Telephone Exchange Division and its sales organization. He was section head of this department during the period 1954—1956, after which he was appointed assistant to the Vice President for Sales. During the years 1964—1969 Fred Sundkvist was head of the Telephone Exchange Division. In 1969 he succeeded Malte Patricks as Vice President in the company management. Fred Sundkvist is also a board member of several companies in the Ericsson Group.



The Brazilian Minister of Communications Euclides Quandt de Oliveira visited Sweden for a few days in June at the invitation of the Swedish Minister of Communications Bengt Norling. During his stay he visited the Telecommunications Administration, ELLEMTEL and LM Ericsson. The main point in the program was the system presentations of stored-program-controlled telephone exchanges, such as AXE and AKE. In connection with a review of the production program of the Transmission Division a trial with fibre optics for the transmission of telephone conversations was demonstrated. In the picture the Brazilian Minister of Communications is flanked by Björn Lundvall, the President of the Ericsson Group, and Björn Svedberg, LM Ericsson

The first LM Ericsson installation in Haiti, a 6000-line local crossbar exchange (ARF), was inaugurated by the President of the Republic, Jean-Claude Duvalier (second from right). Far right, the Head of Télécommunications d'Haiti S.A. in conversation with Torsten Lindstedt, LM Ericsson (far left) and LM Ericsson's representative in Haiti, Jürgen Marqvardt

About a hundred members of the ITU Staff Association, Geneva, visited the Swedish Telecommunications Administration and LM Ericsson in Stockholm during a study tour at the end of May. The picture was taken when the group was welcomed at LM Ericsson. The group discussions that followed were devoted to the LM Ericsson picture telephone project and the internal telephone installation, and also training and staff care questions etc.

LARGE ORDERS

Iran:

Improvement of network

The Iranian Telecommunications Administration has placed substantial orders with the LM Ericsson for the improvement of the telephone network.

The orders, which have a total value of about $22m, cover a survey of the local networks in 11 of the largest cities in the country, excluding Teheran. A considerable part of the orders covers the supply of the network equipment for the scheme.

In Teheran, LM Ericsson already has substantial cable installations in hand.

Nigeria:

International exchange

Nigeria External Telecommunications Limited (N.E.T.) of Lagos, Nigeria, has placed an order worth about $8m with the LM Ericsson.

The order covers the delivery and installation of equipment for a new international telephone switching centre for Nigeria. The equipment will be of the Ericsson crossbar type and the new international exchange is expected to be operational by mid-1978. It will connect Nigerian subscribers direct with subscribers in most other countries via Nigeria's satellite communication systems.

Mexico:

Multiplex for 12,000 channels

Teléfonos de México have signed a contract with Teleindustria Ericsson S.A. for the manufacture and delivery of multiplex equipment for 12,000 channels.

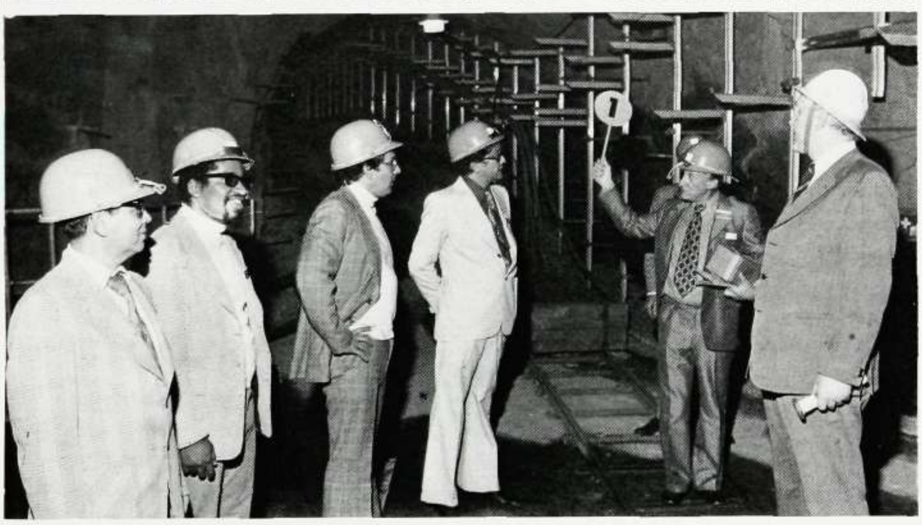
The equipment is to be included in the Mexican Telecommunications Administration's installation program for 1976 and is one of the largest orders for transmission equipment that LM Ericsson have ever received for delivery during one and the same year. As in the case of earlier Mexican orders, the bulk of the equipment will be manufactured by Teleindustria Ericsson S.A.

Teléfonos de México has now ordered multiplex equipment for a total of 42,000 channels from LM Ericsson's Mexican subsidiary company for the installation period 1972—1976.

Maintenance conference 1975

The 15th annual maintenance conference to be arranged by LM Ericsson since the start in 1956 was held in Stockholm during the last week in May. A total of 61 delegates from the Latin American countries and Spain had been invited to the conference, which this year was conducted in Spanish with simultaneous translation into English. There were three guest speakers at the conference, one each from England, Norway and Holland. For the first time since 1962 there was a woman delegate at the conference, M. de Gooding from CANTV in Venezuela. Of the 12 countries that took part 11 had attended before, only Guatemala attending for the first time.

During the five days of the conference, technical and administrative problems were ventilated that concerned the operation and maintenance of telecommunication plant and networks, and personal contacts were established between the representatives of the 19 telephone administrations taking part. During a visit to the Swedish Telecommunications Administration the delegates were shown how the maintenance centre in Stockholm was organized and they also had the opportunity of taking a walk through the imposing cable tunnels under the streets of Stockholm. The new electronic PABX (ERITRONIC ASD 551) was demonstrated in operation at the new plant of ELLEMTEL at Älvsjö, a suburb of Stockholm.



New company presidents for four sub-companies:

Brazil, Venezuela, Mexico, Spain

Valdemar Henriksson in Brazil

Leif Källén in Venezuela

Nils G. Söderqvist in Mexico

Georg Dahlström in Spain

Mr *Gunnar Vikberg,* President of Ericsson do Brasil since 1968, leaves the company on 1st October, 1975.

■ Mr *Valdemar Henriksson,* former President of the LM Ericsson subsidiary company in Venezuela, Compañía Anónima Ericsson, has been appointed Company President in Brazil.

■ The new Company President in Venezuela is Mr *Leif Källén,* who until recently has been the Head of the Telephone Exchange Division in the Spanish subsidiary company Industrias de Telecomunicación S.A. (Intelsa) in Madrid.

■ Mr *Nils Kjellander,* Head of Teleindustria Ericsson, S.A. in Mexico, relinquishes his appointment in the autumn in order to resume his duties in the parent company.

■ Mr *Nils G. Söderqvist,* the present Head of Intelsa in Spain, has been appointed company President in Mexico.

■ Mr *Georg Dahlström,* the present Head of the Production Department in the Spanish subsidiary company, has been appointed President of that company.

Fredrik Markman In Memoriam

Fredrik Markman died on August 23, 1975 and therewith passed away the last of the pioneers from the 1910s, when in many respects the foundations of the modern LM Ericsson were laid.

Fredrik Markman started his career with LM Ericsson in January 1913, when he obtained employment in the laboratory. His first important task was to manage the newly established electricity meter branch, from 1914.

Fredrik Markman will, however, be remembered above all for his work on telephone sets and their electro-acoustic properties. He appreciated at an early stage that it was necessary to establish international standards for telephone equipment if it was to be possible to telephone over national boundaries.

Fredrik Markman took part in the preparatory work, at the beginning of the 1920s, which successively led to the formation of the International Telecommunication Union. The particular questions that Markman dealt with at this time concerned the speech transmission characteristics of telephone connections and measuring methods for assessing these. These studies during the 1920s led to the acceptance of an international reference system, the SFERT system, and the setting up of an international laboratory in Paris, the SFERT laboratory, under the control of CCIF. Here it was possible to evaluate the transmission characteristics of the national telephone networks of the different countries. Fredrik Markman took an active part in this work, both as regards the preparation of standards and the methods for assessing the speech transmission characteristics, which by and large are still valid today. Through Fredrik Markman LM Ericsson became a force to be reckoned with in the field of speech transmission.

At LM Ericsson Fredrik Markman took an active part in the design of the electro-acoustic parts in the epoch-making telephone set of 1932 (the first bakelite telephone set). He also assisted in the marketing of this set. Later on he also led the design work on the miniaturised telephone receivers and microphones which were used in the ERICOFON.

We will remember "Figge" as an engineer who was deeply engaged in his work, with a capacity for work far above the ordinary and with great consideration for his colleagues. We miss his firm handshake and his friendly mien.

Christian Jacobæus

Ciphering equipment with high security level

A ciphering equipment with high security level, intended for telephone conversations within the same local exchange area, for example for large companies or administrations, has been developed by AB Transvertex, a subsidiary company of LM Ericsson which is entirely devoted to information security.

The new ciphering equipment uses digital technique and offers the user 10^{25} different key settings (codes). For comparison purposes it may be mentioned that the number of codes in sophisticated types of conventional speech scramblers is about 10^{3}.

The use of digital technique in the new system makes it impossible to identify speech level, speech frequencies or speech pauses. To an unauthorized listener the enciphered signal sounds like constant noise, even if he has access to ciphering equipment of the same type but does not have the actual key setting.

The signal is digitalized and is enciphered by adding a pseudo-random series. The same pseudo-random series is also added at the receive side, after which the signal is again converted to normal speech.

Apart from a normal telephone set, the new ciphering equipment at each end of the connection consists of a line equalizer with network attachment, designed as a base for the telephone set, and the ciphering unit itself with a code setting unit behind a lockable cover.

New field telephone to the Norwegian Armed Forces

An agreement has been reached between the Norwegian Armed Forces and A/S Elektrisk Bureau, a subsidiary of the Ericsson Group, regarding the delivery of a newly developed field telephone set. The order comprises the supply of 5,000 telephone sets during 1975, 11,000 during 1976 and the option of a further number not exceeding 10,000 during 1977. These comprehensive orders are the result of, among other things, the favourable experience from a trial series of such sets delivered some time ago. It is worthy of note that this field telephone set was awarded the Norwegian design prize for 1973.

Smaller trial series of the set have been delivered to a number of countries.

A detailed description of the field telephone set was given in Ericsson Review No. 4, 1974.

The Ericsson Group

With associated companies and representatives

EUROPE

SWEDEN

Stockholm
1. Telefonaktiebolaget LM Ericsson
2. L M Ericsson Telemateriel AB
1. AB Rifa
1. Sieverts Kabelverk AB
1. Svenska Radio AB
5. ELLEMTEL Utvecklings AB
1. AB Transvertex
4. Svenska Elgrossist AB SELGA
1. Kabmatik AB
4. Holm & Ericsons Elektriska AB
4. Mellansvenska Elektriska AB
4. SELGA Mellansverige AB

Alingsås
3. Kabeldon AB

Gothenburg
4. SELGA Västsverige AB

Kungsbacka
3. Bofa Kabel AB

Malmö
3. Bjurhagens Fabrikers AB
4. SELGA Sydsverige AB

Norrköping
3. AB Norrköpings Kabelfabrik
4. SELGA Östsverige AB

Nyköping
1. Thorsman & Co AB

Sundsvall
4. SELGA Norrland AB

Uddevalla
4. Wamebolaget AB

EUROPE (excluding Sweden)

DENMARK

Copenhagen
2. L M Ericsson A/S
1. Dansk Signal Industri A/S
3. GNT AUTOMATIC A/S

FINLAND

Jorvas
1. Oy L M Ericsson Ab

FRANCE

Paris
1. Société Française des Téléphones Ericsson
2. Thorsmans S.A.R.L.

Boulogne sur Mer
1. RIFA S.A.

Lannione
6. Société Lannionaise d'Electronique SLE-CITEREL

Marseille
2. Etablissements Ferrer-Auran S.A.

IRELAND

Dublin
1. L M Ericsson Ltd.
2. Thorsman Ireland Ltd.

ITALY

Rome
1. FATME Soc. per Az.
5. SETEMER Soc. per Az.
2. SIELTE Soc. per Az.

NETHERLANDS

Rijen
1. Ericsson Telefoonmaatschappij B.V.

NORWAY

Oslo
3. A/S Elektrisk Bureau
2. SRA Radio A/S
4. A/S Telesystemer
4. A/S United Marine Electronics

Drammen
3. A/S Norsk Kabelfabrik

POLAND

Warszaw
7. Telefonaktiebolaget LM Ericsson

PORTUGAL

Lisbon
2. Sociedade Ericsson de Portugal Lda

SPAIN

Madrid
1. Industrias de Telecomunicación S.A. (Intelsa)
1. L M Ericsson S.A.

SWITZERLAND

Zurich
2. Ericsson AG

UNITED KINGDOM

Horsham
4. Thorn-Ericsson Telecommunications (Sales) Ltd.
2. Swedish Ericsson Rentals Ltd.
5. Swedish Ericsson Company Ltd.

London
3. Thorn-Ericsson Telecommunications (Mfg) Ltd.
6. Thorn-Ericsson Telecommunications Ltd.
4. United Marine Leasing Ltd.
4. United Marine Electronics (UK) Ltd.

WEST GERMANY

Hamburg
4. UME Marine Nachrichtentechnik GmbH

Hanover
2. Ericsson Centrum GmbH

Lüdenscheid
2. Thorsman & Co GmbH

Representatives in:
Austria, Belgium, Greece, Iceland, Luxembourg, Yugoslavia

LATIN AMERICA

ARGENTINA

Buenos Aires
1. Cía Ericsson S.A.C.I.
1. Industrias Eléctricas de Quilmes S.A.
5. Cía Argentina de Teléfonos S.A.
5. Cía Entrerriana de Teléfonos S.A.

BRAZIL

São Paulo
1. Ericsson do Brasil Comércio e Indústria S.A.
4. Sielte S.A. Instalações Elétricas e Telefônicas
4. TELEPLAN, Projetos e Planejamentos de Telecomunicações S.A.

Rio de Janeiro
3. Fios e Cabos Plásticos do Brasil S.A.

São José dos Campos
1. Telecomponentes Comércio e Indústria S.A.

CHILE

Santiago
2. Cía Ericsson de Chile S.A.

COLOMBIA

Bogotá
1. Ericsson de Colombia S.A.

Cali
1. Fábricas Colombianas de Materiales Eléctricos Facomec S.A.

COSTA RICA

San José
7. Telefonaktiebolaget LM Ericsson

ECUADOR

Quito
2. Teléfonos Ericsson C.A.

GUATEMALA

Guatemala City
7. Telefonaktiebolaget LM Ericsson

HAITI

Port-au-Prince
7. Telefonaktiebolaget LM Ericsson

MEXICO

Mexico D.F.
1. Teleindustria Ericsson, S.A.
1. Latinoamericana de Cables S.A. de C.V.
2. Teléfonos Ericsson S.A.
2. Telemontaje, S.A. de C.V.

PANAMA

Panama City
2. Telequipos S.A.
7. Telefonaktiebolaget LM Ericsson

PERU

Lima
2. Cía Ericsson S.A.

EL SALVADOR

San Salvador
7. Telefonaktiebolaget LM Ericsson

URUGUAY

Montevideo
2. Cía Ericsson S.A.

VENEZUELA

Caracas
1. Cía Anónima Ericsson

Representatives in:
Bolivia, Costa Rica, Dominican Republic, Guadeloupe, Guatemala, Guyana, Haiti, Honduras, Netherlands Antilles, Nicaragua, Panama, Paraguay, El Salvador, Surinam, Trinidad, Tobago.

AFRICA

ALGERIA

Algiers
7. Telefonaktiebolaget LM Ericsson

EGYPT

Cairo
7. Telefonaktiebolaget LM Ericsson

MOROCCO

Casablanca
2. Société Marocaine des Téléphones et Télécommunications Associée au Group Ericsson "SOTELEC"

TUNISIA

Tunis
7. Telefonaktiebolaget LM Ericsson

ZAMBIA

Lusaka
2. Ericsson (Zambia Limited)
2. Telefonaktiebolaget LM Ericsson Installation Branch

Representatives in:
Angola, United Arab Emirates, Cameroon, Central African Republic, Chad, People's Republic of the Congo, Dahomey, Ethiopia, Gabon, Ivory Coast, Kenya, Liberia, Libya, Malagasy, Malawi, Mali, Malta, Mauretania, Mozambique, Namibia, Niger, Nigeria, Republic of South Africa, Réunion, Senegal, Sudan, Tanzania, Tunisia, Uganda, Upper Volta, Zaïre.

ASIA

INDIA

Calcutta
2. Ericsson India Limited

INDONESIA

Jakarta
2. Ericsson Telephone Sales Corporation AB

IRAQ

Baghdad
7. Telefonaktiebolaget L M Ericsson

IRAN

Teheran
7. Ericsson Telephone Sales Corporation AB

KUWAIT

Kuwait
7. Telefonaktiebolaget L M Ericsson

LEBANON

Beyrouth
2. Société Libanaise des Téléphones Ericsson

MALAYSIA

Shah Alam
1. Telecommunication Manufacturers (Malaysia) SDN BHD

OMAN

Muscat
7. Telefonaktiebolaget LM Ericsson

THAILAND

Bangkok
2. Ericsson Telephone Corporation Far East AB

TURKEY

Ankara
2. Ericsson Türk Ticaret Ltd. Sirketi

Representatives in:
Bahrein, Bangladesh, Burma, Cambodia, Cyprus, Hong Kong, Iran, Iraq, Jordan, Kuwait, Lebanon, Macao, Nepal, Oman, Pakistan, Philippines, Saudi Arabia, Singapore, Sri Lanka, Syria, Taiwan, Republic of Vietnam

UNITED STATES and CANADA

UNITED STATES

New York, N.Y.
5. LM Ericsson Telecommunications, INC
2. Ericsson Centrum, Inc.

CANADA

Montreal
2. L M Ericsson Ltd.

AUSTRALIA and OCEANIA

Melbourne
1. L M Ericsson Pty. Ltd.
1. A.E.E. Capacitors Pty. Ltd.
5. Teleric Pty. Ltd.

Sydney
3. Conqueror Cables Pty. Ltd.

Representatives in:
New Caledonia, Matinique, New Zealand, Tahiti.

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1. Sales company with manufacturing
2. Sales and installation company
3. Associated sales company with manufacturing
4. Associated company with sales and installation
5. Other company
6. Other associated company
7. Technical office

TELEFONAKTIEBOLAGET LM ERICSSON