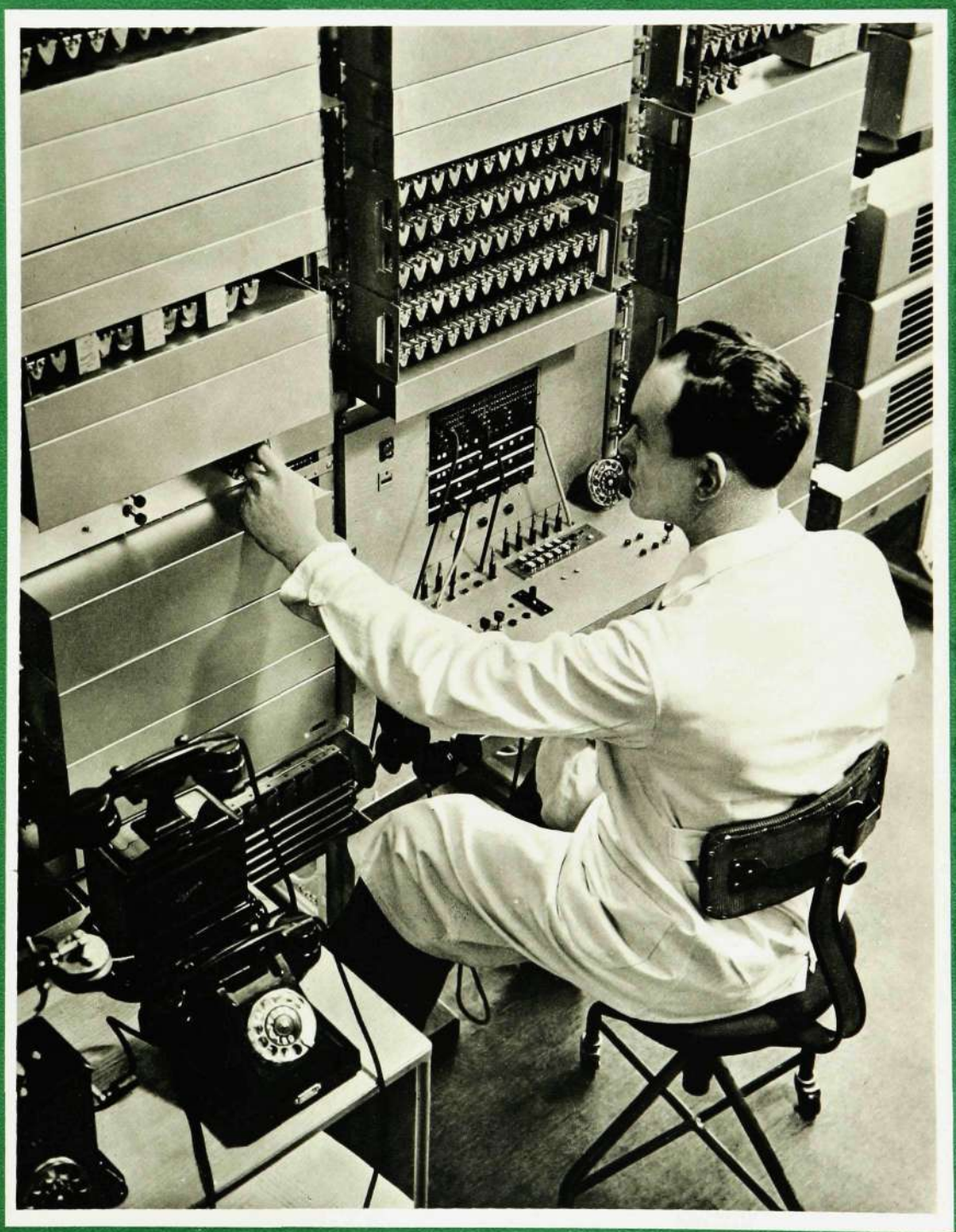
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Rational Charging Methods for Automatic Telephone Traffic

C BERGLUND, TELEFONAKTIEBOLAGET LM ERICSSON, STOCKHOLM

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In automatic traffic the running costs are governed by the duration of conversation and not by the number of calls. The charges should therefore be based on the total time of conversation. This article shows how recording of duration of conversation for local calls can be introduced with advantage.

The charges per 3-minute period begun, as used in manual traffic, are without justification in automatised toll traffic and should be replaced by charges for the actual time of conversation. By means of suitable numbering and distribution of rates it is possible to arrive at effective time zone meters, if the charges are permitted to deviate slightly from what would correspond to the exact geographical distance between the calling and called exchanges.

Automatisation of the telephone operation alters the costs on which telephone rates should be based and provides possibilities for introducing more rational methods of charging calls. Nevertheless it is quite ususal to apply in automatic operation rates that have been drawn up when taking account of manual operation and its more limited possibilities. This would seem chiefly to be due to the reluctance of telephone administrations to depart from rates that have been found to give satisfactory financial yield and which subscribers have become accustomed to and have accepted. Nothing is more likely to rouse criticism among subscribers than changes in rates and these if ill-considered may have catastrophic financial results. It is hardly surprising, therefore, that reforms connected with methods of charging meet with particularly strong opposition and that conceptions from long experience with manual telephone operation are disposed to persist, though they lack all justification after change over to automatic operation.

Nevertheless these circumstances should not be allowed to prevent the introduction of more rational charging methods and it is therefore extremely important that the proper shaping of rates for automatic operation should be investigated objectively and information about them widely disseminated. In this way it should be possible to combat incorrect conceptions and prepare the ground for reforms which are motivated in high degree.

An attempt will be made in this article to consider without prejudice the demands that should be made on rational rates for automatic telephone traffic and to indicate the possibilities of introducing them which present technical practice allows.

Among those who have already dealt with this question is Mr. S A Karlsson of Helsingfors Telephone Society in an address to the Northern Countries Electrotechnicians meeting 1937. Though the author of this present article recommends technical solutions which depart partially from those given by Mr. Karlsson, he shares the latter's opinions on the main question and permits himself to make use of them as points of departure for further reflexions.

Mr. Karlsson puts forward the following demands on an appropriate telephone tariff:

1. It shall promote development of the telephone traffic.
2. The various charges shall correspond to the costs involved.

3. The various charges should not be dependent on one another.
4. The tariff shall be such that it can remain in force for an appreciable length of time.
5. The tariff shall involve small recording and encashment expenses.

There can hardly be any difference of opinion regarding the desirability of the above conditions being fulfilled. It might be possible to supplement them by further requirements which, however, are more of a social or psychological nature and so scarcely of general application.

Local Calls

The old method of charging a fixed rate, independent of the traffic (flat rate) meets point *5* particularly well, but is in such sharp conflict with *1*, *2* and *4* that it cannot be regarded as rational.

The tariff form now customary with a fixed rate plus a charge per call meets point *2* fairly well in manual operation, as in manual systems the running costs are chiefly costs of attendance which are fairly proportional to the number of calls attended to.

In automatic operation, however, almost all running costs are governed by the time of conversation and not by the number of calls. It is therefore undoubtedly more correct that in automatic operation the tariff should comprise a fixed rate plus a variable charge proportional to the duration of conversation. For the subscriber, too, it must appear more fair that he should pay less for a short conversation, *e. g.*, where he only gets word that the person desired is not at home, than for a lengthy conversation. Mr. Karlsson is therefore right in declaring that the promotion of the telephone traffic's expansion should not consist only in recruiting a large number of telephone subscribers but above all in getting the telephone plants to deal with as large a number of useful conversation hours as possible.

In Austria there was introduced a considerable time ago such a tariff, but the charging there was done for the time of occupation both for the subscriber's outward and his incoming calls. It can hardly be considered right that a subscriber should have to pay for calls which he does not initiate. It should be taken as the fair principle that a subscriber should be able to calculate more or less in advance his telephone expenses and by his own efforts keep them within fixed limits. He should therefore be charged only with those calls he himself initiates.

Mr. Karlsson proposes that the time of occupation should only be recorded for the calling subscriber from the moment the first figure is received at the exchange and that for recording of time there should be employed a common impulse machine, which transmits at regular intervals a recording impulse to the calling subscriber's call meter. By means of this recording method simpler devices are obtained at the exchange than are required to send a single impulse to the meter at the close of each effective call. With a certain amount of justice it is declared that the time recording should be begun immediately the exchange is occupied since it is this occupation that for the most part gives rise to the running costs.

However, well-founded opposition against this may be expected from subscribers. These, of course, have no means of estimating the ineffective occupation time's length, as such occupation arises when the called subscriber does not answer or is busy, when delays occur through the number of connecting devices being insufficient and other circumstances over which the individual subscriber has no control. He must therefore consider it unfair that such extra occupation should be charged to him, just because he had the misfortune to be caught by these unavoidable circumstances, disagreeable in themselves. Mr. Karlsson therefore has proposed measures for time recording of effective conversation time only. The supplementary equipment required to avoid

recording of ineffective occupation is not expensive and in the opinion of the author, should in any case not be absent from in a modern automatic telephone exchange. Such an exchange should, to provide for rational recording of toll calls, be so constructed that the facility exists of sending impulses at any moment during the call to the call meter of the calling subscriber. An automatic telephone system equipped in this manner can easily be altered from recording per call to time recording. The supplementary equipment consists only of time impulse devices common to several connecting circuits, which are inexpensive and ought to be there to some extent for the time recording of toll calls.

By employing common time impulse devices the first time impulse will come at no fixed time during the call and the time registration therefore for a single call will be inexact. It is, however, the sum of the time for many calls that is of interest and errors in the individual recordings balance each other so that a satisfactory recording accuracy is ensured. This question is dealt with in the next article »Registering of duration of conversation» in this number of Ericsson Review.

As it is easy to vary the length of the impulse interval it is possible to apply with time charging a higher rate during periods of heavy traffic, thus maybe ensuring more even loading and consequently better utilisation of the exchange connecting devices.

Toll Calls

A manually served toll call involves costs both for setting up and charging the call and for the occupation of the lines and the exchange equipment. The former are dependent on the number of calls, the latter on the conversation time. It would then appear natural that toll charges should consist of a charge depending on the number of calls plus a charge dependent on the total duration of conversation.

With manual recording however such charges, would involve considerable work of computation and there would also arise trouble in getting the subscribers to understand and accept such a complicated tariff. As moreover with manual operation it is not always possible to determine the exact moment when calls terminate, and the operators should not be burdened with or permitted to break in frequently on the connection to check whether conversation is proceeding, the calls are usually charged at a rate per 3-minute period begun. In point of fact such a rate to a certain extent takes into account that the costs are dependent both on the number of calls and the time of conversation, seeing that on the one hand for each call, irrespective of its length, a certain minimum charge equivalent to a 3 minute conversation is obtained and on the other hand a higher charge is obtained when the call exceeds 3 minutes in length. Nevertheless such a tariff is not ideal, as for instance a call of 3 minutes is obtained for the same price as a call of 1 minute, despite the fact that the former, especially with long distance calls, involves appreciably higher costs. It is equally obvious that the first 3-minute period involves higher costs than the subsequent ones and that consequently long calls are charged considerably higher than can be considered just. However, it is hardly possible for practical reasons to find a more suitable form of tariff with manual operation.

On the automatisation of the toll traffic practically the whole cost for a call will be dependent on the occupation time and moreover it is nearly proportional to it. This very simple relation makes it possible to arrive at a really simple and rational tariff, namely one by which the subscriber is charged a rate which is directly proportional to the occupation time. Neither would it then be right to charge according to periods started of certain duration, as in the manual system. As the costs are directly proportional to the occupation time the subscriber should be debited according to the real call duration, so that the cost for a call of 5 minutes will cost exactly 5 times as much as a call of 1 minute.

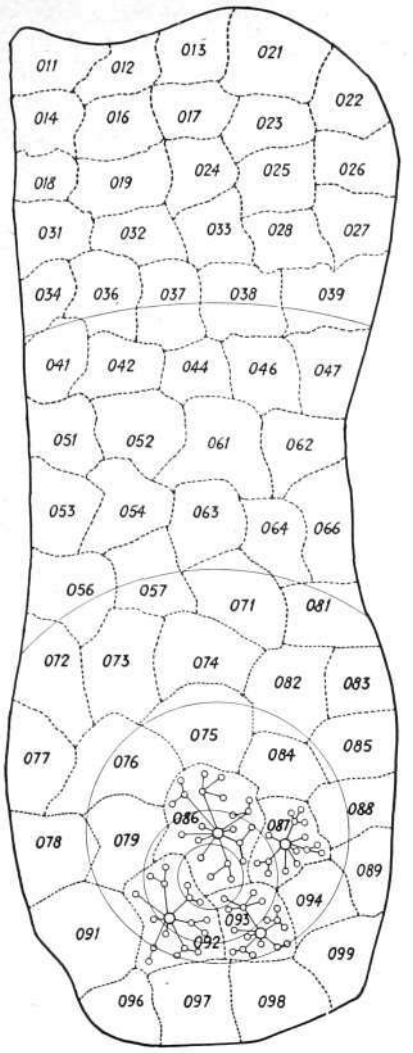


Fig. 1 X 4305
Area divided up into network groups

Charging of toll calls according to actual duration of conversation is most simply arranged in manner similar to that described above for local calls but, in order that the rate may be varied according to the distance between the subscribers talking, the time recording must be multiplied by a zone factor. This is done by the interval between the impulses of the subscriber's call meter being made correspondingly shorter.

Mr. Karlsson has recommended that each line section over which the call is carried be equipped with simple impulse devices which transmit, at impulse intervals adapted to the length of the line section, time impulses to the subscribers call meter. The time impulses from the line sections comprised in the call connection are then added up by the subscriber's call meter and a recording is obtained which corresponds to the total length of line over which the call is carried. Automatised networks, however, are usually built up radially from a network group centre. Thus, for example, the distance between two terminal exchanges may then often be fairly short though the call is routed the long stretch by way of the network group centre. It cannot be right that the subscriber should, for a call between two such terminal exchanges, be charged a high rate because the call is actually carried over a long detour because this, taking account of the collected traffic of the network group, involves less expense to the telephone administration. Later Mr. Karlsson worked out a modified proposal which provides for the application of a single time tariff for traffic within one network group and for recording of traffic to other network groups being done by means of time zone meters located at the network group centre.

Time Zone Meters

Distance rates should be based on the crow-flight distance between the departure and receiving exchanges. The apparatus which transmit a number of impulses corresponding to the fixed distance rates to the subscriber meters are time zone meters. These would be very complicated if in an extensive rural automatisation network the charging was to be adapted exactly to the geographical distance between the exchanges. They can, however, be made quite simple if certain approximations are permitted. If an area, the traffic in which is to be automatised at some future date, is divided into network groups, see Fig. 1 there will be obtained for the calls over long distances an accuracy that is satisfactory in determining rates if only the distance between network group centres is taken into account.

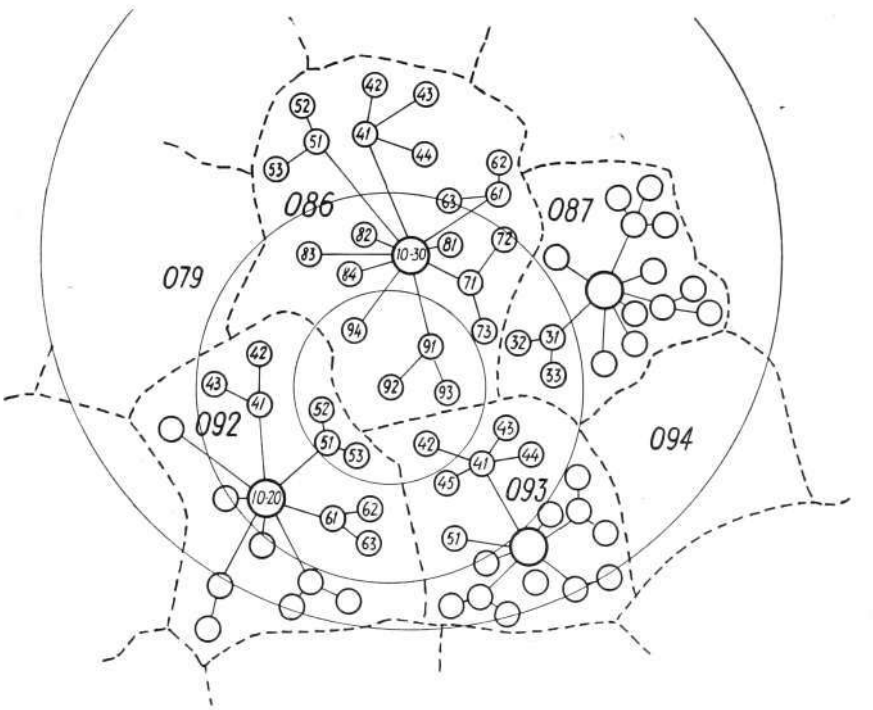


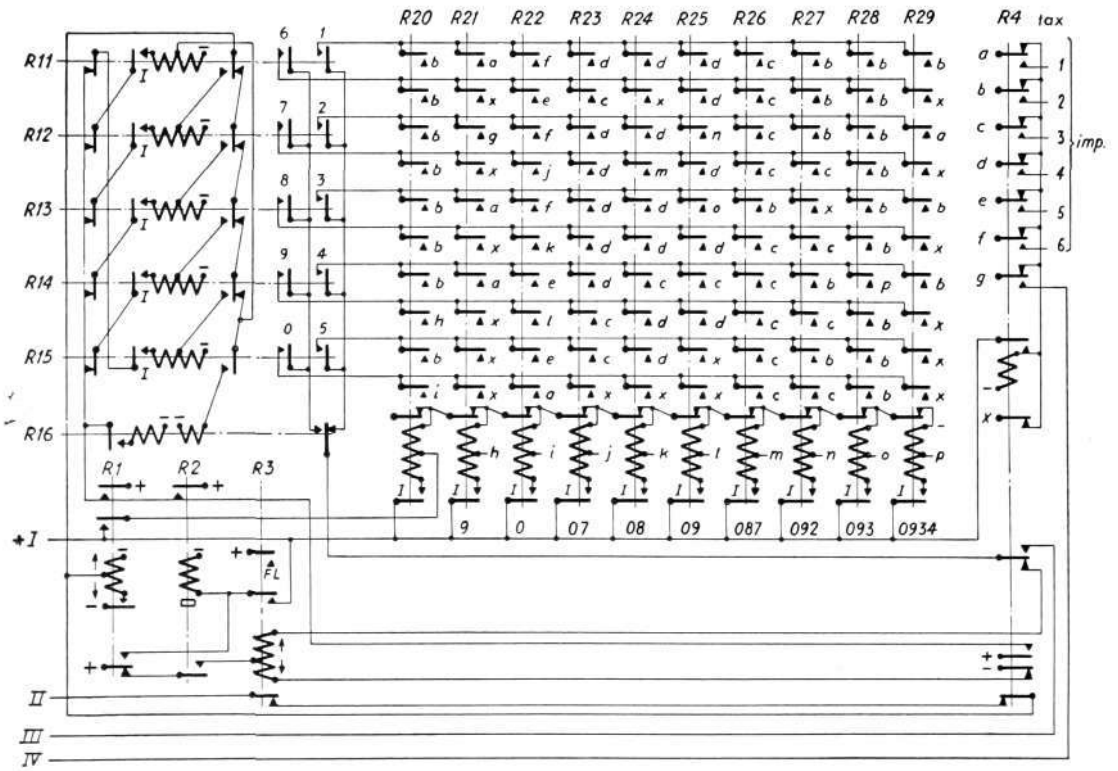
Fig. 2 X 6043
Network group 086 and adjoining network groups

For calls between exchanges in adjoining network groups, see Fig. 2, however, such an approximation would not be satisfactory. The distance between exchange *92* in network group *086* and exchange *52* in network group *092* constitutes, for instance, merely a fraction of the distance between the respective network group centres. Similarly it can hardly be considered right to apply, as is at present usual, the same rate for all calls between intermediary places within a network group. Thus it cannot be regarded as fair that calls within the network group *086* between exchanges *91* and *93* should be charged equally as high as calls between exchanges *92* and *42*. An acceptable approximation is arrived at, however, if the cheapest distance rate is fixed exactly in conformity with the crowflight distance between exchanges — for exchange *92* to other exchanges within the innermost circle in Fig. 2 — while the next cheapest rate is applied to all other exchanges in the same network group and to other exchanges in other network groups which lie at a fixed distance from the calling exchange — in the area between the two innermost circles. If these approximations are accepted and it is decided that calls to other exchanges in the whole area are to be charged according to the distance between the network group centres, then possibilities have been created of arriving at simple time zone meters.

Fig. 3 shows a form of construction for a time zone meter which, for exchange *92* in network group *086*, fulfils these rate conditions for the area as per Fig. 1. It is assumed that for traffic within a single network group there is dialled only the subscriber number and that the two first digits in that number determine the exchange. For traffic between the network groups there is dialled before the subscriber number the routing number for the network group, this consisting of *0* plus two digits.

The dial impulses come in on wire *II*, see Fig. 3, over a relay set in the outgoing end of the intermediate exchange line. The number dialled is registered by the relay chain *R 11*—*R 16*. These relays, like relays *R 20*—*R 29*, operate in such a manner that when + V. C. is connected to the centre point only contact *I* is made, the remaining contacts being actuated only when + V. C. disappears and the short-circuiting of one of the windings ceases. When the first impulse series ceases *R 20* actuates all contacts and during the delayed release time for *R 2* there is closed a circuit to one of the contacts on *R 20*, which are connected to the contacts on *R 4*, or to other relays in the relay

Fig. 3 X 7872
Time zone meter principle in diagram



chain *R 21—R 29*. All contact points designated by the same letter are linked to each other.

From Fig. 2 it will be seen that all exchanges within the network group *086*, with the exception of those having subscriber numbers beginning with *9*, should be charged the next to lowest rate, rate 2. Thus, if the first figure *4* is received by the time zone meter a circuit is closed over the *b*-contact on the rate relay *R 4* to its coil. *R 4* is energised and connects in impulses, at a speed corresponding to rate 2, to outgoing wire *III* from the time zone meter. When the conversation begins these impulses are connected in to the subscriber's call meter. If the first figure *9* is dialled relay *R 21* is energised over contact *h* on *R 20*. Before the next impulse series is received the relay chain *R 11—R 16* is restored so that it can register the next figure. According to Fig. 2, calls to exchanges *91*, *93* and *94* are to charged as per rate *1*. After the second figure has been registered *R 4* is energised over its contact *a* and connects impulses for rate *1*. If on the other hand the second figure were *2*, *i. e.*, the number dialled is for subscriber's own exchange *92*, then *R 4* will be energised over its contact *g*. In this case no rate impulses will be connected in but a circuit will be made between the outgoing wires *III* and *IV*. By means of a relay not shown in Fig. 3 the routing of the connection for internal traffic is directed.

If another network group is to be called, the figure *0* is first dialled, this causing energising of *R 22*. From Fig. 1 it can be seen that for more than one network group the rate can be directly fixed by the next succeeding figure. For traffic to the network groups *011—019*, for example, the rate *6* will always be applicable. If *01* is registered *R 4* is energised over contact *f* and it connects in impulses for rate *6*. Nevertheless in many cases the rate cannot be determined by the second figure. For example, if the call is for exchange *42* in network group *093* the rate can only be fixed after the fifth figure has been received. The connecting process will then be such that when the second figure is dialled *R 25* is energised, when the third figure is received *R 28*, when the fourth figure comes *R 29* and finally when the fifth figure is registered *R 4* is actuated and connects in the corresponding rate impulses.

In principle this form of construction for time zone meters allows an unlimited number of rates to be employed and permits the figure combinations which determine the rate to contain any number of figures. However, if the conditions in this respect are very complicated there is required a large number of relays having the same function as *R 21—R 29*. By suitable numbering of the network groups and exchanges and by limiting of the number of rates, which is also desirable from other points of view, it should in most cases be possible to have time zone meters which do not require appreciably more of such relays than indicated on Fig. 3.

Time zone meters constructed on these principles will be so simple that they can with advantage be installed even at small terminal exchanges. If the time zone meters are centralised to junction exchanges extra expenses arise to determine whence the call comes and to transmit impulses over the junction circuits. It is then customary to have discriminating selectors at the terminal exchanges, among their functions being to re-route for internal traffic. These discriminating selectors must contain a large part of the equipment which is comprised in time zone meters.

As regards intermediate exchange calls the charging method proposed will certainly have a stimulating influence, as it makes available to the subscriber a new kind of telephone call, *viz:* intermediate exchange calls of short duration for a low charge. In Ericsson Review No. 2/1943 it was demonstrated with some specimen computations that it is the expensive manual charging method that is chiefly responsible for short duration intermediate exchange calls being disproportionately expensive, and that nevertheless this traffic is frequently rather poor business for the telephone administration. This disadvantage can best be remedied by automatisation, but only by introducing the charging here recommended based on actual duration of conversation would it be possible to attain really effective popularising and good yield from this traffic.

Registering of Duration of Conversation

C BERGLUND, TELEFONAKTIEBOLAGET LM ERICSSON, STOCKHOLM

U.D.C. 621.395.663.2:654.155.4

In registering the duration of calls by impulses to the call meters of subscribers from common time impulse units the times recorded for each individual call will contain errors. Nevertheles such errors compensate each other over a charging period, so that satisfactory accuracy of measurement is attained. This article indicates the magnitude of the deviations and the excess recordings that arise.

In automatic telephone operation the running costs are not governed by the number of calls executed but by their total duration. It is therefore right that with local calls it should be the total duration of calls and not the number of calls which constitutes the basis for charging.

It should be possible to employ a small electricity meter for each subscriber to measure the duration of the calls, thus giving the possibility of noting the exact time for each individual call. Such a recording device would, however, be more expensive and take up more space than the customary impulse driven call meters, which can advantageously be used for time registration as well, by arranging so that during the course of the call they receive, at fixed intervals, impulses from a common time impulse unit. The first impulse to the call meter then comes at some indefinite moment during the call and the time recording for a single call is thus not always exact. If the conversation terminates before the first impulse arrives the call meter will not record the call at all. But as during a charging period a large number of time recordings will occur for each subscriber the errors in the individual recordings balance each other, and with proper selection of impulse interval a satisfactory accuracy will be achieved. Doctor C Palm has published a mathematic investigation of the subject, from which the particulars below are derived.[1]

[1] Tekniska Meddelanden från Kungl. Telegrafstyrelsen 1941, No. 7—9.

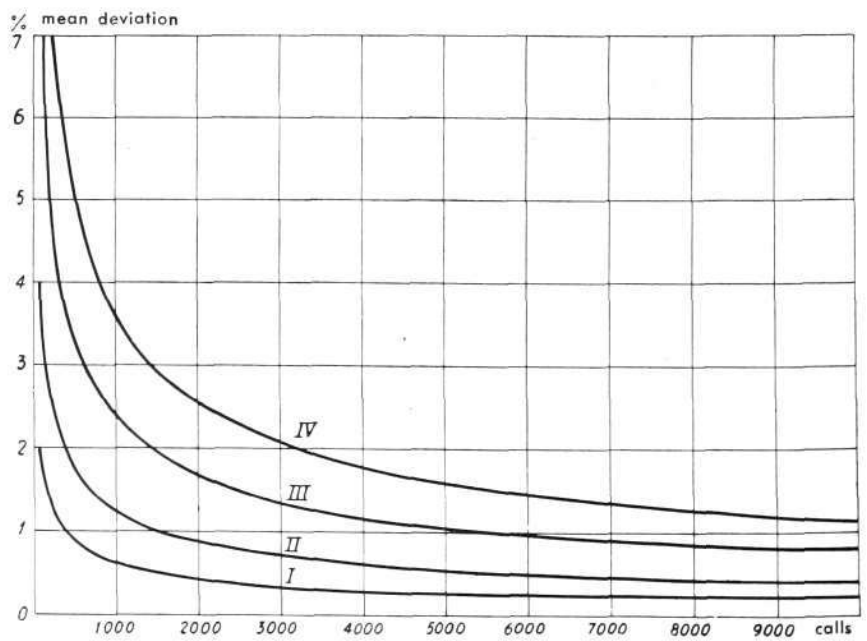


Fig. 1 X 6040

Meter readings' mean deviations in % as function of number of calls read

Curve I impulse interval/mean call duration=½
" II " " / " " " =1
" III " " / " " " =2
" IV " " / " " " =3

Accuracy of measurement is dependent both on the ratio between the length of the impulse interval and the mean duration of calls and on the number of calls during the period of time for which measurement accuracy is to be calculated. The estimated *mean deviation* for different values for these magnitudes may be read in Fig. 1. It is assumed that the mean deviation for one year is to be computed for subscribers with an average of 2000 calls of 2 minutes per year. If the impulse interval is put at 6 minutes, the impulse interval/mean call duration = 3 and there is read from curve IV for 2000 calls a mean deviation of 2.6 %. If the impulse interval is shortened to, *e. g.*, 1 minute considerably greater measurement accuracy is obtained. From curve I the mean deviation of 0.5 % may be read for this case.

However, it is not the mean deviation alone that is of interest but, above all, the excess recordings for which the subscriber is charged. Doctor Palm has therefore computed the probability of excess recordings of various magnitudes in relation to the mean deviation occurring, see Table I.

With the aid of the curves in Fig. 1 and Table I it is possible to compute the probability of a given excess recording being exceeded. Thus if there is sought an excess recording value which may only be exceeded in one case per 1000 (i. e., with the probability 0.001) there is obtained by interpoliation in Table I a value of $z = 3.1$. In the above examples with mean deviation 2.6 % or 0.5 % there is then obtained in one case per 1000 excess recordings of $3.1 \times 2.6 = 8.06$ % or $3.1 \times 0.5 = 1.55$ %.

Generally a subscriber is required to bind himself for one year for a telephone subscription and it is therefore the error recording during one year's time that is particularly important. Usually however a subscriber retains the telephone subscription for many years, so that the over and under recordings for these years will compensate each other, and therefore in the long run the amounts charged will agree still more with what the subscriber ought by rights to have paid.

Charges are usually paid by quarter. There is therefore a certain importance that correct charges should be debited each quarter, as the subscriber might possibly observe variations in amounts debited from quarter to quarter. The error recording for such a shorter period would naturally be relatively greater than for a whole year. In the above example there is obtained a traffic of 500 calls per quarter. The mean deviation is then read from the curves IV and I in Fig. 1 to 5.2 % and 0.95 % respectively. In one case per 1000 the excess recording is exceeded by $3.1 \times 5.2 = 16.1$ % and $3.1 \times 0.95 = 2.9$ %.

The probability of excess recordings of such order of magnitude that will be noticed by the subscriber should be kept small and it may therefore be convenient to fix the excess recording value at not more than one case per 10000, *i. e.*, with the probability 0.0001. In this case there is obtained from Table I $z = 3.9$, which gives 28 % higher excess recording value than if excess could occur in one case per 1000.

The above method for time charging can be used with advantage also for trunk calls with time zone charging, in which case the length of impulse interval varies according to the zone. As the impulse intervals will be shorter and the average call duration be longer with trunk calls than with local calls the percentage of deviation per call will be appreciably lower for trunk calls than for local calls. It should also be observed that as the impulses to the call meters for trunk calls are added to the impulses for local calls, the total percentage of error falls.

Account should also be taken of the fact that the telephone charge should consist of a fixed charge together with the variable charge which is governed by the duration of call. The percentage of error on the variable charge debited represents therefore a smaller percentage of error on the total charge debited. The smaller the traffic a subscriber has the larger will be the percentage of

error on his call meter. As, however, with a subscriber having small traffic the fixed charge constitutes proportionately a larger part of the total charge, the error in proportion to the total charge will usually not be greater for such subscribers than for subscribers with heavy traffic and the total error debited will be relatively independent of the subscriber's traffic.

When introducing the above described system of debiting according to duration of calls there should first be decided the accuracy of measurement that is considered necessary. The impulse interval is then selected to ensure the measurement accuracy decided upon. Nevertheless the impulse interval should not be made too short, as this strains the call meters unduly. The impulse interval should not be so short that there is risk with some subscribers that the figure drums of the call meter during the period of reading go beyond the positions they had at the beginning of the period. Call meters are generally made with four drums allowing of 9999 impulses being received during a reading period. If such call meters are employed and these are read once a quarter it would for this reason not be advisable to make the impulse interval for local calls shorter than 1 minute. Moreover a completely satisfactory accuracy of measurement is obtained if the impulse interval is made longer. If greater measurement accuracy is required, necessitating the introduction of shorter interval, meter reading may be done for subscribers with heavy traffic more than once per quarter or call meters with five figure drums may be installed.

When charging according to number of calls established, no matter what the duration of call, there occurs a certain uncertainty in the recording, as calls that never lead to real conversation, *e. g.*, calls to P. B. X., are recorded as established calls. To allow for this there is sometimes made a deduction of a certain percentage, *e. g.*, 5 % of the number of recordings, when calculating the charges for debiting.

If, in conclusion, it is considered essential that even small excess recordings shall only occur to small extent, it is possible even with debiting according to duration of calls to introduce a deduction. For example, if the impulse interval has been fixed so that a subscriber with normal traffic in one case per 10000 gets excess recording greater than 5 % and a deduction of 5 % is made, this means that for such subscribers excess recording in general only occurs in one case per 10000. In reality it is obviously rather immaterial whether the deduction is made, as in that case the charge per unit should be put 5 % higher than if no deduction were to be made.

Table I. Probability S for an excess recording greater than z times mean deviation

z	S	z	S
0.0	0.50	3.0	0.0014
0.2	0.42	3.2	0.00069
0.4	0.34	3.4	0.00034
0.6	0.27	3.6	0.00016
0.8	0.21	3.8	0.000073
1.0	0.16	4.0	0.000032
1.2	0.12	4.2	0.000013
1.4	0.081	4.4	0.0000054
1.6	0.055	4.6	0.0000021
1.8	0.036	4.8	0.00000080
2.0	0.023	5.0	0.00000029
2.2	0.014	5.2	0.00000010
2.4	0.0082	5.4	0.000000034
2.6	0.0047	5.6	0.000000011
2.8	0.0026	5.8	0.000000004
		6.0	0.000000001

8-Channel Carrier Systems for Unloaded Cables

S JANSON, ROYAL BOARD OF TELEGRAPH, & R STÅLEMARK, TELEFONAKTIEBOLAGET LM ERICSSON, STOCKHOLM

U.D.C . 621.395.44

Older, loaded cables can after unloading be made available for carrier operation with frequencies up to 60000 to 65000 c/s.

Methods and apparatus for re-splicing the cable and for balancing the far-end crosstalk is treated, and a description of characteristics and design of the carrier equipment is given in this article, which will be continued in the coming number of this periodical.

General Principles

When the developing work of modern multi-channel carrier systems for non-loaded cables was started in earnest, the interest was concentrated on so-called U-systems. These systems were designed for transmitting the same frequency band in both directions but on different cables, hereby getting around the difficulties with the near-end crosstalk. The number of channels was mostly 12 or 16 and the frequency range 12—60 kc/s. These systems have and will most certainly for a considerable length of time play an important part in the construction of the long distance network in different countries. The communication circuits obtained in this way are of high quality, and thanks to the short and practically constant propagation time within the frequency range of a channel, circuits with a length of 10000—20000 km can be connected without the propagation time being more than 50—100 ms.

The interest of later years, perhaps especially in Sweden, has turned to a new field of application for carrier systems of similar types. Sweden has a large network of loaded cables which have been used for two-wire circuits on long distances. Some of these cables were installed in the early 1920's. The cut off frequency was low, 2300 c/s, and the loading interval large, 2700 m. These circuits were thus in modern meaning of poor quality regarding transmission properties and improvements sooner or later were unavoidable. As at the same time the traffic on the state cables showed a tendency to increase steadily and this at a quicker rate than what was expected, all reserves were soon exhausted and one faced the problem of quickly bringing forth new circuits.

It was then necessary to investigate, if these cables after unloading could be used for carrier systems and in such a case to choose a suitable system. Also abroad, in U. S. A. and Germany, one had got on to the same line of thought, but the lines of development have to a certain extent gone different ways on account of local conditions. In Sweden there is usually only one cable along the same route. One can therefore not use the usual U-system like in the U. S. A., as it requires two separate cables. On several routes, as for example Stockholm—Gothenburg, there are, however, two cables but they follow *different* routes, and the number of repeater stations would then have to be doubled, which was not considered suitably neither in economical nor technical point of view.

After the measurements of one unloaded test-section of the old state cable Stockholm—Gothenburg had shown, that this cable was very well suited for carrier operation after resplicing and balancing were made over again

according to methods which are described elsewhere in this paper, a carrier system was designed to work on one cable, the so-called 8-channel system. In this system the two directions of transmission are devided into two frequency ranges, one 8.4—33.6 kc/s and one 38.4—63.6 kc/s. In each group 8 channels are transmitted. By dividing into groups the two directions of transmission can be separated by means of filters instead of using two cables.

At a light study it may seem, as if this method of arranging the carrier systems for non-loaded cables, always ought to be economically more favourable than the U-system, but this is not the case. On one side stands the cost of one cable against on the other side the cost of the filter equipment and the fact that the amplifying unit is not fully employed. In comparison with a 16-channel system for instance each unit amplifies only half as many speach channels. For news projects when also the cable is to be laid, this solution has shown, at a closer investigation, not to be economically justified, as the two-cable system comes far lower in cost.

In the present case, where the cable already is installed, and where the unloading, re-splicing and balancing are the only charges on the cable account, the 8-channel system is, however, superior. In a border-line case the 8-channel system can probably compete with the U-system even on new installations such as sea-cables and special deep-sea cables with pressure protection.

Finally, it must be pointed out the great importance at the present time with the shortages of raw material, that a large network of 8-channel systems can be manufactured within the country without drawing on the stocks of copper and lead. The project of extension for new facilities based on this carrier system which the Royal Swedish Telegraph Administration now has started and plans to continue, would be impossible to realize under present conditions if it assumed laying new cables, loaded or of carrier-type.

Choice of Frequencies and Levels

The usual U-system, 12- as well as 16-channel systems, works as mentioned within the frequency range 12—60 kc/s. Between the two groups, one for each direction, a certain frequency band must be left unused between the two groups, so that the filters without mobilizing too many elements can give the required attenuation. The larger this band is the lower the cost of the filters. At the same time, however, the useful transmission frequency range becomes smaller, *i e.* a less number of circuits can be operated. For several reasons it is not good practice to use higher frequencies than 60 to 65 kc/s. The circuit loss will be so great that more than two unattended repeater stations must be placed between those for the loaded circuits existing repeaters, and this one wants to avoid when considering station supervision. Furthermore the difficulties to reduce the far-end crosstalk in the cable by balancing increases at higher frequencies. The lower frequency limit can without inconvenience be fixed lower than 12 kc/s but on account of the risk of interference to any low frequency radio program circuits, it ought not to be set much lower. Furthermore the phase velocity decreases at lower frequencies.

Based on the above the aproximate frequency range was fixed at 8—64 kc/s.

When choosing between the much discussed 3000 or 4000 c/s-band one stands between Scylle and Charybdis. The 4000 c/s interval recommended by C. C. I. F., 1938, for international circuits, would only allow six channels to be placed within the given frequency band.

With the 3000-interval the number of channels will be eight, but then there is no possibility of transmitting the cable-circuit band recommended by C. C. I. F. which would be a disadvantage even if the majority of all circuits are national. From an economical stand point the difference between six and eight circuits is of decisive importance.

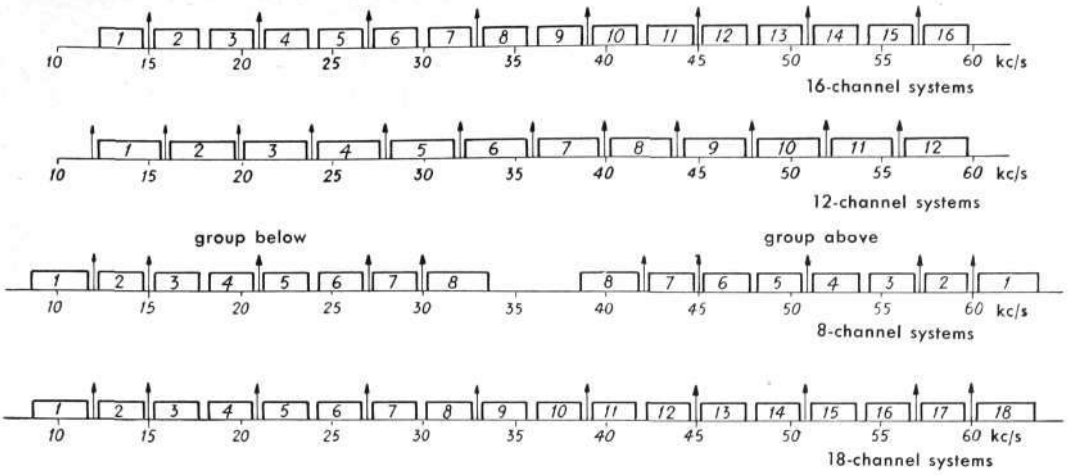


Fig. 1 X 7378
Frequency allocation of 16-, 12-, 8- and 18-channel systems

The final solution means a compromize, as six of the circuits are arranged with 3000 c/s-interval while two have the band of 4000 c/s recommended by C. C. I. F. and consequently can be used for international circuits.

The 8-channel system frequency allocation is shown in Fig. 1, which for the sake of completeness also shows the frequency allocation of all the carrier systems that L M Ericsson at present manufactures for non-loaded cables. In this diagram it is shown, that the 8-channel system is arranged in such a way that 12 of its 16 frequency bands coincide with corresponding frequency bands in the 16- and 18-channel systems. Those filters, modulators and demodulators in the terminal equipment which handle the same frequency bands in the different systems, are identical as level conditions, and loss and gain requirements etc. have been kept alike.

As the number of channels is less one ought to be able to transmit with higher levels than in the 12-, 16- and 18-channel systems, without risk for intermodulation in the common amplifiers, but several reasons go against this. The high frequency output level has been chosen alike for all systems, being + 0.5 neper (272 mW) for each channel when the input level is equalled to zero level (1 mW). The high frequency amplifiers, which are of the same type for all these systems, become therefore over-dimensioned as employed in the 8-channel system as regards the output power. This condition has, however, been taken as a pretext to work the amplifiers in the unattended repeater stations with a lower anode voltage, 85 V, instead of the usual voltage of 130 V. Hereby are essential advantages gained. The new power supply equipment for these stations can be made more simple, the anode current drain is 60 % of normal and the life of the valves which is of greatest importance for the dependable operation of the unattended repeater stations, will increase considerably. The length of the repeater section has been chosen so that the circuit loss amounts to not more than 7 nepers at 64 kc/s, which corresponds to an input level to the amplifiers of — 6.5 nepers.

Direct Crosstalk

In a carrier system of this type the transmission circuits must meet certain requirements as regards freedom from crosstalk and from interference. In this case special care must be taken to improve the crosstalk on account of the cable lines from the beginning not being intended for carrier transmission. In the following, different kinds of crosstalk that can occur, and methods for improving it, will be described, primarily with reference to the conditions of the old trunk-cable Stockholm—Gothenburg. On this cable 10 quads were arranged for carrier operation. As all quads in the cable were loaded, the loading coils of the selected quads had to be removed to allow transmission of the rather high frequencies of the 8-channel system. It was also found suitable to improve the crosstalk between the cable pairs affected by the

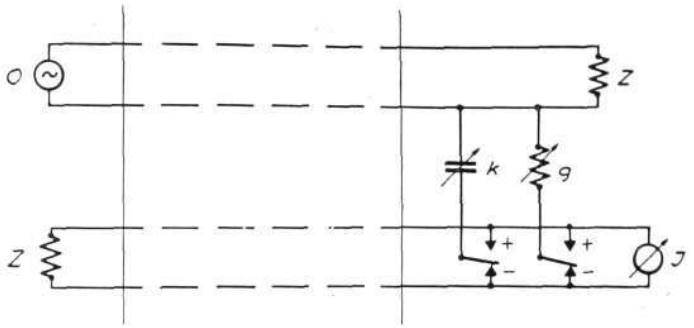


Fig. 2 X 6050
Schematic of far-end crosstalk compensation
0 oscillator
1 indicator instrument
2 terminating impedance
k, g variable elements of unbalance

removal of the loading coils. As different frequency bands were chosen for each direction of transmission only the direct far-end crosstalk was of importance. Near-end crosstalk may however be of importance for indirect crosstalk.

Direct crosstalk between two circuits arises through inductive and capacitive unbalance conditions. The terms for the relation of the crosstalk to respective unbalance conditions are as known

$$\begin{cases} v_M = \dfrac{j\omega M}{2Z} \cdot V \\ v_k = \dfrac{j\omega kZ}{8} \cdot V \end{cases}$$

In these terms, M and k stand for inductive and capacitive unbalance respectively, while Z is the characteristic impedance of the circuit. V stands for the voltage in the disturbing circuit, and v_M and v respectively denote crosstalk voltages in the disturbed circuit.

Through comparison between these terms it is evident that the crosstalk voltages increase in straight proportion to the frequency, whether they are caused by capacitive or inductive unbalance. On the other hand the impedance characteristics differ according to the terms above. This is the reason why the inductive unbalance has a greater effect than the capacitive unbalance in non-loaded cable circuits, while the condition is the opposite for loaded circuits. Estimatively $Z = 130$ ohms for nonloaded cable circuits, while for loaded circuits of the type in question this figure was about 1300 ohms for the side-circuits. When removing the loading coils the impedance characteristics fall in proportion 10:1, by which the relation between the inductive and the capacitive crosstalk voltages rises in proportion 100:1.

In connection with the removal of the loading coils the unbalances were measured on the loaded sections. The measuring arrangement for this is shown in Fig. 2. As seen in this figure the far-end crosstalk is compensated on the measured section between the two pairs by means of connecting variable

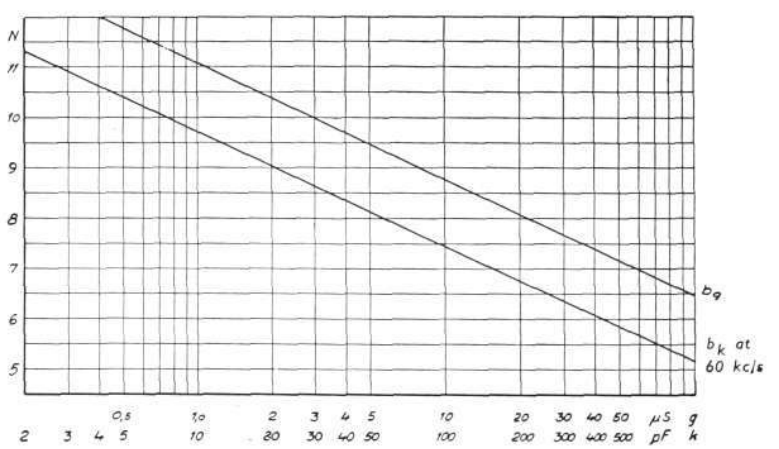


Fig. 3 X 6051
Relation between crosstalk attenuation (b_k, b_g respectively) and unbalance figures (k, g respectively) in nonloaded cable pairs

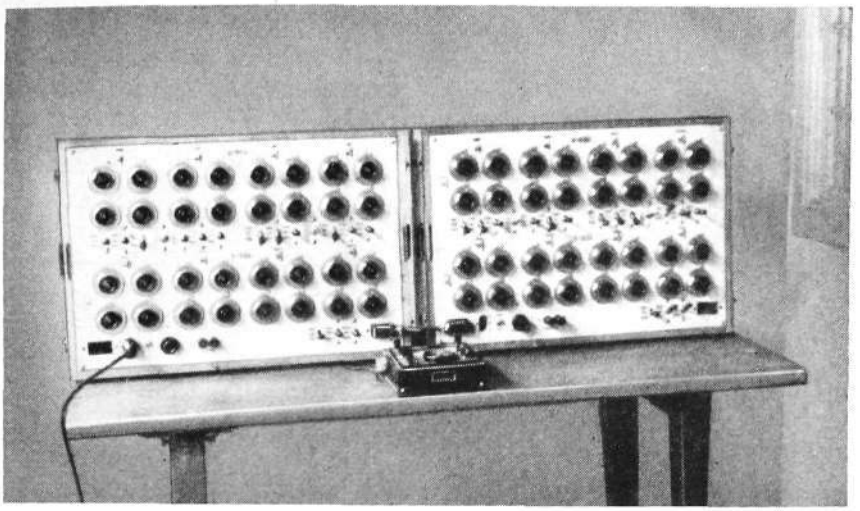


Fig. 4 X 6052
Instruments for splicing calculations

leakage resistance and capacitive unbalance. These measurements were as a rule made with 60 kc/s. When the far-end crosstalk between the two circuits, usually caused by inductive unbalance, becomes compensated with a capacitive unbalance, k, usually also a real unbalance is required, g, owing to the fact that z is imaginary.

When measuring unbalance with 60 kc/s on the loaded sections, sometimes very high figures of unbalance were obtained, within-quad as well as between different quads. The highest obtained figure of unbalance on one loaded section (2700 m) thus reached some over 300 pF, being equivalent to a crosstalk attenuation of about 6.3 nepers as shown in Fig. 3. The purpose was to arrange special end-balancing of the far-end crosstalk by connecting compensating elements of unbalance on all repeater stations. It was, however, for several reasons desirable to try to improve the unbalances also on the cable sections in connection with the splicing at the loading points, so that the unbalances in the different sections as far as possible would compensate each other. The grounds for doing so will be given in the section about indirect crosstalk.

At the usual capacitive balancing only the capacitive unbalances *within* the quads will be lowered. For a group of 10 quads the number of unbalances to be considered are 30 on each side of the splice. When balancing side-side within and between quads the number of unbalances are $190\left(=\frac{20 \cdot 19}{2}\right)$ on each side of the splice. The number of splicing possibilities for 10 quads, if the quads are not split, are given partly by $\underline{|10}$ possiblities in selecting quads on both sides and partly by 8 possible splicing plans for each quad. The total number of splicing possibilities are thus

$$\underline{|10} \cdot 8^{10} \simeq 2^{52}$$

This means that e. g. sign could be chosen arbitrarly for 52 combinations. When balancing, the 30 unbalance figures within the quads, in addition a certain amount of liberty is given for combining, the unbalancing figures from both sides of suitable values. When balancing the 190 unbalances within and between the quads apparently not even the sign for more than a fraction of the combinations can be free of choice. It is easily understood that it is more difficult to systemise the splicing calculations in this latter case. At the crosstalk measurements in question the unbalance figure could then not be brought down to zero in the same way as at the usual capacitive balancing, and a final end-balancing of the repeater section was therefore required. By doing the balancing in connection with the splicing, the far-end crosstalk was improved on the average by about 1 neper, at which the minimum figures were improved considerably.

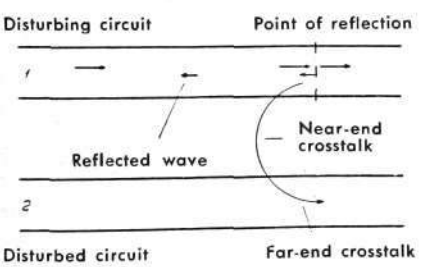


Fig. 5 X 4309
Arise of reflected near-end crosstalk

The new repeater sections covered on the average 11 loading sections. These loading sections were spliced in succession into two half-sections while the measured direct far-end crosstalk at 60 kc/s was taken into consideration. At

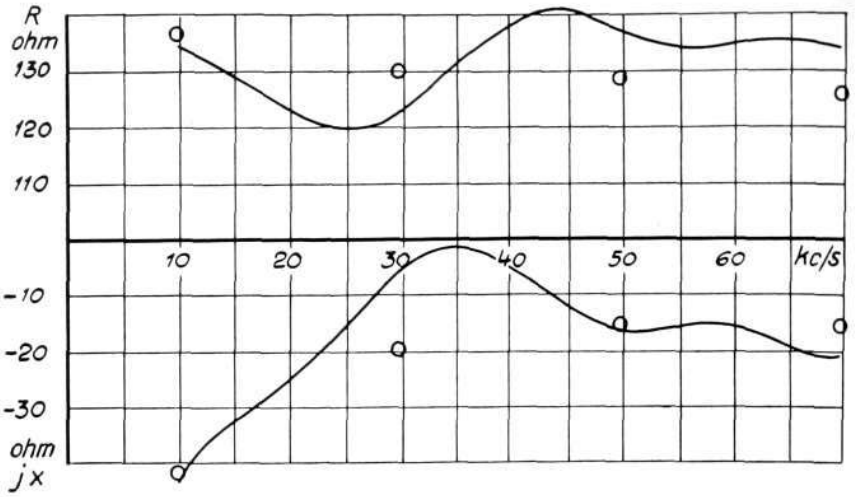


Fig. 6 X 6053
Typical impedance characteristics for nonloaded, 1.3 mm side circuit in trunk cable Stockholm—Gothenburg
O mean value of total circuits

the mid-point splice of the repeater section more extensive measurements were performed, and when making this splice the indirect couplings were chiefly taken into account, about which more comes in the following.

In order to simlify the splicing calculations a special calculating machine was made, see Fig. 4. This machine contains a number of potentiometers on which respective unbalance figures can be set, and keys for testing the different splicing plans. The readings on the attached instrument give that splicing plan which gives the best R. M. S. value of the resulting unbalances. Despite the possibilities of adding and subtracting related unbalance figures by the splicing procedure, it has been shown that the criterian of the best splicing plan in the above mentioned respect is derived from the product of the related unbalances. The calculating machine is therefore designed in such a way that the meter deflection according to the above is a measure of the sum of these products for the different unbalances, at which signs are depending on the splicing plans.

Indirect Crosstalk

The direct crosstalk is, according to above, dependent on the frequency in a simple relation, and furthermore, the direct crosstalk which is caused by an unbalance, can be completely compensated with a reversed unbalance at a point free of choice on the circuit on the assumption that the two circuits have identical transmission properties. This, however, is not the case with the direct far-end crosstalk, which among other things is dependent on its frequency characteristics being comparatively complicated.

Indirect far-end crosstalk between two circuits can be caused by reflected near-end crosstalk, by double crosstalk over other circuits and by differing transmission properties of the two circuits.

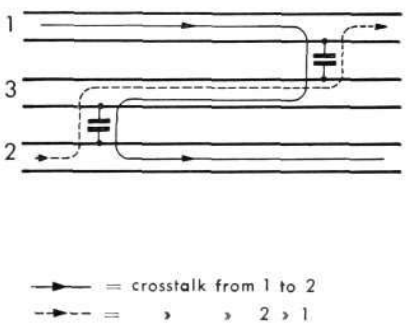


Fig. 7 X 4324
Indirect far-end crosstalk over third circuit

How reflected near-end crosstalk arises is shown in Fig. 5. The direct wave in circuit 1 (disturbing) gives at the point of reflection the rise to a reflected wave which in its turn through near-end crosstalk to circuit 2 (disturbed) causes indirect far-end crosstalk, in the latter.

Each splicing point can become a point for reflection, when the near-by pairs in respective splicing sections have comparatively different impedance characteristics. This condition is shown with the measured impedance curves of already spliced circuits, of which Fig. 6 gives an exemple. Very large differences can evidently occur between separate pairs. Points of reflection are furthermore found at the repeaters, when their input and output impedances do not entirely correspond with the differing impedances of the circuits. These points of

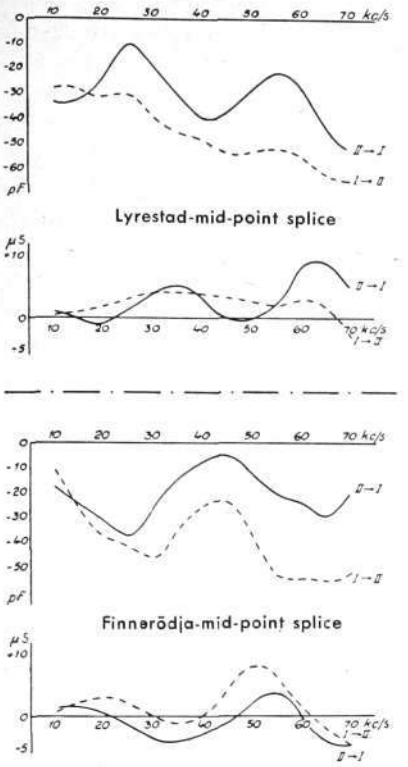


Fig. 8 X 4310
Far-end crosstalk coupling within-quad (frequency characteristics of parts sections)

reflection are of special importance, when the near-end crosstalk its deteriorated at these points by connecting extra elements of unbalance at the end-balancing. This fact is one of the reasons why crosstalk balancing is done on the line. In this way the size of the extra elements for unbalance is brought down.

As is shown in Fig. 7 indirect far-end crosstalk can also occur between two circuits, 1 and 2, through double crosstalk over a third circuit.

Then the crosstalk current from circuit *1* to circuit *2* will pass a considerably longer way than corresponding currents from circuit *2* to circuit *1*. Corresponding crosstalk attenuations can therefore also be quite different. When measuring the unbalances on a longer section with the measuring arrangement as in Fig. 2, different figures can as a rule be obtained if the sending pair is interchanged with the receiving pair. The difference between these unbalances, the so-called coupling-difference, is a measure of the direct couplings. It is obvious that coupling differences are also caused by other indirect couplings, for instance through reflected near-end crosstalk.

According to the foregoing a direct coupling between two circuits can be entirely compensated by an equally great reversed coupling at some other point of the circuits, provided they have identical transmission properties between the coupling points. If this condition is not fullfilled, but the two circuits then have different attenuation or different propogation time, full compensation cannot be obtained. To make improvements in this respect with given properties of the circuits it is evidently necessary to keep the line sections between the splicing points, with each other compensated unbalances, as short as possible, *i e.* the unbalances have to be brought down as far as possible when splicing the repeater sections.
In addition to this reason for making the crosstalk balancing out on the section, the risk of making the near-end crosstalk to high if only end-balancing is used has previously been pointed out. Futhermore the following reason can be given; if the balancing is made only at the end-points, the balancing elements as an average become bigger, and the risk for variations in them on account of the temperature etc. thereby also becomes greater. It can furthermore be expected that unbalances on a cable section in general can be better compensated all over the frequency range with unbalances on another cable section than with condensers and resistances.

As mentioned previously the different sections of a repeater section were spliced in succession into two half-sections taking the measured direct unbalances at 60 kc/s into consideration. These half-sections were then spliced at the mid-splice of respective repeater sections after more extensive measurements of unbalance at different frequencies and chiefly considering the indirect couplings. These couplings can, as a matter of fact, even to a certain degree be reduced when splicing, despite they sometimes go under the name »couplings not possible to balance». The indirect unbalances according to the above give rise to coupling difference and cause, furthermore, rather complicated frequency characteristics for the far-end crosstalk. If therefore the resulting unbalances between two pairs are measured at different frequencies with the measuring arrangement as in Fig. 2 coupling figures varying with the frequency are obtained, which furthermore are different for the two measuring combinations (crosstalk from circuit *1* to *2* and from *2* to *1* respectively). In Fig. 8 a typical example is shown of this which is taken from measurement on the section Lyrestad—Finnerödja. The frequency variations and the coupling differencies were so great, especially for the combinations within the quads, that relatively poor final results would have been obtained for the far-end crosstalk after end-balancing, if nothing had been done to improve these conditions. Trials were therefore made with good results to match the quads on respective half-sections, see Fig. 8, so that after the splicing both the frequency variations and the coupling differences were decreased if possible.

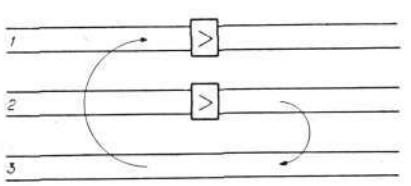


Fig. 9 X 4311
Far-end crosstalk over third circuit at intermediate repeater (feed-back)

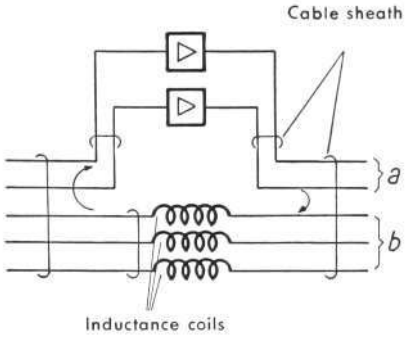


Fig. 10 X 4325

Arrangements at intermediate repeater station for suppressing feed-back

a carrier circuits
b loaded circuits

In addition to the above described types of couplings there is still another possibility for indirect crosstalk, and that is interacting crosstalk over a third circuit at the intermediate repeaters. The conditions in this case are shown in Fig. 9. This type of indirect crosstalk is evidently a very serious matter as on this account a very strong crosstalk can occur owing to the difference in level between the points of coupling (from the high level side of circuit *2* to the low level side of circuit *1*). This difference in level can be as high as 7 nepers equivalent to the highest loss for the transmitted band. As about 9 nepers is desired as an average of the effective crosstalk attenuation between the different circuits, the measured crosstalk between outgoing and incoming pairs in a repeater station, the so-called feed-back, must evidently come up to about 16 nepers. Special steps must be taken to meet these rigorous requirements. A crosstalk attenuation of 16 nepers is at 60 kc/s equivalent to a capacitive unbalance of only 0.02 pF. To begin with, incoming and outgoing pairs therefore had to be laid in two separate cables. When laying the pairs in the same cable hardly higher figures than about 9 nepers would have been obtained. According to Fig. 10 these precautions, however, are not enough, but special arrangements must also be made for preventing the crosstalk currents to be induced from the outgoing to the incoming carrier pairs over the passing loaded circuits. In Fig. 10 these arrangements have been shown as inductance coils in the passing circuits, which coils therewith suppress the crosstalk currents of higher frequencies. In reality the new intermediate repeater stations have been placed at loading points and the two cables to the intermediate station were spliced on each side of the loading point. The loading coils prevent hereby the crosstalk currents from getting through over the passing, loaded side- and phantom circuits. This is, however, not sufficient, as also by-passing phantom circuits of a higher order may allow interacting crosstalk. According to the measurements the crosstalk attenuation came up about 12 nepers at 60 kc/s without extra coils. From performed measurements its seems as if twisted circuits cause this crosstalk. One branch of this twisted circuit is formed of one quad (the four conductors in parallel) and the other branch is the lead sheathe (or earth). Such a circuit is ony loaded with the mutual inductance of the loading coils which is in the order of 1 mH.

In order to improve the feed-back attenuation it was necessary to insert extra inductance coils in the twisted circuits. At each intermediate repeater station a so-called suppressing coil box therefore was inserted which contains coils with four-wired windings which were spliced into the loaded quads. The coils introduce an inductance of about 30 mH in the twisted circuits and they are tuned to parallel resonance right below 60 kc/s. These coils have a very slight effect on the v. f. side- and phantom circuits. After insertion of these coils an improvement of the feed-back attenuation with about 5 nepers at 60 kc/s was obtained which was quite acceptable. The measured feed-back attenuation (R. M. S. values) after the insertion and the required amplification at different frequencies are given in the table below.

f kc/s	10	30	60	64
Feed-back attenuation nepers	15.9	15.2	17.4	16.4
Amplification = max. cable loss nepers	3.4	4.7	6.7	7.0
Difference neper	12.5	10.5	10.7	9.4

The difference given in the table is equivalent to the effective crosstalk that is caused by the feed-back and apparently these figures are sufficient.

Modern Radio Loudspeakers

E LINDSTRÖM, SVENSKA RADIOAKTIEBOLAGET, STOCKHOLM

U.D.C. 621.396.623.7

Svenska Radioaktiebolaget took up the manufacture of electro-magnetic loudspeakers in 1928 and has continued with it since then, applying and improving the principles introduced with the dynamic loudspeaker. The following article gives an account of a number of problems connected with the manufacture of loudspeakers and in addition gives a short description of the design and manufacture of Svenska Radioaktiebolaget's latest types of radio loudspeakers.

Right up to 1928 horn loudspeakers had been predominant in the domain of loudspeakers. The sound system in these funnel loudspeakers consisted of an enlarged telephone receiver of electro-magnetic type. Unfortunately the self-resonance for the vibrating device lay right between the speech and music registers to the disadvantage of high and low frequencies. Coupled to the sound system was a horn of sheet-metal or wood, often shaped for its appearance, which directed and strengthened the sound. The valves of old battery receiving sets could not deliver any distortion-free capacity and the music reproduction was therefore cracked and not enjoyable.

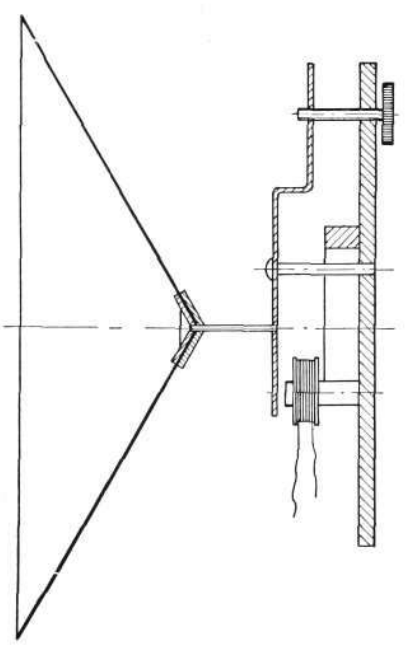
In conjunction with the design of new types of valves and the construction of receiving sets for connection to the lighting mains, the amplification and the output capacity could be increased. In addition the cone loudspeaker quickly made its appearance. By replacing the circular sheet-metal diaphragm by a soft iron tongue, to which was attached a cone of cardboard, see Fig. 1, it was possible, while building the whole system into a wooden case, to lower the self-resonance of the system. As regards music the quality was acceptable, but as the self-resonance coincided with the lower voice frequencies 200—300 c/s the intelligibility of the speech was difficult, especially as frequencies over 2000 c/s were entirely lacking.

In 1928 Svenska Radioaktiebolaget, after prolonged experiment, were ready with their first loudspeaker design. The magnet system was of simple construction with adjustable tongue and the material for the cone consisted of drawing-paper, stamped out, pasted over forms and sprayed with cellulose laquer. Instead of having the cone edges gummed in the case, wich had been the practice hitherto, it was allowed to swing freely being attached only by four fabric strips. This arrangement, together with the small depth of the loudspeaker case, served to reduce considerably »boom-boom» resonance.

By fitting the radio receiving set itself in the loudspeaker case there was then introduced the »all-in-one» principle, and in this way the wireless receiver obtanied its modern shape.

If it is a question of transmitting large capacity, the electro-magnetic loudspeaker will be too small with poor acoustic efficiency and doubtful reproduction. In order that the music shall be enjoyable, the loudspeaker should have a fairly straight frequency curve between 100 and 4000 c/s. The dominant downwards causes »boom» in speech and makes a violin seem like a cello. Peaks in the upper register make the music thin and without acoustic space. Should these peaks lie between 1500 and 2500 c/s moreover they coincide with highest range of sensitivity of the ear and have an irritating effect.

In America Rice-Kellog and others succeeded in designing the type of loudspeaker which ever since then has been practically the only one: the dynamic loudspeaker.



X 4306

Fig. 1
Cross-section of loudspeaker

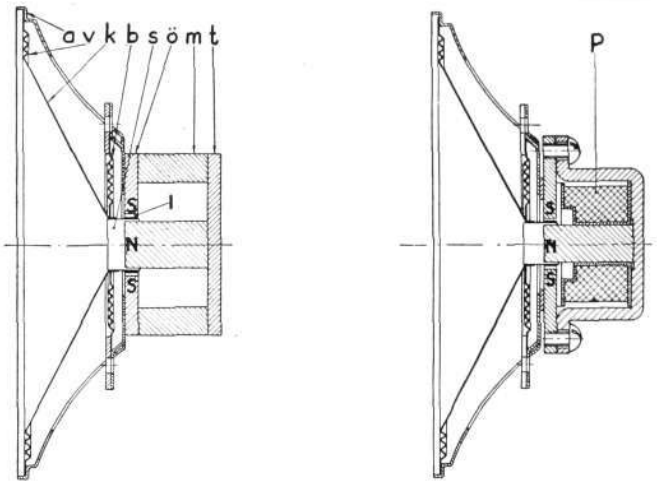


Fig. 2 X 6044
Cross-section of dynamic loudspeaker
left, with permanent magnet
right, with magnetising coil
a basket edge
b spreader
k cone
l air-gap
m magnet
p magnetising coil
s cylindrical coil
t core with under-piece
v folds
ö upper piece

The principle of this will be seen from Fig. 2. The cone, *k*, is fitted towards the apex with a cylindrical coil, *s*, which lies in the circular air-gap, *l*. At the base the cone is enlarged and provided with folds, *v*, and pasted to the basket edge, *a*. To ensure that the cone moves perfectly parallel with its axis, it has at the apex a guide, the spreader *b*. The air-gap, *l*, is traversed by a magnetic field generated by a permanent magnet, *m*, or by a magnetising coil, *p*, see Fig. 2 right. The polarity will be, *e. g.*, *N* at the core *t* and *S* at the edge of the hole in the upper piece *ö*. If the cone coil receives an alternating tension it will move to and fro in the air-gap in time to the A.C. tension. In these movements the cone accompanies its coil and, with sufficiently high frequency, generates a tone.

Design

Before designing a loudspeaker one should be clear regarding its range of employment. The aim is not always to produce a »good» loudspeaker, *i. e.*, a loudspeaker which reproduces all audible frequencies with the same intensity. A good loudspeaker should have fairly straight frequency curve, 40—5000 c/s. When great demands regarding reproduction are imposed, such as with sound films, a number of different loudspeakers are used, each one covering its allotted part of the register.

For a battery receiver, *e. g.*, a portable radio, it is necessary before designing the loudspeaker system to investigate what output capacity and what degree of distortion the apparatus has. Distortion is a deformation of the curve originally sinus shape, which gives rise to overtones that have an irritating effect on the ear. A portable radio should be made as light as possible and should be cheap in operation. The valves and batteries must be as small as possible and the sound quality suffers. Nevertheless, if the loudspeaker is suitably designed the sound can still be surprisingly good. For example, the cone paper may be fitted with resonance folds, causing the loudspeaker to lose its ability to reproduce high frequencies and the undesirable overtones arising in the apparatus are not heard. In order that the register shall be well balanced, such a loudspeaker should not reproduce too much base and the cone will thus be small and rigidly suspended.

In a mains wireless receiving set of ordinary size there often arise case resonances. These should not be amplified by the loudspeaker, but the aim should be to make a »hole» in the register for the resonance frequencies in question.

How large shall the loudspeaker be for a given receiver case? The lower cut-off frequency is the deciding factor.

If a loudspeaker system is placed on the table and allowed to play, no base whatever will be heard in spite of the cone giving large amplitudes. The sound waves radiated from back and front of the cone have a mutual phase shift

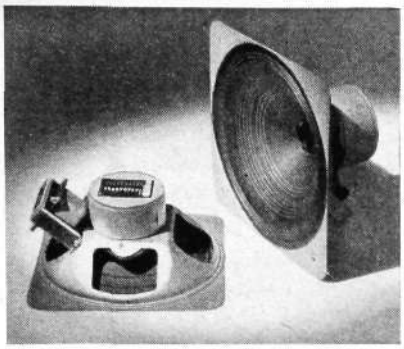


Fig. 3 X 4308
Loudspeakers HPU—918 and HPU 1021 F

of 180° and therefore cancel out each other. If the loudspeaker system is fitted in the hole of a sound screen, about 1 m square, there will at once arise a full sound, the contrabase is heard clear and soft and the loudspeaker attains its full efficiency. The length of the screen side should theoretically be equal to half the longest wave length to be heard, *i.e.*, the lowest frequency. If the loudspeaker is to reproduce clearly 100 c/s, the side length should be 1.5 m. In practice, however, considerations of space require one to be satisfied with much more modest dimensions. Moreover it has been found that the ear is generally satisfied with the first overtones of the basic tone.

The measure of a loudspeaker's base reproduction is what is known as suspension resonance. This is governed by the rigidity of the cone and the spreader, *i. e.*, the mobility of the whole cone system. The moulding of the cone is then made with the edge thinner than the remainder of the cone material. The spreader is corrugated in circles and must not be allowed to lose its springiness with temporary overload.

A large cone reproduces a given amplitude of base frequencies better than a small one, on account of the larger volume of air it sets in motion. If the smaller cone were to reproduce the same frequency with the same strength the amplitudes would be so great that there would be risk of the cone coil jumping out of the air-gap or causing distortion. It is therefore bad economy to fit a large and certainly more expensive loudspeaker in a small case with poor screening, with resultant inferior base reproduction.

Frequencies from 1000 c/s upwards have a marked direction effect. If one is at the side of the apparatus the S-sound, for example, will be heard much worse than right in front.

The magnetic field in the air-gap is generated either by a permanent magnet or by a small D.C. fed magnetising coil. The permanent magnets are circular and consist of an alloy of iron, nickel and aluminium. The intensity of a magnet system is expressed in the number of lines of force per cm² that flow through the air-gap. The measurement unit is called Gauss. The greater field intensity the magnet has the greater distortionless acoustic effect and the straighter the frequency curve it is possible to get from the loudspeaker. But as the price per kilo of the magnet steel is high and the weight rises with the square of the field intensity, the aim should be to be economical with lines of force. The upper piece, the under piece and especially the core must have small remanence and are made of soft iron. The air-gap is made as small as it can conveniently be. The cone coil in Svenska Radioaktiebolaget's loudspeaker has 0.20 mm air at each side.

In apparatus for alternating current, field-fed loudspeakers are most often used. The magnetising coil may be used as screen choke for the rectified A.C. The tension field over the coil is sufficient to ensure a large enough field in the air-gap. The unscreened A.C., which is superimposed on the magnetising current would, were there no compensating, induce tensions in the cone coil, which are heard as noise in the loudspeaker. On account of this there is laid over the magnetising coil a winding, connected in series with the cone coil and so wound that the induced tensions in it and the cone coil counter balance each other.

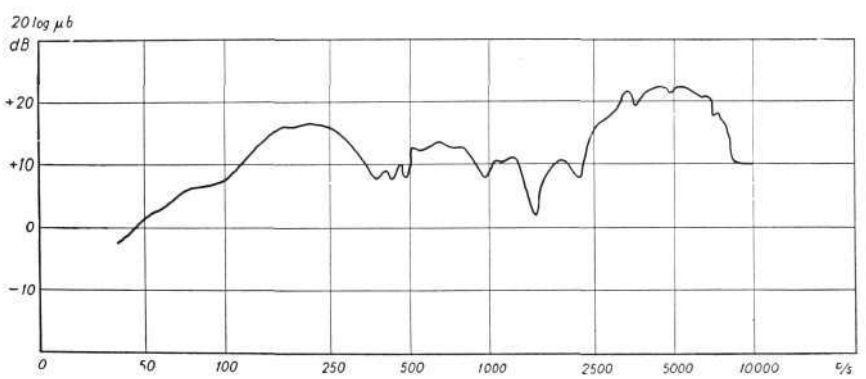


Fig. 4 [X 6045
Sound pressure delivered at 75 cm distance from loudspeaker HPU 1021 F
inserted in 100×100 cm baffle and with 1 V tension over the voice coil

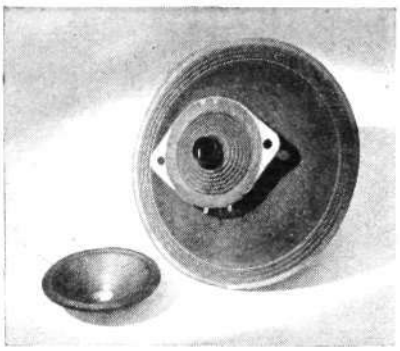


Fig. 5
Loudspeaker cones

X 4307

Manufacture

The raw material for the making of the cones consists of paper pulp, supplied in semi-dry-form. The pulp is soaked in water and stirred until the fibres are separated and then put in a semi-automatic moulding machine. The moulded cone is subjected to centrifugal force to remove as much water as possible, after which it is pressed in strong heat in a hydraulic press. The speed and pressure of the press are varied according to whether the cone is to be hard or soft, thick or thin. The cone apex (neck) and resonance folds if any are pressed in special forms, after which the cone is weighed for checking and examined.

The spreader is made of rather longer fibred pulp than the cone and in the same way. Depending on the suspension resonance desired and the loudspeaker size, the spreaders are made in four qualities. As great demands are imposed on the spreader it must be subjected to particularly careful inspection. Each spreader is examined through light to ascertain if the fibres are properly felted together and that there are no spots or clots.

The cone and spreader are impregnated to protect them against damp. Exacting demands are placed on the impregnating material, as a finished cone should be capable of being immersed in water without being deformed when dry. Two different impregnating materials are used, one for soft and one for hard cones. The former should not affect the consistency of the paper itself, while the latter, which consists of a resin solution with a fixed viscosity, stiffens the paper when it dries.

The cone coils are wound on a hard short-fibre frame about 0.03 mm thick for the smaller loudspeakers. For the larger loudspeakers there is used a material like presspahn, 0.1 mm thick. The low impedance coils, 2—8 ohm, are wound with two layers of enamelled copper wire, the 20 ohm coils are wound with four layers. Each layer is copiously coated with paste which dries hard and tough. In order that they shall not lose their circular form the coils must dry on their mandrels for 24 hours.

The joining of cone paper, spreader and cone coil is done on templets, a rapid drying paste being used. After drying in an oven the cones are ready for fitting in the loudspeaker chassis. They are pasted to the basket edge and centred, after which the finished loudspeaker is ready for testing.

Loudspeaker Types

Svenska Radioaktiebolaget's loudspeakers are made in three constructions as per Fig. 7. Technical data for these will be found in the table below.

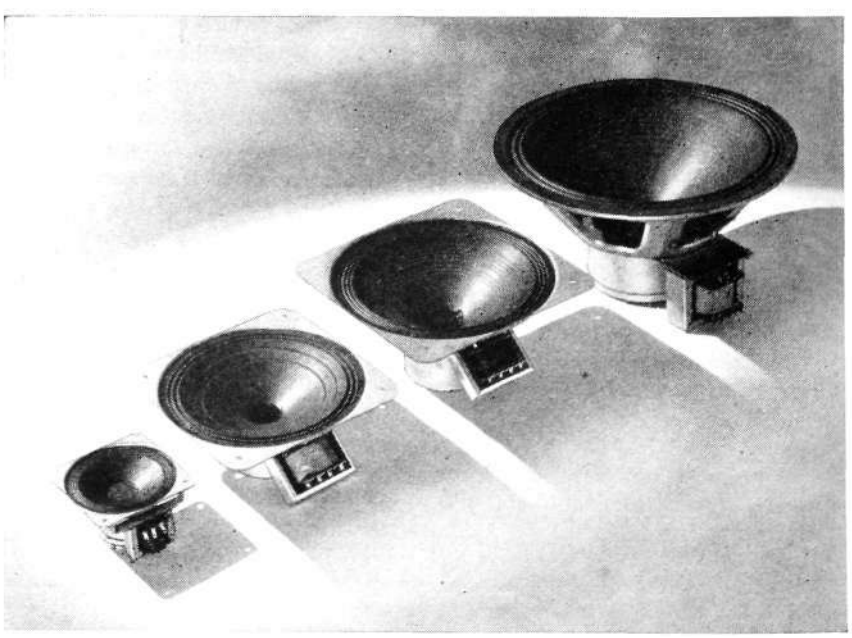


Fig. 6
Loudspeakers

X 6048

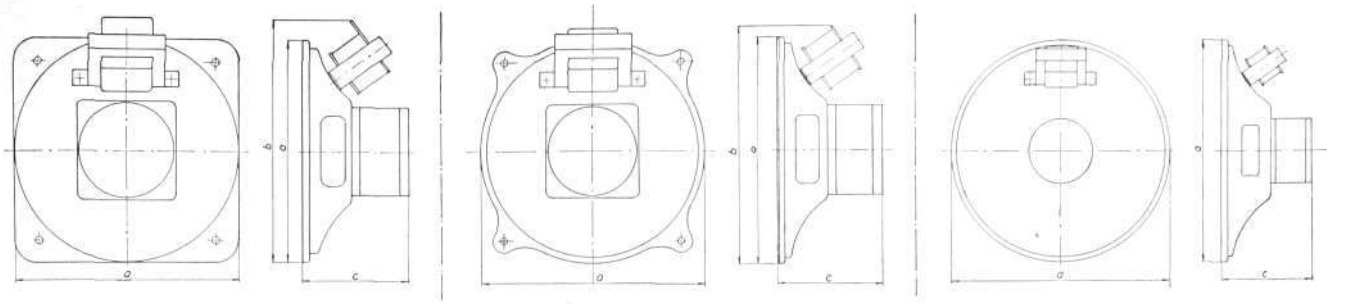


Fig. 7
Dimension sketches of Svenska Radioaktiebolaget's loudspeaker types

Table I
Technical data of Svenska Radioaktiebolaget's loudspeaker types

Type[1]	Construction[2]	Dimension a	Dimension b	Dimension c	Field intensity in air-gap	Magnetising capacity	Cone suspension resonance	Max. load	Loudspeaker transformer's nonreflexion resistance
		mm	mm	mm	Gauss	W	c/s	W[3]	ohm
HP—710	1	97	—	55	7000	—	170	0.5—1	—
HPU—710	1	97	108	55	7000	—	170	0.5—1	20, 1000, 3000, 7000
HP—713	1	125	—	60	7000	—	170	1—2	—
HPU—713	1	125	145	60	7000		170	1—2	20, 1000, 3000, 7000
HF—613	1	125	—	70	6000	3	170	1—2	—
HP—716	2	162	—	67	7000		120	3—4	—
HP—916	2	162	—	73	9000		120	4—5	—
HPU—916	2	162	181	73	9000		120	4—5	20, 100, 500, 1000, 2500, 3000, 3500, 4000, 6500, 7500
HF—616	2	162	—	77	6000	3	120	4—5	
HP—718	1	186	—	76	7000		90	4—5	
HP—918	1	186	—	82	9000		60—90	5—6	
HPU—918	1	186	190	82	9000		90	5—7	20, 100, 500, 1000, 2500, 3000, 3500, 4000, 6500, 7500
HF—618	1	186	—	86	6000	4—5	60—90	5—6	
HP—921	1	213	—	108	9000		70	6—8	
HP—1021	1	213	—	108	10000		70	7—9	
HPU—921	1	213	—	108	9000		70	6—8	20, 100, 500, 1000, 2500, 3000, 3500, 4000, 6500, 7500
HPU—1021	1	213	—	108	10000		70	7—9	
HP—924	3	237	—	99	9000		65	7—9	
HP—1024	3	237	—	102	10000		65	8—10	
HPU—924	3	237	—	99	9000		65	7—9	20, 100, 500, 1000, 2500, 3000, 3500, 4000, 6500, 7500
HPU—1024	3	237	—	102	10000		65	8—10	
HP—1330	3	305	—	160	13000		60	12—15	
HPU—1330	3	305	—	160	13000		60	12—15	20, 115, 150, 500, 750, 1000, 1500, 2000, 2500, 3000

[1]) HP designates loudspeakers with permanent magnets.
HF » » » magnetising coils.

[2]) Construction refers to basket, no matter whether the loudspeaker is of P-type or F-type.

[3]) Lower figure applies if loudspeaker connected to amplifier with full register.
Higher » » » » » » » » cut-down base register.

New L M Ericsson Exchanges 1939—1944

During 1939—1944 the following exchanges and switchboards on the LM Ericsson system with 500-line selectors were put into service:

town	exchange	number of lines	year of opening
Argentine			
Godoy Cruz	(extension)	500	1940
Mendoza	(extension)	1000	
Santiago del Estero	(extension)	500	
Tucumán	(extension)	1000	
Santa Fé	(extension)	1500	1941
Mendoza	(extension)	1000	1942
San Juan		2500	
Tucumán	(extension)	2000	
Salta		3000	1943
Santiago del Estero	(extension)	500	
San Rafael	(extension)	300	1944
Bolivia			
La Paz		2500	1941
Cochabamba		1000	1944
Brazil			
Blumenau		500	1939
Juiz de Fora	(extension)	500	1940
Manáos	(extension)	500	1942
Natal		500	1943
Natal	(extension)	500	1944
Colombia			
Medellin		10000	1940
Dutch West Indies			
Curacao		1500	1939
Rotterdam		2000	1940
Rotterdam	(extension)	3700	
Rotterdam		5000	1941
Rotterdam		5000	1942
Rotterdam	(extension)	5000	1944
Esthonia			
Tartu		2500	1939
Finland			
Ekenäs	(extension)	100	1940
Helsingfors	PABX	250	

town	exchange	number of lines	year of opening
Jyväskylä	(extension)	500	1941
Tammerfors	(extension)	1000	
Mariehamn		1000	1942
Åbo		7000	
Forssa		700	1943
Rauma	(extension)	500	
Åbo	(extension)	1000	
Vasa	(extension)	1000	
Kuopio		3000	1944
Tammerfors	(extension)	500	
Italy			
Milan	PABX	260	1939
Venice	(extension)	500	
Sondalo	PABX	400	
Treviso		1500	
Napoli	PABX	120	1940
Torino	PABX	160	
Bologna	PABX	100	1941
Brescia	(extension)	500	
Venezia	PABX	300	
Vercelli	(extension)	500	
Libia			
Tripolis	(extension)	500	1940
Morocco			
Tanger	(extension)	1000	1944
Mexico			
México D. F.	(extension)	4500	1939
Guadalajara	(extension)	1000	
Puebla		1000	
León	(extension)	500	1940
México D. F.	(extension)	1000	
México D. F.		2000	
Puebla	(extension)	1000	
Toluca	(extension)	500	
México D. F.	(extension)	4500	1941
Puebla	(extension)	2000	
Guadalajara	(extension)	500	1942
México D. F.	(extension)	7500	
Merida	(extension)	500	1943
México D. F.	(extension)	2500	
New Zealand			
Wangarei	(extension)	400	1940
Norway			
Fredrikstad	(extension)	500	1939
Halden		1200	
Kristiansand	(extension)	500	
Oslo	PABX	600	
Arendal	(extension)	500	1940
Halden	(extension)	300	
Hamar	(extension)	300	
Stavanger		6000	

town	exchange	number of lines	year of opening
Haugesund	(extension)	500	1941
Larvik	(extension)	500	1943
Trondheim		9000	
Fredrikstad	(extension)	500	1944
Halden	(extension)	300	
Kristiansand	(extension)	200	
Poland			
Bydgoszcz	(extension)	500	1939
Lublin	(extension)	500	
Warsaw	(extension)	4000	
Slovakia			
Nitra	(extension)	580	1943
Spain			
San Sebastián	(extension)	1500	1942
Sweden			
Barkarby	PABX	50	1939
Fagersta	PABX	260	
Göteborg	PABX	570	
Göteborg	PABX (extension)	120	
Hälsingborg	PABX	120	
Kinna		700	
Norrköping	PABX	670	
Skelleftehamn	PABX	180	
Stockholm		11700	
Stockholm	(extension)	3160	
Trälleborg	PABX (extension)	20	
Uddevalla	PABX	3500	
Viggbyholm	PABX	50	
Västerås	PABX	320	
Örebro	PABX	120	
Bollnäs		1500	1940
Djursholm		5000	
Hälsingborg		11000	
Södertälje		4000	
Various places	39 exchanges PABX	4510	1940
Various places	8 exchanges PABX	420	1940
Borås	(extension)	2000	1941
Göteborg		5000	
Göteborg	(extension)	5500	
Karlstad		6500	
Norrköping		2000	
Skellefteå		2500	
Stockholm		5000	
Stockholm	(extension)	12000	
Västerås		7000	
Örebro	(extension)	2000	
Various places	21 exchanges PABX	2110	1941
Various places	13 exchanges PABX	570	1941
Göteborg	(extension)	3500	1942
Göteborg	(extension)	2000	
Karlskoga		3500	
Kristinehamn		3000	

town	exchange	number of lines	year of opening
Lidingö	(extension)	500	1942
Mölndal		2500	
Stockholm		11660	
Sölvesborg		800	
Various places	PABX	4690	1942
Various places	PABX (extension)	1080	1942
Eskilstuna	(extension)	7600	1943
Göteborg		5300	
Stockholm		5500	
Stockholm	(extension)	26000	
Uddevalla	(extension)	500	
Various places	45 exchanges PABX	5140	1943
Various places	28 exchanges PABX	926	1943
Göteborg	(extension)	8000	1944
Hälsingborg	(extension)	1000	
Karlstad	(extension)	1200	
Lund		7500	
Stockholm		2000	
Stockholm	(extension)	14000	
Södertälje	(extension)	2500	
Sölvesborg	(extension)	200	
Upsala		12000	
Västerås		1000	
Various places	35 exchanges PABX	5400	
Various places	22 exchanges PABX (extension)	1120	1944
Union of South Africa			
Moddersfontein		190	1939
Cape Town	PABX	130	1940
Turkey			
Ankara		2000	1939
Istanbul		2000	
Ankara	PABX (extension)	100	1941
Ankara	(extension)	2000	1943
Istanbul	(extension)	3000	

During 1939—1944 the following exchanges and switchboards with 100, 25 and 12 line selectors have been delivered. Extensions to existing plants are not included in the figures.

	number	number of lines
Exchanges with 100 line selectors	43	6170
Switchboards with 100 line selectors, system AHD	75	7003
Switchboards with 25 and 12 line sectors, system OL	1338	30912

Concerning the exchanges on British Post Office system opened during 1939—1944 by Ericsson Telephones Ltd., London-Beeston, and the exchanges on the Rotary system put into operation by Société des Téléphones Ericsson, Colombes, no information is available.

Ericsson Technics No 6, 1939

T Laurent: Transformation fréquentielle des réseaux d'impédances correcteurs d'affaiblissement

In Ericsson Technics No 3, 1937, it was shown how it is possible mathematically to treat attenuation correcting impedance networks by frequency transformations. The present article constitutes a complement to that work with regard to the continued development of the frequency transformations. To begin with it is shown how all correction attenuations may be determined with frequency transformations by a single universal original attenuation curve. There are then presented new graphic methods for direct transformation according to the summation method, which has proved to be of great significance for attenuation correction networks. Moreover the graphic treatment of properties is supplemented by a successive direct transformation with inclined construction rays, through which the procedure becomes just as general as the summation method. It is then demonstrated how it is possible to transform direct with indirect functions, which in certain frequency ranges makes the phase shift of the correction network equal to zero. Finally it is shown that the complicated frequency transformations are only justified in exceptional cases for correction attenuation and that it is then possible to treat the attenuation graphically if the original attenuation is allowed to vary with frequency.

From this work it should be clear that frequency transformations with a small number of frequency functions enable the attenuation correcting impedance networks to be mathematically controlled in a simple and clear manner, as has previously been shown to be the case with electrical filters, circuits etc.

Ericsson Technics No 43

Håkan Sterky: Übertragungsverhältnisse auf bespulten und wahlrufbetriebenen Fernsprechleitungen

Selective calling telephone lines present much of interest, not only because of their properties enabling telephone traffic peculiar to railways, but also from purely technical points of view. At the request of a special committee appointed by the Royal Board of Railways the author has carried out certain computations and measurements with the object of making clear the general transmission properties of selective calling telephone lines. The results of these computations are noteworthy from a number of standpoints.

On loading selective calling telephone lines shunted by telephone instruments there is obtained in certain cases, contrary to expectations, a rise instead of a fall in the attenuation constant. In the paper the explanation of this is given, both by application of the band pass filter theory and by reference to general formulae. The transmission properties of the selective calling telephone line may be compared with those of the Pupin-Thomson line. The computations have been confirmed by extensive measurements on various types of line and with different selective calling telephone instruments. The agreement between theory and practice is good, though the telephone posts in practice are not distributed along the line so regularly as must be assumed for mathematical treatment.

In addition there is dealt with the question of the most advantageous instrument impedance in order to arrive at a suitable compromise between low attenuation constant and best transmitter and receiver reference equivalents. An account is also given of intelligibility tests carried out with a proposed new type of selective calling telephone instrument. The paper concludes with general directions for the planning of sectional telephone circuits for various types of aerial and cable lines, with or without coil loading.

U.D.C. 621.395.663.2:654.155.4.032.16

BERGLUND, CORNELIUS: *Rational Charging Methods for Automatic Telephone Traffic.* Ericsson Rev. *22* (1945) No 1 p. 2—7.

In automatic traffic the running costs are governed by the duration of conversation and not by the number of calls. The charges should therefore be based on the total time of conversation. This article shows how recording of duration of conversation for local calls can be introduced with advantage.
The charges per 3-minute period begun, as used in manual traffic, are without justification in automatised toll traffic and should be replaced by charges for the actual time of conversation. By means of suitable numbering and distribution of rates it is possible to arrive at effective time zone meters, if the charges are permitted to deviate slightly from what would correspond to the exact geographical distance between the calling and called exchanges.

U.D.C. 621.395.663.2:654.155.4

BERGLUND CORNELIUS: *Registering of Duration of Conversation.* Ericsson Rev. *22* (1945) No 1 p. 8—10.

In registering the duration of calls by impulses to the call meters of subscribers from common time impulse units the times recorded for each individual call will contain errors. Nevertheless such errors compensate each other over a charging period, so that satisfactory accuracy of measurement is attained. This article indicates the magnitude of the deviations and the excess recordings that arise.

U.D.C. 621.395.44

JANSSON, STIG & STÅLEMARK, RAGNAR: *8-Channel Carrier Systems for Unloaded Cables.* Ericsson Rev. *22* (1945) No 1 p. 11—18.

Older, loaded cables can after unloading be made available for carrier operation with frequencies up to 60000 to 65000 c/s. Methods and apparatus for re-splicing the cable and for balancing the far-end crosstalk is treated, and a description of the characteristics and design of the carrier equipment is given in the article, which will be continued in Ericsson Rev. *22* (1945) p. 30.

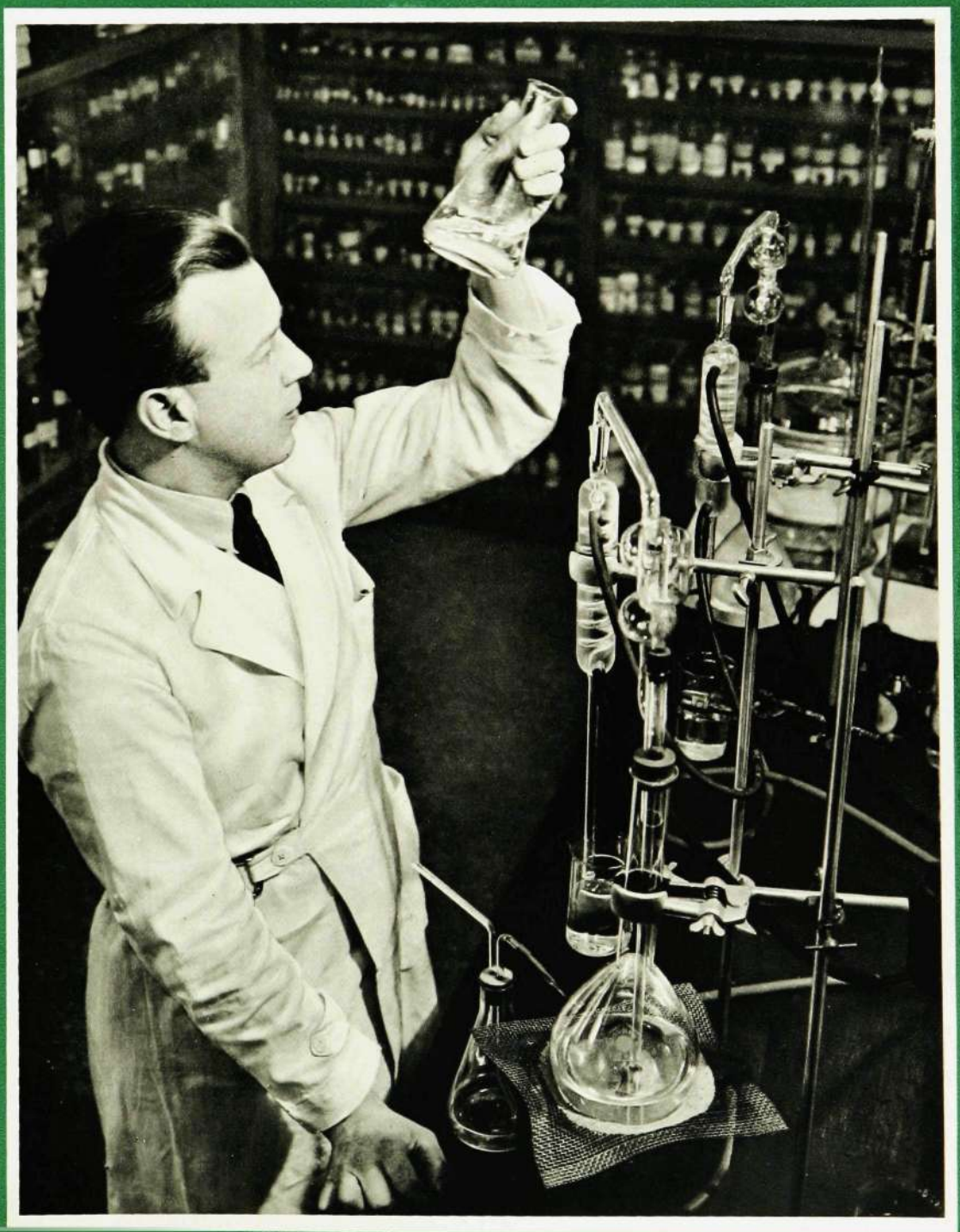
U.D.C. 621.396.623.7

LINDSTRÖM, ERIK: *Modern Radio Loudspeakers.* Ericsson Rev. *22* (1945) No 1 p. 19—23.

Svenska Radioaktiebolaget took up the manufacture of electro-magnetic loudspeakers in 1928 and has continued with it since then, applying and improving the principles introduced with the dynamic loudspeaker. The following article gives an account of a number of problems connected with the manufacture of loudspeakers and in addition gives a short description of the design and manufacture of Svenska Radioaktiebolaget's latest types of radio loudspeakers.


Ericsson
LM

Ericsson Review



No 2
1945

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On cover: Inside view of L M Ericsson's chemical laboratory: determining the nitrogen content of steel.

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Ericsson Technics 67

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The Employment of Crossbar Selectors in Shunt Circuit Systems

C JACOBÆUS, TELEFONAKTIEBOLAGET LM ERICSSON, STOCKHOLM

U.D.C. 621.395.344.

The crossbar selector in its modern form is a Swedish invention dating from 1917—1918. It was originally designed to cheapen the relay system at that time prevalent. In a test exchange on the relay system in Stockholm for 400 subscribers crossbar selectors were put in for certain connection functions. The results of this trial operation were in many respects encouraging. In the Swedish telegraph administration considerable work has been devoted to the developing of systems with crossbar selectors. The crossbar selector has in these to a large extent been used as decimal step-by-step-driven selector. In addition the selectors have found great employment as registering devices in registers. As however the selector has come into new prominence as connecting element in telephone exchanges with shunt circuit systems a survey will be made here of the most usual connecting facilities on these principles.

Design of the Crossbar Selector

A crossbar selector, Fig. 1, consists of a number, usually 10, of vertically set up units which are called bridges. Such a bridge can most nearly be compared to a relay with connecting spring groups operated individually. The bridge consists therefore of 10 contact spring groups and a holding magnet. The fixed springs in the spring group are stamped out of sheet metal and have therefore conducting connection with each other. The mobile springs on the other hand are individual for each spring group. The spring groups are constructed as make-contacts. The number of make-contacts per group is equivalent to the number of poles in the selector. To actuate the spring groups there are devices common to the whole selector, the bars. These, 25 in number, are fitted horizontally over the selector. A bar can be turned in one or the other direction by the energising of the one or the other of its bar magnets. On the bars an indicator wire for each bridge is mounted. The indicator wires are of steel with spring attachment to the bar, see Fig. 1 a.

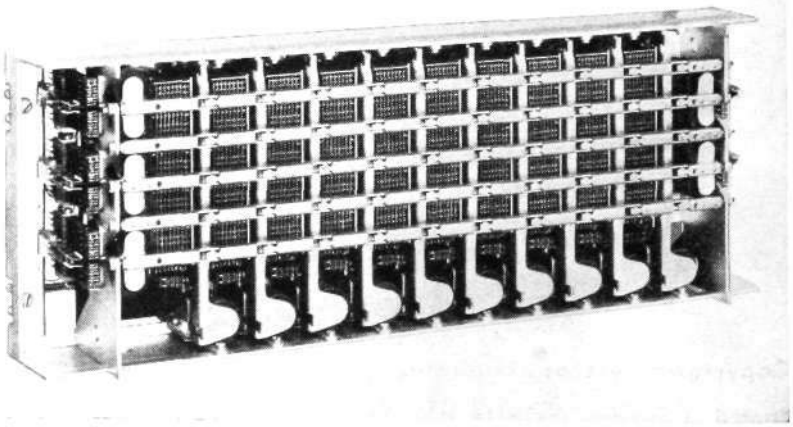


Fig. 1 X 6078
Crossbar selector with 10 bridges and 5 bars

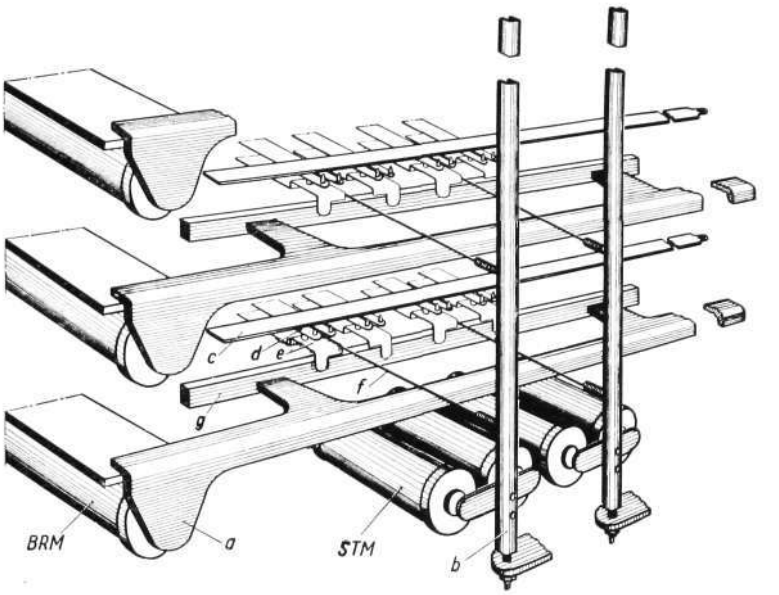


Fig. 1 a X 6083

Detailed sketch of crossbar selectors (selector made single-pole)

BRM bridge magnet
STM bar magnet
a bridge armature
b bar
c fixed contact springs common to the bridge
d mobile contact springs
e lifting spring
f assignment wire
g rod on bridge armature, which actuates lifting spring

Fig. 2 shows in diagram the contact bank in a 10 bridge crossbar selector. The vertical lines represent the fixed contact springs on the bridges. For each bridge 10 mobile contact springs are shown. Thus, to actuate the 6th contact group on the 3rd bridge, the bar magnet 6 is first energised and the 3rd bar turns in one direction. Its indicator wire 6 then will lie under the 6th spring group on all the bridges. When the bridge magnet 3 is energised the indicator wire is gripped fast below the spring group which is actuated. The bar magnet can then release, whereupon the bar returns to home position. The indicator wire is still held by the energised bridge magnet and the contact group 36 remains actuated as long as the bridge magnet is energised.

The crossbar selector therefore consists of a number of relay selector units, the bridges, which are set up by a common device, the bars with their magnets. The operation of a contact group in the selector is very rapid as all that is required is energising of a bar magnet followed by energising of a bridge magnet.

For each bridge, up to 5 contact groups can be actuated simultanously. Limitation is due to the fact that of each pair of contact groups only the one group can be actuated, as the same indicator wire (in both positions of the bar) is used for both contact groups. Usually, however, only one contact group per bridge is energised in the selector.

A bridge that has 10 contact groups works as one 10-line selector. By increasing the number of contact groups to 12 and making them with double the number of make-contacts the bridge can work as a 20-line selector. The crossbar selector will then have six bars. By operation of one of the five ordinary bars of the selector there is selected the pair of lines to which belongs the line the selector is to be contacted to. By means of the 6th bar the upper or under part of the selector's contact groups is connected in. The line wanted in the selected pair will thereby be connected. The 6th bar thus selects the tens in the 20-selector. It may thus be said that it selects the floor level, see Fig. 3. The extra bar may be replaced by one relay for each bridge, which switches between the lower and the upper contact assembly.

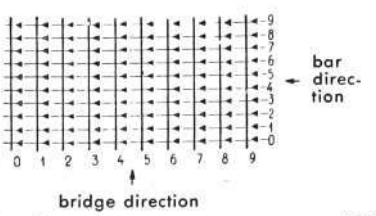


Fig. 2 X 4350

Diagram of the connecting field of the crossbar selector

General Connecting Principles

In exchanges with shunt circuit systems, the crossbar selectors are used distributed into units, i. e. as a number of 10-line or 20-line selectors. Sometimes greater capacity may be required of the selector, which is then built up of a number of 10-line or 20-line selectors. The foundation of this system is therefore the crossbar selector bridge.

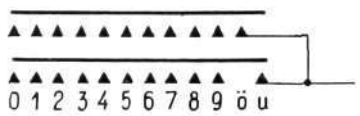


Fig. 3 X 4330
Contact devices in bridge for 20 lines (selector with 6 bars)

In exchanges with shunt circuit systems the setting of the selectors is checked by devices common for one or more selector steps, called *markers*. Both the numerical and the non-numerical parts of the selector setting are entirely referred to the markers. The markers deal with one connection at a time. They take account of the free connecting routes available for the connection concerned, select one of them, the selection taking place according to certain definite rules, and carry out the connecting by actuating the bar and bridge magnets for the selector units over which the connection is to be routed. The selectors thus carry out no selection or hunting when they are working.

As the devices for the setting of the selectors are wholly concentrated to the markers, only that equipment can be linked with the connecting route that is required for functions taking place after the selectors have been set, such as current feed, ringing, call metering, etc. This equipment can be located at that place in the contacting route where the best utilisation of the devices is ensured.

Basic Principles for Selector Grouping

In an ordinary 10-bridge crossbar selector where multipling between the bridges in the bar direction is carried out, each of the bridges may be connected to any one of the lines, Fig. 4. The crossbar therefore in this case works as ten 10-line selectors. The connecting bank represented by the crossbar selectors can obviously be given any desired form, for instance, by lengthening the entrances, when several bridges on the same entrance are connected in parallel. The selector capacity will then be a multiple of 10. Similarly the exits (multiples) will be common for any desired number of bridges. In the extreme case one would get 10 bridges per entrance and 100 exits and then have a selector which can be directly employed in a decimal system.

By connecting two part selectors (bridges) in series according to the basic principle used in the above described connectings there is formed a selector system with a line capacity equal to the square of the capacity of the part selectors used. With 10-line bridges one would then get 100 line capacity and with 20-line bridges 400 line capacity in the selector system. Fig. 5 shows how the selectors are grouped in such a connecting; 10-selectors are here used as units. The selectors are divided into two groups, primary selectors and secondary selectors. The connection is therefore built up by two selector steps, *A*-step and *B*-step. The *A*-step (like the *B*-step) is built up of 100 unit selectors which are assembled 10 and 10 with common multipling. In both steps therefore one gets ten 10-bridge crossbar selectors. The entrances on the *A*-step are connected to the verticals (bridges) on the crossbar selectors and the exits to the horizontals. The exits continue in links to the *B*-step where they go in on the verticals in the selectors. The connecting between the *A*- and *B*-steps is therefore done in such a way that from each selector in the *A*-step a link goes to each selector in the *B*-step. From selector *A 0* therefore one link leads to *B 0*, one to *B 1* and so on; from selector *A 1* one link to *B 0*, one to *B 1* and so on. From the standpoints of order and accessibility but of no significance otherwise, it is convenient to have the links from *A 0* lying on the verticals *0* in the selectors in the *B*-step, the links from *A 1* to the verticals *1* in the *B*-step and so on. The exits from the *B*-step constitute the exits of the whole connecting process.

It is obviously possible to connect each of the selector system entrances to each of the exits. There is then taken the link that leads from the primary selector concerned to the secondary selector where the exit is located. The selector system will then have a capacity corresponding to 100 decimal 100-line selectors. If the crossbar selector is employed as decimal 100-line selector there will in this case therefore be required $10 \times 100 = 1000$ bridges. In the selector system according to Fig. 5 there are required, however, only $10 \times 10 \times 2 = 200$ bridges. With the proposed connecting process therefore the number of part selectors has been reduced to $^1/_5$. It should, however, be noted that these selectors are not independent of each other but there is obtained

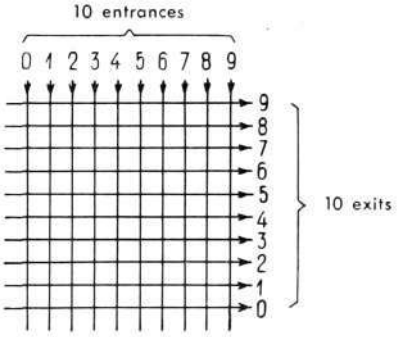


Fig. 4 X 4331
Entrances and exits in a 10 bridge crossbar selector with 10 lines bridge capacity

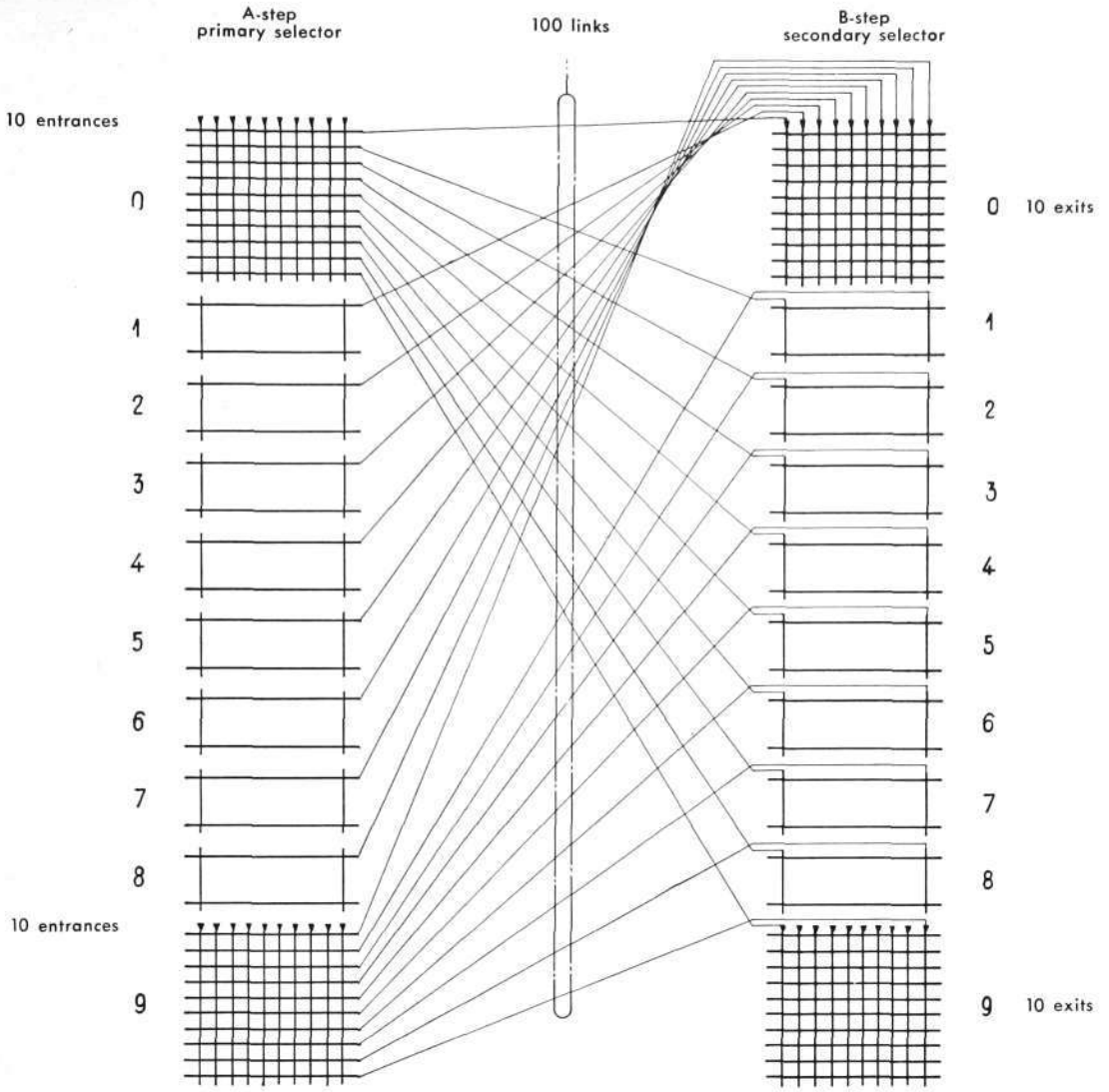


Fig. 5 X 7379
Basic connection in the crossbar selector system

internal blocking in the system due to the links between the *A*- and *B*-stages allowing of only one connection between each of the primary selectors and each of the secondary selectors.

The connecting process shown in Fig. 5 is symmetrical for each selector as regards entrances and exits. One may therefore allow entrances and exits to change places without any alteration in the nature of the connecting process.

The connecting process described permits of a through multipling over 10 and 20 bridges respectively. Bare wire connections can be used here, which is not possible in crossbar selector systems in direct driven systems when the multiple contacts of the bridges in a crossbar selector have individually connected exits.

The real nature of the basic connecting process will perhaps stand out more clearly if each part selector is designated by the usual symbols for selectors. The connecting process shown in Fig. 5 will than have the appearance seen in Fig. 6 a. It will be noted from this that a certain entrance that is connected to a part selector in the *A*-step over its multiple can obtain connection with any one of 10 selectors in a vertical line in the *B*-step. Each of these selectors has access to 10 exits. In this way each exit has the facility of access to any one of the 100 exits. Nevertheless the link between the *A*- and *B*-steps, over which a free exit can be reached, may be blocked by a prolonged connection and then there will arise an *internal* blocking. It is therefore important that the connecting process is so executed that risk for such blocking

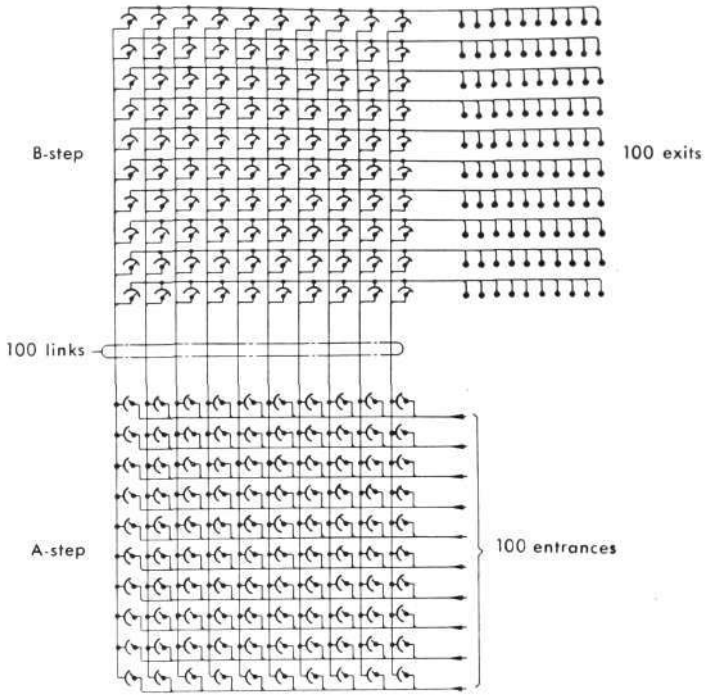


Fig. 6 a
X 6074
Basic connecting process in crossbar selector systems, using ordinary selector symbols

will be small. The selection in the A- and B-steps is therefore made as restricted selection, which means that an A-selector can only be connected to a B-selector that has access to a free exit. As will be seen from what follows, other measures too are taken to reduce the internal blocking so that its influence is slight. Nevertheless it is incontestable that such a connecting process does not achieve the same efficacy as an ordinary selection with full accessibility and that some small increase of the number of connection devices must be made to arrive at the ordinary selector's capacity of handling traffic.

The method of designation referred to above involves rather complicated figures and may with advantage be replaced by the following simplified method of designation, which gives the same information but facilitates the presentation of different groupings. In this the designation **o** for device or circuit current in teletraffic practice is taken as foundation. In the case where the device consists of a unit selector (bridge) it is provided with an indicator mark **ȯ**, the direction of the mark pointing to the place in the diagram where the selector's multiple will be found. A number of selectors which have the same multiple are drawn in line with each other, e. g. **o o o**, and the common multiple will be found in the direction →.

The connecting process shown in Fig. 5 is drawn in Fig. 6 b with this new symbol. The A-step in this case comprises 100 unit selectors distributed in 10 vertical rows with 10 selectors in each. Each of these vertical rows corresponds to the crossbar selector in Fig. 5. The devices that are connected to the A-devices multiples consist of the unit selectors in the B-step. In this step each horizontal row, comprising 10 unit selectors, is equivalent to the crossbar selector in Fig. 5. From each vertical in A there is thus obtained connection with a unit selector in each horizontal in B. The exits from the B-step will be found at the right as 10 lines to each of the horizontals. The selectors in the B-step will in relation to the A-step selectors be at an angle of 90°.

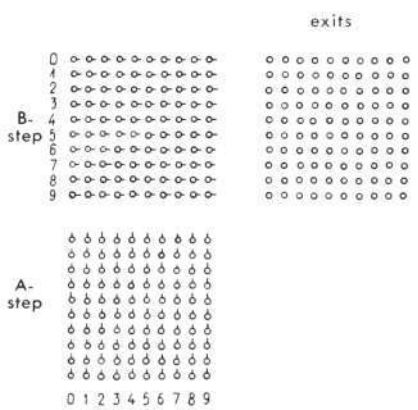


Fig. 6 b
X 6073
Basic connecting process in crossbar selector systems, presented by symbols

Group Selector Connections

If the basic connecting process is used as group selector connecting there is taken out from the B-step an exit to each route from each crossbar selector. In Fig. 7 and 8 therefore there is a total of 10 routes with 10 circuits in each route. With such a connecting process we obtain an equivalent to selectors of the Strowger type which of course provides the facility to selection over

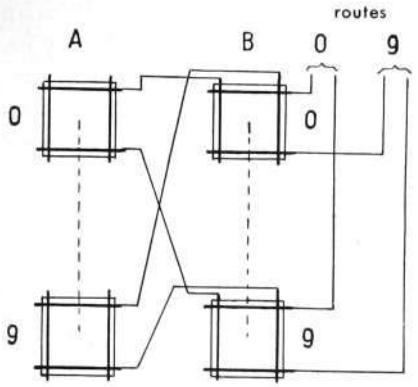


Fig. 7 X 4332
Basic connecting process used as group selector (intermediate circuit connecting)

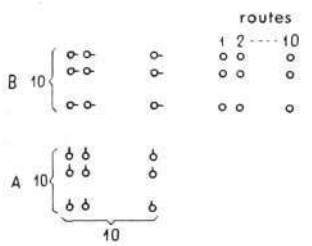


Fig. 8 X 4333
Basic connecting process used as group selectors, presented in symbols

10 routes with 10 exits in each. Compared with the conventional group selector connecting process, there is the difference that in the first selection (in the *A*-step) the circuit in the route is selected while in the other (in the *B*-step) the route itself is selected. Both the selections are made simultanously in the marker.

The basic connecting process used as group selector is called intermediate circuit connecting. If this connecting process is built up with 10-selectors there is obtained as a natural unit a connection for 100 lines; if, however, 20-selectors are used, the natural units for the connection will be 400 lines. For a symmetrical distribution of the lines to the routes in the *B*-step the »natural number of routes» will be in both cases 10 and 20 respectively. As the numerical function of the connecting process is entirely directed to the markers, any number of routes whatever may be taken, however. As the internal blocking in the system increases as the number of routes increases, then the number of routes to which one can go, will be essentially a question of the traffic which falls on the entrances to the intermediate circuit connecting. In ordinary cases the »natural number of routes» is not exceeded. For any other number of routes the object should be to try to distribute the exits from the *B*-step as evenly as possible over the different routes. The routes may also be made of different sizes which would be the case, for instance, if in some direction there are junction circuits to other exchanges.

In the intermediate circuit connecting, the selectors in the *B*-step may be divided up and the bridges which are connected to a certain selector in the *A*-step may be joined up instead. In this way there are formed smaller units consisting of an *A*-selector and a *B*-selector which are partitioned off from the other selectors in the connections. One will then not have through multipling in the bar direction in the *B*-selectors but each selector has all the exits in its multiple.

The intermediate circuit connection is not tied to the natural units of 100 or 400 lines but can be made in any desired size. Fig. 9 shows an intermediate circuit connection for 60 lines and 4 routes. From an *A*-selector connection is obtained two or one bridges in each selector in the *B*-step. When increasing the number of circuits in such an incomplete intermediate connection unit, alteration must be made in the distribution of the links between the *A*- and *B*-steps. The exits from the connection are only indirectly affected by this in that the new exits obviously must be allocated to the different routes. This may necessitate a redistribution of the lines on the different routes especially if — as is often the case — the number of routes is at the same time increased.

The different lines in a route may be hunted and occupied quite indiscriminately. There is then obtained an approximately random distribution of the occupation of the links between the *A*- and *B*-steps. There is, however, less blocking in the connection if ordered hunting is introduced. The exits from the *B*-step will then for instance be occupied in such a manner that exits from one selector coming lower in the order of numbers should be occupied before exits from selectors with higher numbers.

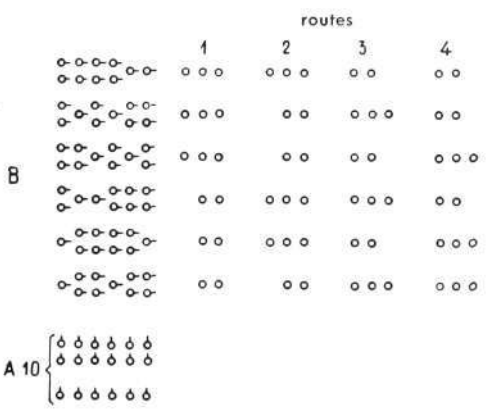


Fig. 9 X 6075
Intermediate circuit connection for 60 devices with selection over 4 routes

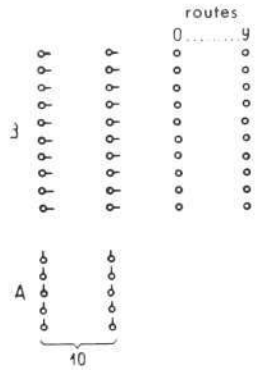


Fig. 10 X 4334
Intermediate circuit connection with expanding A-step

By occupation in order, conditions are created for making a graduation between different intermediate circuit units. Such graduation, for example, would be advisable when several intermediate circuit units have exits, say, to another exchange. Even for internal routes, graduation may be justified as devices are saved in succeeding selector steps. The ordinary rules for connecting graduations should apply also for graduated exits from intermediate circuits.

An ordinary intermediate circuit connection is carried out with equal numbers of entrances and exits. Compared with a conventional group selector connection there is in this case a definite difference, as this always has more exits than entrances. The ordinary group selector connection is thus in itself extremely expanding. It is, however, made less expanding or even concentrating by the partial connecting up of the exits that takes place in the graduations. At times there is need to make the ordinary intermediate circuit connections expanding or concentrating. An expansion should in such case take place in the *A*-step, while the concentration should occur in the *B*-step, as in this way the internal blockings are kept low. Fig. 10 shows an intermediate circuit connection expanding in a ratio 1 : 2, with the expansion entirely confined to the *A*-step.

With the object of increasing the utilisation, for instance of junction lines, there may be introduced a special secondary line switch step after the intermediate circuit step. The secondary line switching can be carried out wholly or partially in accordance with what is usual in the direct driven systems. Fig. 11 shows such a connection in diagram. The exits from the *B*-step are in this case led direct to the lines in the routes or to secondary line switches which in their multiples have access to further lines in the routes. The selectors in the secondary step should only be occupied if no passable way is to be found direct to the exits of the route in the *B*-step. As the secondary line switchers are set to the same speed as the *A*- and *B*-selectors, the arrangement will be almost the same as secondary line switches with presetting to free line in the conventional system.

When only a small number of routes is available it is possible to make a combination of an ordinary group selector connection and an intermediate circuit connection. Some of the exits from the *A*-step, which then are hunted and occupied in the first place, are led direct to the routes, while the remainder are connected over a *B*-step with circuits in the routes. Fig. 12 shows such a connection for 60 lines and 3 routes. The *A*-step's selector has direct access to one circuit in each route, while the other circuits in the routes are reached over the *B*-step. The *B*-step in this connection has the same function in relation to the *A*-step as the secondary line switch step has to the *B*-step in Fig. 11.

The basic connection used as group selector thus offers the same facilities from the grouping point of view as group selectors of the conventional type. Against this, the basic connection has the advantage that the number of

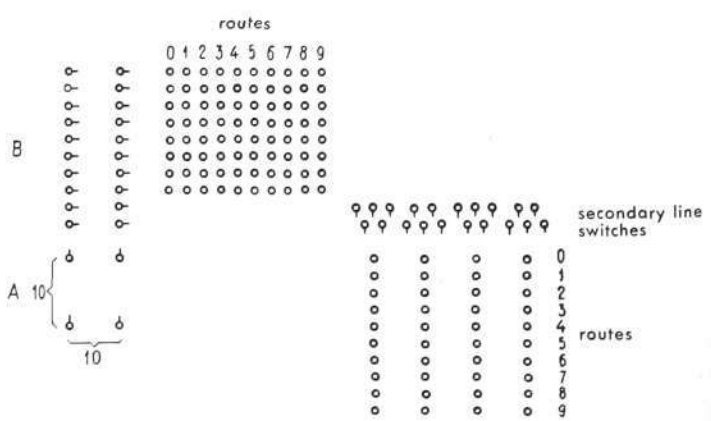


Fig. 11 X 6076
Intermediate circuit connection with secondary line switches for peak traffic

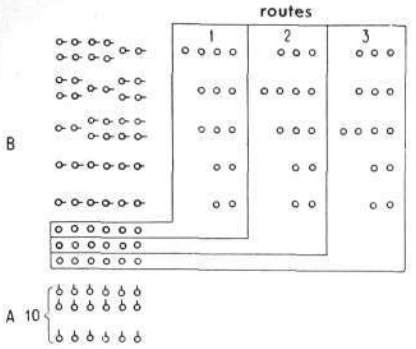


Fig. 12 X 4335
Shortened intermediate circuit connection for 60 lines and 3 routes



Fig. 13 X 4336
Subscriber step where the A-step is connected as pre-selector

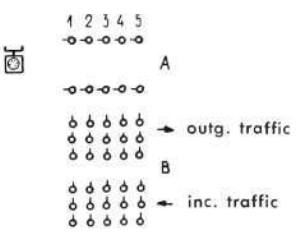


Fig. 14 X 4337
Subscriber step where the A-step is connected as finder and with evenly divided B-step

routes and the distribution of the lines to the different routes can be made arbitrary in wide limits. On the other hand there is internal blocking in the basic connection which grows with the traffic and the number of routes.

Connections for the Subscriber Step

The connections used in finder and final selector steps are all variants of the basic connection. As the connection is carried out in two steps, the finder and final selector steps can be combined to one common step, the subscriber step. The selector lying nearest the subscriber lines (the *A*-step) will then be used for both directions of traffic. The traffic is divided up into incoming and outgoing traffic in the *B*-selectors in the connection. By making the *A*-step entirely common the selectors in this step are better utilised, which is of importance as the selectors used have small capacity. On the average there is by this means a saving of 25 % in material in the *A*-step. In addition the advantage is gained that subscriber multiples are only to be found at one spot in the exchange.

As a basis for division for the groupings in the subscriber step one may take the form of execution of the *A*-step devices. In relation to the subscriber line the *A*-selector is connected as pre-selector or call finder. In the former case each subscriber line is allotted a bridge. In the latter alternative a subscriber line is reproduced in the multiples on a number of bridges.

When each subscriber line has a bridge the connection receives a grouping such as is shown in Fig. 13. The connection will obviously more nearly coincide with the intermediate circuit connection shown in Fig. 8, where the exits are spread over two routes. Normally, however, the subscriber step must also concentrate the traffic from the subscriber lines to the relatively few devices needed for same with normal dimensioning. This concentration takes place in both the *A*- and the *B*-steps. The number of exits from an SLV group with this arrangement will evidently be entirely governed by the capacity of the selectors used. If there are 10-selectors in both the *A*-step and the *B*-step there will be obtained 100 exits from the group. If instead 20-selectors are used the number of exits will be 400. In both cases these may be distributed between the incoming and outgoing traffic directions in any desired way.

The size of the group is characterised by the number of exits from it. Therefore there are placed in the group as many subscribers as, with the traffic which these on the average receive and send out, will ensure the traffic loading of the exits that is desired. In the *A*-step the number of lines in each vertical row (column, Fig. 13) will be determined by the traffic which the common links (10 or 20) to the *B*-step can bear. The number of columns, however, should always be the same, as this will be determined by the concentration factor in the *B*-step, which in turn is dependent on the relation between the traffic handling capacity of the links between the *A*- and *B*-steps and the exits. Increase or decrease of the number of lines in the group is done by adding or taking away lines in the different vertical rows. The insertion of the *A*-selectors in the subscriber step as pre-selectors involves therefore that the size of the subscriber group is so fixed that a certain constant for traffic/subscriber group is attained. In this way the numbering in the exchange has no direct connection with the grouping, which is a disadvantage from the standpoints of maintenance and supervision. The subscriber groups will be fairly large — with the connection outlined in Fig. 13, carried out with 10-selectors in both steps, 500—1000 subscribers/group — so that the connection is only suitable for large exchanges. Moreover the material used in the *A*-step, at least if traffic/subscriber-line is not very large will be proportionally great. On the other hand it is possible to make a saving of the subscriber line break relays, as these are replaced by the bridge magnets.

If the *A*-step is carried out with the selectors connected as finders over the subscriber lines there will be obtained the grouping of the devices as per

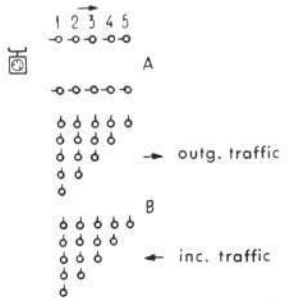


Fig. 15
Subscriber step where the A-step is connected as finder and with »graduated» B-step

Fig. 14. Each horizontal row in the *A*-step serves 10 or 20 subscriber lines, according to the capacity of the bridge used. The *B*-selectors are connected to the *A*-selectors in such a way that there is in the *B*-selector's multiple an *A*-selector for each 10 (20). The subscriber group will assume with this execution a certain natural size, namely 100 lines with 10-selectors and 400 lines with 20-selectors. The *B*-step selectors can be divided up in any way for the two traffic directions. In principle, however, the division should made in conformity with Fig. 14, *i. e.*, along a division line at least mainly horizontal and with the direction shown on the figure. A vertical division line in the *B*-step between devices for the two traffic directions would mean that the traffic even in the *A*-step would be one-way, seeing that part of the *A*-selectors are then exclusively used for outgoing traffic while the remainder are taken into service for incoming traffic.

In both the *A*-step and the *B*-step there is a certain concentration. The concentration in the *B*-step should be approximately constant for varying subscriber traffic. The occupation per device in the *A*-step rises with constant blocking, according to the number of devices per sub-group. At the same time the number of exits in the *B*-step is increased so that the whole group of *B*-selectors is augmented. One can then in this case also increase the occupation per device.

The rules for hunting and occupation in subscriber steps of this type require special attention. For an arrangement as per Fig. 14 to function with the least possible blocking, care must be taken that there is obtained approximately the same occupation of all columns in the *B*-step. This is achieved by making a circulating occupation of the devices in the *A*-step. The first call in the whole group occupies devices in column 1, the second call devices in column 2 and so on. If connection cannot be established in the column that is in turn, it goes to the next higher in number and so on. The occupation and hunting of the devices thus is done always in the same order, but the point of departure for hunting moves a step forward for each new call in the group. The same effect can be attained by making in each sub-group of the *A*-step the occupation in a certain order individual for the group. By thus distributing the traffic in this way evenly over the columns in the *B*-step the probability is reduced of a blocking owing to free exits in the *A*-step not having access to free devices in the *B*-step, while at the same time the free devices in the *B*-step have not free devices in its multiple in the sub-group concerned.

If the devices in the *A*-step are occupied in the same order in all sub-groups, say in order 1—5, there will normally be a crowding of occupations in column 1 of the *B*-step, while the occupations in the following columns will naturally be progressively smaller. It should then be natural to adapt the grouping of the *B*-step to the usual occupation distribution. Fig. 15 shows an example of such a grouping in the *B*-step. In column 1, where the occupation is greatest, there are 10 devices, 8 in column 2 and so on up to column 5 where only 2 devices have been put in. The grouping in the *B*-step will thus be based on a similar idea as led to the ordinary graduations. The distribution of the devices in this manner has therefore been designated »graduated *B*-step». The graduated *B*-step with occupation in order will probably give about the same blocking as a *B*-step with even distribution of the devices (and traffic) over the different verticals, but it has the disadvantage that the multiples in the *B*-step will be of different lengths. The even distribution of the devices also provides simpler markers.

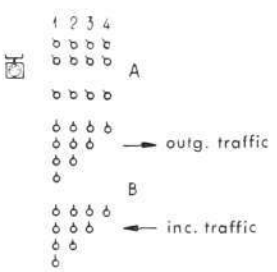
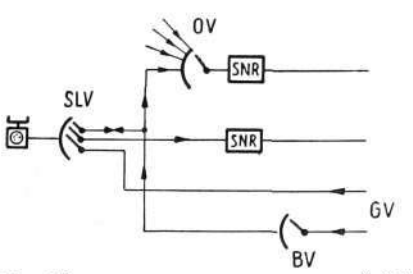


Fig. 16
Subscriber step where the A-step is transposed and the B-step »graduated»

In the above it has been assumed that the *A*-step is constructed with straight multiples, *i. e.*, each tens and twenties subscriber line is allotted a number of bridges and the lines to these bridges are arranged similarly in the different bridges. In this way the possibility is obtained of making a bare wire connection in the bridge multiples. With the object of arriving at a smoothing of the traffic variations between the different sub-groups (10s or 20s) constituting a subscriber group, it is possible to insert the subscriber multiples in

unit figures	0 1 2 3 4 5 6 7 8 9		
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	1 2 3 4 0 1 2 3 4 0		
	2 3 4 0 1 2 3 4 0 1		
	3 4 0 1 2 3 4 0 1 2		
»	4 0 1 2 3 4 0 1 2 3		selector 2
	5 6 7 8 9 5 6 7 8 9		
	6 7 8 9 5 6 7 8 9 5		
	7 8 9 5 6 7 8 9 5 6		
	8 9 5 6 7 8 9 5 6 7		
	9 5 6 7 8 9 5 6 7 8		
	0 2 4 1 3 0 2 4 1 3		
	1 3 0 2 4 1 3 0 2 4		
	2 4 1 3 0 2 4 1 3 0		
	3 0 2 4 1 3 0 2 4 1		
	4 1 3 0 2 4 1 3 0 2		
»	5 7 9 6 8 5 7 9 6 8		selector 3
	6 8 5 7 9 6 8 5 7 9		
	7 9 6 8 5 7 9 6 8 5		
	8 5 7 9 6 8 5 7 9 6		
	9 6 8 5 7 9 6 8 5 7		
	0 3 1 4 2 0 3 1 4 2		
	1 4 2 0 3 1 4 2 0 3		
	2 0 3 1 4 2 0 3 1 4		
	3 1 4 2 0 3 1 4 2 0		
	4 2 0 3 1 4 2 0 3 1		
»	5 8 6 9 7 5 8 6 9 7		selector 4
	6 9 7 5 8 6 9 7 5 8		
	7 5 8 6 9 7 5 8 6 9		
	8 6 9 7 5 8 6 9 7 5		
	9 7 5 8 6 9 7 5 8 6		
	0 4 3 2 1 0 4 3 2 1	bridge 0	
	1 0 4 3 2 1 0 4 3 2	» 1	
	2 1 0 4 3 2 1 0 4 3		
	3 2 1 0 4 3 2 1 0 4		
	4 3 2 1 0 4 3 2 1 0		
»	5 9 8 7 6 5 9 8 7 6		selector 5
	6 5 9 8 7 6 5 9 8 7		
	7 6 5 9 8 7 6 5 9 8		
	8 7 6 5 9 8 7 6 5 9		
	9 8 7 6 5 9 8 7 6 5	bridge 9	
unit figures	0 1 2 3 4 5 6 7 8 9		

Fig. 17
Example of the arrangement of the subscriber lines in the A-step multiples on transposition



X 4340

Fig. 18
Subscriber step with partial B-step and graduating in the A-step

BV secondary switch
GV group selector
OV overflow selector
SLV subscriber step
SNR connecting circuit relay set

different manners in the various devices of the *A*-step. Such multiples are designated according to Fig. 16 with the ordinary device signs but with inclined indicator strokes in relation to the multiple directions. The multipling is called »transposed» and the execution may be seen in Fig. 17. The figure shows a transposed multipling for 500 lines for 5 selectors. In all the selectors the subscriber numbers with the same unit figure are all comprised on the same bar number. The lines are comprised in selector *1* in the usual manner, *i. e.*, with the *0* tens taken to bridge *0*, the *1* tens to bridge *1* and so on. In selector *2* a shifting of the lines has been introduced so that *0* bridge comprises lines *00, 11, 22, 33, 44, 05, 16, 27, 38, 49, 1* bridge the lines *10, 21, 32, 43, 04, 15, 26, 37, 48, 09* and so on. In selector *3* the *0* bridge has the lines *00, 21, 42, 13, 34, 05, 26, 47, 18, 39,* in selector *4* the lines *00, 31, 12, 43, 24, 05, 36, 17, 48, 29* and in selector *5* the lines *00, 41, 32, 23, 14, 05, 46, 37, 28, 19*. There are thus assembled in each selector as far as possible lines on the different bridges which do not have common bridges in the other selectors. There is obtained from this a good smoothing of the variations in traffic intensity between the different 10s. The connecting may be regarded

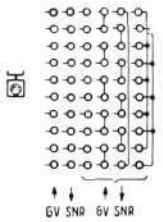


Fig. 19 X 4341
Example of the connection in the A-step in Fig. 18
GV group selectors
SNR connecting circuit relay set

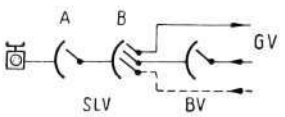


Fig. 20 X 4342
Connection of the secondary switch to the subscriber step
BV secondary switch
GV group selector
SLV subscriber step

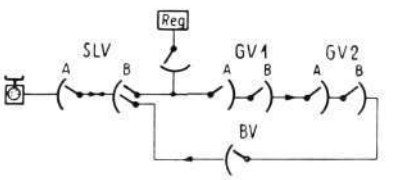


Fig. 21 X 4343
Distribution diagram for crossbar system exchange with subscriber step, two group selector steps and secondary switch step
BV secondary switch
GV_1, GV_2 group selectors
SLV subscriber step

as an ideal graduating. The benefit as compared with the execution with straight multiple is, however, reduced somewhat by the fact that in calculating blocking with straight multiple the probability should be taken into account that new calls in the small subscriber groups under consideration — 10 or 20 lines — decrease with the occupation of the group. Moreover the transposition involves a complication as regards fault seeking, as the marker will be more complicated and the *A*-step cannot be made with through multipling.

An alternative execution of transposition would be more adequately described as »twisting». In this case the subscriber multiples in the different selectors have their directions changed 90°, 45° and 135°, with the effect in the first case that the two crossbars change places and in the latter cases that the lines are laid in with the diagonals in the original multiple arrangement as points of departure.

When there is transposition in the *A*-step one should, to get the benefit of all the advantages of the transposition, have order hunting. This means that one should have graduated *B*-step. The graduating in the *B*-step will not, however, be the same as if one had straight multiple, as a shifting of the devices towards the vertical rows formerly lying in the hunting direction must take place.

With the object of saving devices in the *B*-step, the *A*-step can be made partially directed. There is then obtained a connecting diagram as per Fig. 18. The subscriber step comprises selectors for both outgoing and incoming and two-way traffic. The outgoing selectors are connected direct to the connecting circuit relay sets *(GV 1)*, while the incoming are directly placed in the group selector multiple. The two-way selectors are given for outgoing traffic direction a selector step *OV*, which is common to a number of subscriber groups. For the incoming traffic the two-way selectors in *SLV* are placed in the multiple in the selector step *BV*. Fig. 19 shows the grouping in the subscriber step. The two first devices in each sub-group carry only incoming or outgoing traffic respectively, while the last four carry traffic in both directions. The devices in the *SLV*-step are connected in a graduation as per the figure. The devices first hunted have a capacity = the subscriber group and carry one-way traffic; those following in the hunting process have the same capacity but two-way traffic. Then come devices with double capacity and finally devices with capacity equal to 5 times the basic capacity. On account of the relative large number of devices required to obtain a tolerable good graduation this connection can only be used when the traffic per subscriber line is high.

The Build up of the Exchange

Exchanges built up of crossbar selectors on the shunt circuit system are made up of a subscriber step and a number of group selector steps. The number of group selector steps is determined by the capacity desired for the exchange. If 10-selectors are used and *SLV A* are used as finders, the size of the subscriber group will be 100 and the natural number of routes for the intermediate circuit connecting will be 10. There will then be obtained, as with the ordinary decimal systems, a capacity of 1000 lines for one group selector step, 10000 lines for two group selector steps and so on. With 20-selectors the subscriber group will be 400 lines and the natural number of routes in the group selector connection 20. The capacity will then grow with powers of 20, as further group selector steps are added. With one group selector step the capacity will be 8000 lines, with two steps 160000 lines.

When connecting the last group selector step to the subscriber step the internal blockings to be found in the group selector step will, in certain cases at least, collaborate unfavourably with the internal blockings in the subscriber step. In this way there will arise an extra blocking. With the object of doing away with this extra blocking there is inserted between the last group selector step and the subscriber step a non-numerical selector step, consisting of one cross-

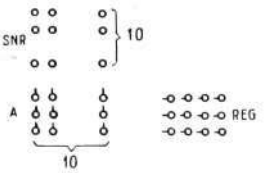


Fig. 22 X 4344

Register finder connection in two steps for 100 connecting circuits

REG register
SNR connecting circuit relay set

bar selector bridge per exit, which produces full accessibility or almost full accessibility between the group selector exits and the subscriber step entrances. As there is hunting in order in the group selector step, the secondary switch may possibly be made partial, *i. e.*, the exits in the group selector step that are first occupied are led direct to the *B*-selectors in the subscriber step (dotted line in Fig. 20). It is obviously unnecessary to introduce secondary switches for the outgoing traffic, as it is immaterial on which connecting circuit the call comes. For a similar reason it is also unnecessary to connect in secondary switches between the group selectors.

Fig. 21 shows an example of a distribution diagram for an exchange with subscriber step and two group selector steps (also secondary switch). The registers are connected over a finder to the links between the subscriber step and *GV 1*. The secondary switch is inserted between *GV 2* and the subscriber step. When a subscriber calls he is connected over *SLV A, SLV B* and the register finder apparatus to a register. The register gives out dialling tone and receives the number which the subscriber dials. When the whole number has been dialled the connection is established from the link used between the subscriber step and *GV 1* to the wanted subscriber. The relay sets for current feed to the subscribers, ringing, call metering etc. (connecting circuit relay sets) may be put in at any place whatever in the connecting chain. It is advisable to put them where the smallest number is required, for instance, between *GV 1* and *GV 2*. Otherwise the connecting route contains no relay sets but only holding magnets for those bridges which are taken into operation as line and break relays.

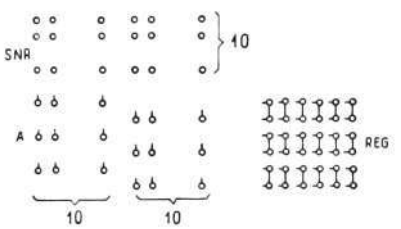


Fig. 23 X 4345

Register finder connection in two steps for 200 connecting circuits

REG register
SNR connecting circuit relay set

Register Connecting Devices

The crossbar switch has for long been employed to connect the registers to the connecting circuits, *e. g.*, in the 500-selector systems. For this it is usual to equip each register with a 100-line crossbar switch in the multiple of which the connecting circuits have been placed. Each hundred connecting circuits has then received a common register group.

The crossbar switch is extremely suitable as register connecting device as it operates rapidly and can be given an unlimited number of poles. The utilisation of material will, however, be fairly considerable if each register is to be equipped with a crossbar switch. By making the register connecting device in two stages instead an appreciable saving of material and space can be obtained. An example of such a connection is shown by Fig. 22. A connecting circuit group of 100 *SNR* is served by a register group of 8—12 registers. In the example selected each sub-group of 10 connecting circuits will have access to three devices in the *A*-step of the register finder. The devices in the *B*-step are permanently connected to the registers and are distributed in three groups, corresponding to the three devices that each 10-group connecting circuit has in the *A*-step. The connecting must be done in such a manner that even load on the different register groups is obtained, by which the least blocking in the connection will arise. A saving of about 65 % in the material for the register connecting apparatus is achieved in this way. If still further saving in registers is desired, 200 connecting circuits can be assembled in one group, when the diagram will have the appearance shown in Fig. 23. In principle the *B*-step works in the connection over two *A*-steps connected side by side as per Fig. 22.

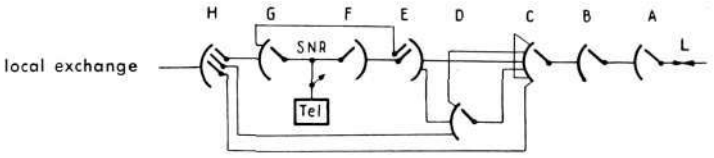
Automatic Trunk Exchanges

Crossbar switches are extremely well suited as connecting devices in automatic trunk exchanges on account of their good contact reliability, their rapidity and because any number of poles can be arranged. These exchanges should be constructed for a comparatively low blocking, as the lines they serve are expensive. Moreover the traffic is always high on the lines as they are always well utilised. As regards grouping the exchanges are built up on the inter-

Fig. 24 X 6077
Distribution diagram for automatic trunk exchange

A
B
C
D
E } selector steps
F
G
H

SNR connecting circuit relay set
TEL operator
L trunk lines



mediate circuit principle, usually in several steps. To obtain low blocking the intermediate circuits are made very expanding. It is also possible to insert into the connecting extra selector steps which have the character of secondary switches without being tied to any particular route. These secondary switches may be economy connected to a large extent.

An example of the lay out of a trunk exchange that is partially served by operator is shown in Fig. 24. The trunk traffic initiated in the local exchange is assumed here to be handled by operators who have the connecting circuits *SNR* at their disposal. The local exchange is reached over the selector steps *G* and *H*. Access to the trunk circuits is over the selector steps *F*, *E*, *(D)*, *C*, *B*, *A*. The operator can also set up transit calls, for which the direct route between *G* and *E* is used. Adaptation to the loads of the different traffic routes can be obtained by suitable connecting of the exits from the selector step *C*. The number of selector steps in an exchange of this kind will be mainly dependent on the line capacity of the exchange.

The crossbar switch has also found employment in connecting cord-circuit repeaters in both manual and automatic trunk exchanges. Each repeater is then allotted a selector for its two connecting sides. These selectors must have a capacity equal to the number of lines that are to have amplifying facility. In this case also it is possible to make a considerable saving of connecting devices by arranging the connecting devices in two steps. Principles similar to those applied for the register connecting apparatus are then applied.

8-Channel Carrier Systems for Unloaded cables II

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U. D. C. 621.395.44

Older, loaded cables can after unloading be made available for carrier operation with frequencies up to 60000 to 65000 c/s

This article which started in the previous issue is a continuation of an account of methods and apparatus for resplicing the cable and for balancing the far-end crosstalk and of characteristics and design of the carrier equipment.

Interference

In this type of carrier system interference may be expected partly from V. F. telephone and telegraph circuits, partly from open-wire lines connected tc cable lines and partly from the resistance- and valve-noise from the amplifiers

As regards interference from V. F. telephone circuits, for instance harmonics from ring signals, it appears that these to the greatest part are eliminated by the line-transformers which always are used in these circuits. These transformers introduce a comparatively high attenuation for the higher harmonic frequencies.

Interference from D. C. telegraph circuits working in cables is considerably reduced by connecting retard coil boxes at the existing repeater stations. The cable-telegraph circuit repeaters are namely usually placed at these stations and, as is well known, as the telegraph repeaters work in superphantom circuits, *i. e.* in two twist-circuits, the choke coils in the twist-circuits prevent the higher harmonic frequencies from entering the cable.

The open-wire lines, which are connected to cable-lines, can admit both atmospheric interference of higher frequencies and radio interference from certain long-wave transmitters, for instance Grimeton with 17.2 kc/s and Karlsborg with 50 kc/s. The open-wire lines function in this case as antennas and the interference picked up is admitted through the joining points into some of the circuits in the cable, especially twisted circuits. Through crosstalk from these twisted circuits interfering voltages occur in the carrier circuits. Also for this interference the transformers and the retard coils give sufficient protection.

As is said in the above, the same arrangements that were made at the repeater stations for improving the feed-back attenuation, also served to reduce interference in the carrier circuits. That these measures have been sufficient is evident from the fact that practically no interference of up to now mentioned type has been noticed in the new carrier circuits. The only exception is that the telegraph transmitter in Karlsborg (50 kc/s) can be heard very faint in a few circuits. The interfering tone is in the worst case 7.1 nepers below the speach level, which is fully acceptable.

That type of interference, which furthermore can come into question, is as mentioned previously the resistance-noise from the common amplifiers. Through suitable design of these amplifiers the valve-noise has been reduced but as regards the resistance-noise or the thermal-noise unfortunately no reducing measures can be made. This noise is as known evenly distributed over the whole frequency range and corresponding interfering voltages amount to

$$V = \sqrt{4kTRf}$$

where k = Boltzmans gas constant = $1.37 \cdot 10^{-23}$
T = absolute temperature
R = resistance
f = frequency band

Evidently the power of the resistance-noise, $\frac{V^2}{R}$, is directly proportional to the absolute temperature and the width of the frequency band but independent of the impedance. With a frequency band of 1 kc/s and an absolute temperature $T = 300$, corresponding to 27° C, the level of the interference is, as calculated according to the above formula, 16.2 nepers below zero level (1 mW) independent of the impedance. For a band width of f kc/s the corresponding level will be = $(16.2 - \frac{1}{2} \ln f)$ nepers. The effective interference level per channel is estimated to about 16 nepers below zero level considering the band width and the differing disturbing effects at different frequencies.

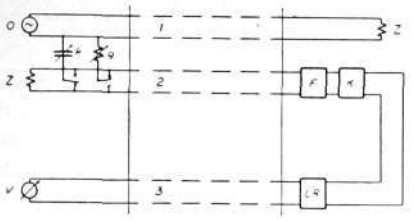
As mentioned previously, the length of the repeater sections has been chosen so that the lowest incoming speach level at a repeater station will be 6.5 nepers below zero level. This level figure evidently applies to the highest, transmitted frequency. Ahead of the common amplifiers, however, correcting networks are inserted, whose attenuation varies with the frequency in the opposite way to the cable loss, so that the total attenuation will be nearly constant within the transmitted frequency band.

These correcting networks will also attenuate the highest frequencies somewhat, why the lowest speach level will be lower than the previously quoted figure. This level will probably be 7 to 7.5 nepers below zero level and the difference between it and the level of the resistance-noise — 16 nepers, will consequently not be quite 9 nepers. The last figure gives the effective interference, which in this way occurs at each amplifier, except at those stations where the length of the repeater sections is rather short. The added interference from the different amplifiers add up and the resulting interfering voltage of the whole circuit Stockholm—Gothenburg will hereby be 7 to 8 nepers below speach level. This figure is fully acceptable, but it ought to be pointed that if the length of the circuits are increased considerably the interfering noise is also increased.

End Balancing

The crosstalk figures were improved with about 1 neper at the far-end crosstalk balancing in connection with the re-splicing as described in the foregoing. The far-end crosstalk attenuation per repeater section was after that, on the average, 8.2 nepers at highest, transmitted frequency. Relatively great unbalances still remained and these were improved through a special end-balancing. At this, opposing unbalances in form of condensers and resistances were connected between the different pairs. These elements were placed in a special balancing bay at the repeater stations.

On account of the remaining interacting couplings the resulting unbalances of a repeater section showed a relatively pronounced frequency dependence and differences in coupling. The unbalance elements, which were to be connected, had to be chosen with a compromise in regard to the unbalances at



X 4312

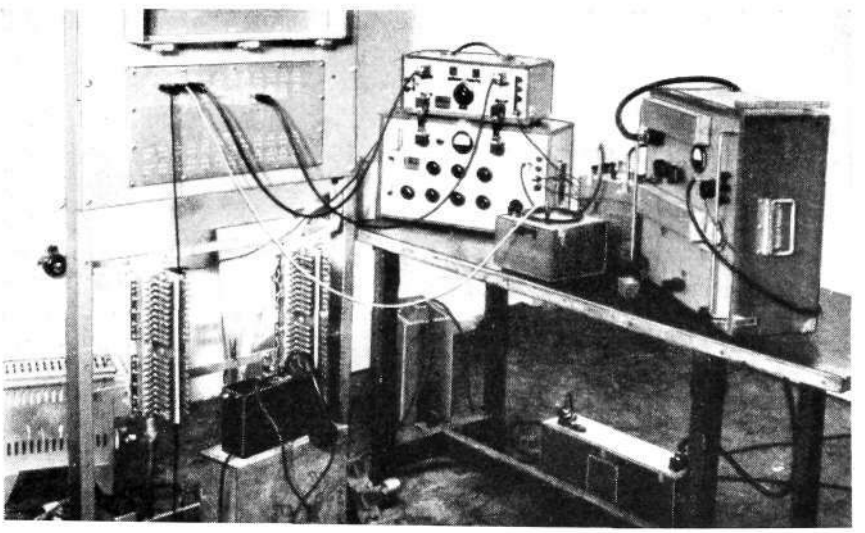
Fig. 11
Schematic of end balancing

F amplifier
K equalizing network
LR rectifier
O oscillator 8—64 kc/s
V volt meter
Z terminating impedance
k, g variable balancing elements

different frequencies and to the two measuring combinations of the pairs (crosstalk from *pair 1* to *2* and from *pair 2* to *1* respectively). Fig. 11 shows in principle the measuring arrangement which was used for the select-test of the unbalance elements at the end-balancing. The figure shows the circuit for the balancing of the crosstalk from *pair 1 to pair 2* and a switching arrangement at the measuring end for interchanging the pairs. The oscillator *O*, which was continually variable within the used frequency range, was placed at the same station as the balancing bay for respective repeater section. In the opposite station the far-end crosstalk currents were amplified and rectified, after which the resulting D. C. current, which then was a measure of the far-end crosstalk, was admitted back to the transmitting station on an special auxiliary circuit. As the auxiliary circuit had to run in the same cable as the tested pairs, the D. C. current had to be very carefully smoothed so as not to affect the measurements. The purpose of the inserted compensating networks at the amplifiers was to equalize the cable loss at different frequencies so that a certain, received D. C. current, represented a certain degree of crosstalk independent of the frequency. The D. C. current was read on an instrument placed close to the oscillator and the balancing bay. The measuring frequency and the balancing element could simultaneously be varied as the obtained far-end crosstalk was observed. After controlling over the whole frequency band with the two measuring combinations (crosstalk from *pair 1* to *2* and vice versa) the best compromise-balancing then could be selected. Fig. 12 shows a balancing bay and the instruments used for the end-balancing.

In this measuring arrangement the accuracy is dependent on the resistance-noise. The amplifier must of course pass a rather wide frequency band, about 60 kc/s, and the resistance-noise will then be relatively high. Some improvements in this respect have, however, been obtained by inserting an equalizing network *after* the amplifier, according to Fig. 11.

After the previously described end-balancing of all combinations between the pairs, the far-end crosstalk was measured at different frequencies within the transmission range. Hereby a mean value of 9.3 nepers was obtained at the highest frequency, and as a mean value for the whole frequency band 9.6 nepers was obtained. The crosstalk was evidently higher at the higher frequencies, which was expected, and it was also higher between pairs in the same quad than between pairs of different quads. In order to obtain compensation, the pairs have systematically been mixed on the different repeater sections, so that the transmission circuits of two systems run in the same quad in one repeater section at the most. Furthermore a frequency changing arrangement was used in Örebro for the passing carrier circuits Stockholm—Gothenburg, with that result that the different channels are shifted in the frequency band. Hence the lowest channel transmitted from Stockholm,



X 6054

Fig. 12
Equipment for end-balancing

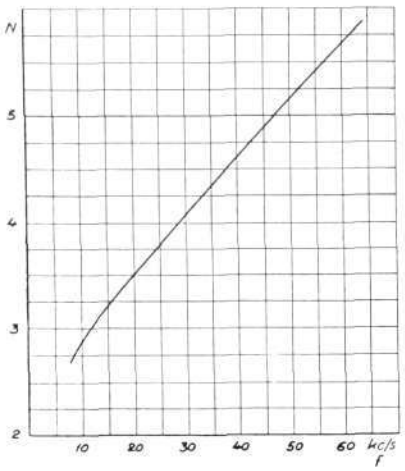


Fig. 13 X 4313
Loss in 30 km nonloaded 1.3 mm side-circuit in the trunk cable Stockholm—Gothenburg

8—12 kc/s, is shifted in Örebro to the frequency band 60—64 kc/s and thereby received in Gothenburg as the highest channel. In this way the different channels of the systems will be about equal as regards crosstalk. Far-end crosstalk measurements on completed circuits Stockholm—Gothenburg (of the same channels in different systems) have given 8.2 nepers in mean value and 7.0 nepers in minimum value (écart diaphonique). The mean value agrees very well with the value that had been calculated on the basis of the measuring results. The obtained results must be considered as fully satisfying.

Repeater Stations

On account of the relatively high attenuation at 63 kc/s, see Fig. 13, the number of repeater stations must be greater than for the V. F. amplified circuits on the loaded pairs. Considering the interference level it was evident that the attenuation per repeater section should not amount to more than 7 nepers and that the repeater distance hence must be limited to at the most 35 to 36 km. This means, that one, often two repeater stations must be built for the 8-channel system between existing stations. These stations will thereby in many cases be placed at locations that have no technically trained staff although they are in the best cases populated. It has, therefore, been necessary to arrange the stations as unattended, which already earlier has been practised with good results for, among others, the 12-channel system on the west coast cable. What there was experienced has naturally been taken into consideration leading to improvements and simplifications of the power supply equipment, which now, as regards working dependability, will be at the top of what with reasonable means can be accomplished. These unattended stations are, however, not entirely left adrift but are controlled through a well dimensioned remote control system from the nearest attended station, where to indications of alarms and operating conditions are passed and from which different measurements of the unattended stations can be performed.

When planning the repeater stations, considerations were taken for future additions without making the cost of the initial installations too high. If for example twenty pairs are unloaded but only ten 8-channel systems are intended to be worked in the first stage of installation, a considerable saving in the installation cost is gained by arranging the two directions of transmission on separate pairs. Hereby a good deal of the filters will be unnecessary, which filters according to the following are necessary when the transmission works on the same pair. The two types of transmission will in the following be mentioned, however not quite proper, as four-wire and two-wire respectively. In Fig. 14 is demonstrated how the far-end crosstalk between two pairs can occur through interacting near-end crosstalk over the mid-circuit belonging to the opposite direction of transmission.

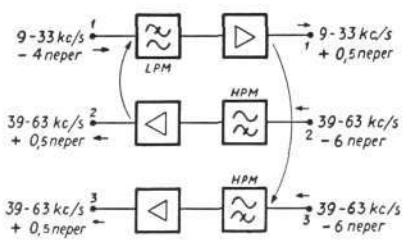


Fig. 14 X 4320
Far-end crosstalk due to interacting near-end crosstalk over other circuits in opposite direction of transmission
HPM high-pass filter
LPM low-pass filter

The near-end crosstalk between different pairs in the cable is about 8 nepers at 63 kc/s. The crosstalk then has for example from pair *1* to *2* an absolute level of — 7.5 nepers or only 3.5 nepers lower than the working level in pair *2*. If there is no *LPM* filter the crosstalk will be amplified and enters pair *1* with an absolute level of — 3 nepers. From here the crosstalk attenuation to pair *3* is again 8 nepers and we have there a crosstalk level of — 11 nepers or only 5 nepers below the working level, which was — 6 nepers.

We then have between pair *2* and *3*, which carry the same frequency band, an unintelligible crosstalk of only 5 nepers by way of the amplifier in pair *1*. The remedy for this is to insert a low-pass filter *LPM*, which will suppress all frequencies belonging to the opposite direction of transmission. The same thing naturally applies for the reversed direction, and filter *HPM* then ought to be a high-pass filter. In this figure only a few amplifiers are shown when

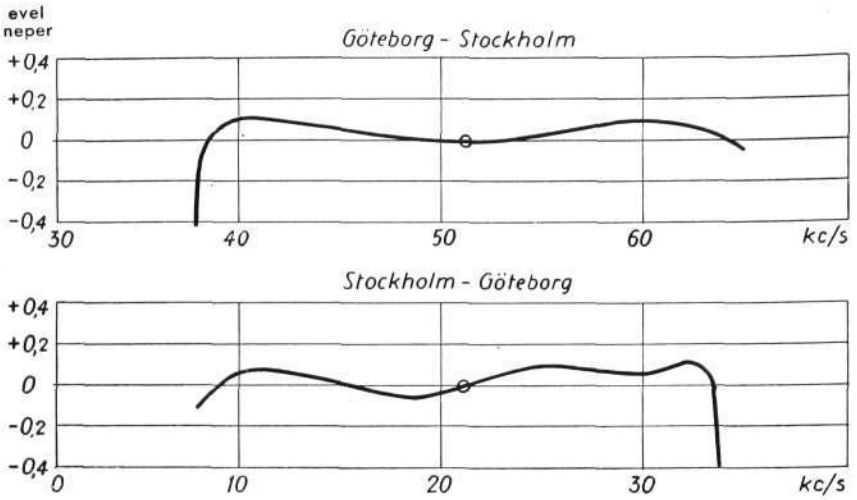


Fig. 15 X 6066
Over-all high frequency characteristics Stockholm—Gothenburg

in reality, naturally all n amplifiers of one direction contribute to the crosstalk why the assumed crosstalk is $^{e}\log \sqrt{n}$ neper lower than the just mentioned figure of 5 nepers.

At two-wire operation the same problem remains, but besides the risk of feedback and of harmonic production in the amplifier is added. Filters are therefore needed also on the high-level side of the amplifiers. These filters are the so-called directional filters, which are expensive on account of the very high requirements on the filter elements as regards non-linear distortion. If harmonics arise, for example in the filters of the low frequency direction, and these are of such a frequency that they fall within the high frequency band, interference will appear due to the great difference in level between the outgoing and incoming signals on the same pair. As an example of how high the requirements are, it can be pointed out that the transformer in the above mentioned directional filter is not allowed to give a higher non-linear distortion level of the third harmonic than 16 nepers below the level of the fundamental. Expressed in figures it is about *one ten millionth*.

Through above mentioned measures, careful shielding and well planned wiring between the different units of the repeater station, it has been possible to keep the added far-end crosstalk from the repeater low as compared to that of the cable. It appeared at measurements of the far-end crosstalk of the whole distance Stockholm—Gothenburg, that the R. M. S. of the crosstalk attenuation was only a few hundredths of a neper lower than that value that had been calculated with on basis of the crosstalk figures of the different cable sections.

The equalizing of the cable loss is done with correcting networks, which are made up of a fixed network and one or several auxiliary networks variable in slope of 0,15, 0,3 or 0,6 nepers. These auxiliary networks are connected as required so that the loss correction at an intermediate repeater always is right within $\pm$ 0,2 neper, after which a more accurate adjustment is done at the terminal.

In Fig. 15 a curve is shown of the measured over-all loss of the distance Stockholm—Gothenburg and vice versa. The cable loss is, however, not constant with the time but is changing slowly with the seasons depending on the temperature in the ground. Even if the temperature dependence as seen percentally is relatively little, the absolute variation will be so great that if no measures were taken interference in the operating circuits would occur.

According to measurements seasonal temperature variations of 15° C can normally be expected. The temperature affects chiefly the resistance of the cable circuits. Fig. 16 shows the loss variations at different frequencies on

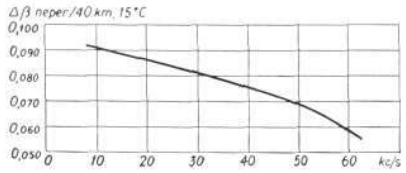


Fig. 16 X 4322
Cable loss temperature dependence

a cable section of a length of 40 km at 15° C temperature change. Within the frequency range of the lower group the difference in loss between the highest and lowest frequencies is about 0.012 neper and in the upper group 0.023 neper.

For the cable Stockholm—Gothenburg, which is of a different construction the variations of the slope for the whole distance could amount to 0.2 neper for the lower and 0.37 neper for the upper group. These values are in themselves not serious but are, however, equalized by the frequency change in Örebro, which city is situated at about the middle of the distance Stockholm—Gothenburg. The two frequency groups change places there in such a way that the highest channel in the upper group after the frequency change passes on as the lowest channel in the lower group. The main reason for introducing the frequency change was, however, not based on a desire to equalize the influence of the cable temperature variations on the circuit loss. As already mentioned, an improvement of about 0.3 neper of the far-end crosstalk is accomplished by means of the frequency change, and this is the real reason for its existence.

The absolute change of the circuit loss Stockholm—Gothenburg at for example 21 kc/s can at a 16° C temperature change amount to about 2.7 nepers according to measurements, which have been made on a test section of this cable. These variations are equalized by periodical adjustments of the amplification at the different repeater stations.

Fig. 17 shows block schematics of intermediate repeaters with and without frequency change. The frequency change is produced in a modulator with a carrier of 72 kc/s, at which the frequency band that in the schematics for the sake of simplicity is given as 9 — 33 kc/s, is changed to 72 — (9 — 33) kc/s = = 39 — 63 kc/s.

Modulating System

In Fig. 18 the modulating scheme for the 8-channel system is given. The double modulating procedure known from the LM Ericsson's 16- and 12-channel systems as earlier published (the Ericsson Review No. 2 1939) has also been used in the 8-channel system.

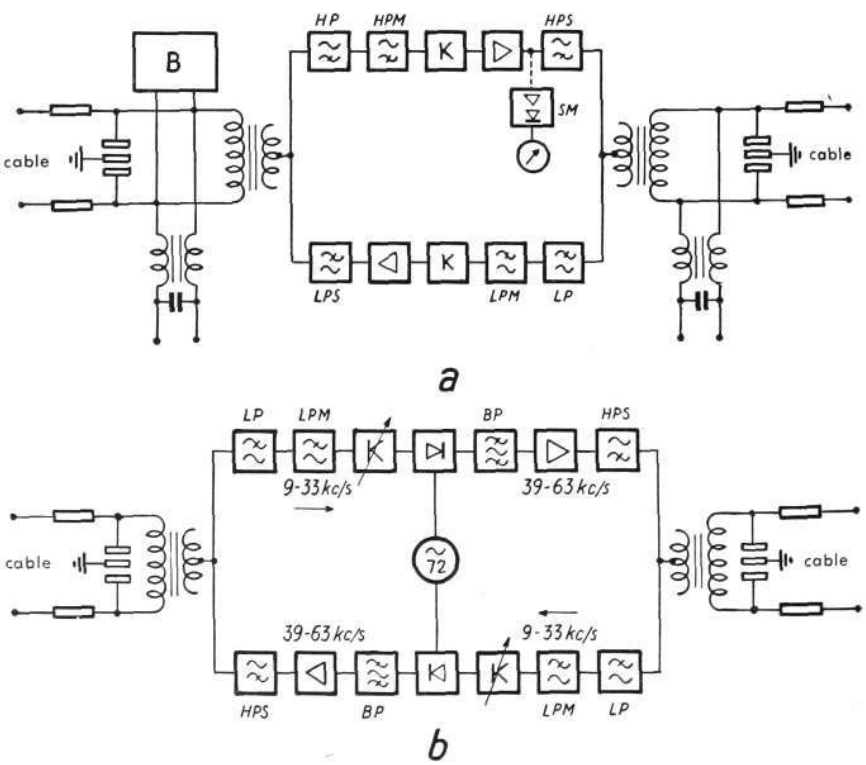
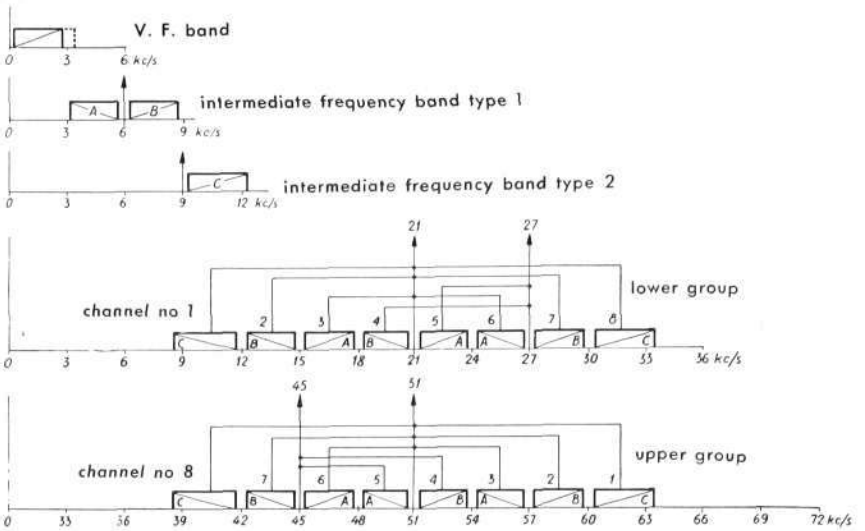


Fig. 17 X 6068
Simplified schematic of intermediate repeater for 8-channel system

a wihtout, b with } frequency change
B balancing rack
BP band filter
HP, HPM, HPS } high pass filter
K equalizer
SM pilot receiver



X 6071

Fig. 18
Modulating circuits for 8-channel system

The different frequency bands are produced in the following way.

For the six frequency bands in the lower group with 3 kc/s interval between 12 and 30 kc/s a first modulation is done with 6 kc/s and a second with 21 or 27 kc/s as carriers. If the V. F. speach-band covers 200—2700 c/s, two side bands are produced at the first modulation, one 6.2—8.7 kc/s, and a second 3.3—5.8 kc/s, of which one or the other is suppressed in a band filter, which, however, admits the other. At the second modulation with, for example, 21 kc/s, likewise two side bands are produced, of which one is suppressed. The position of these side bands is determined by which of the side bands of those produced at the first modulation is going to be used.

The two wide frequency bands are produced by means of using a carrier of 9 kc/s at the first modulation from which the side band 9.2—12.6 kc/s is used in the second modulation with a carrier of 21 kc/s, which gives one or the other of the side bands 8.4—11.8 kc/s and 30.2—33.6 kc/s respectively.

The bands of the upper group are derived in a quite analogous way, if 21 kc/s is changed to 51 kc/s and 27 kc/s to 45 kc/s as carriers for the second modulation.

The two groups are symmetrical around the mid-frequencies 21 and 51 kc/s respectively, a thing which has proved valuable in many respects.

Oscillator Equipment

The oscillator equipment is designed so, that it can be used in either the 8-, 16- and 18-channel systems. All carriers are produced in separate oscillators which, however, are synchronized so that their frequencies solely are dependent on the frequency of a crystal-tuned oscillator of 120 kc/s. Fig. 19 shows the working principle of the oscillator equipment. The arrows indicate the direction of the power. The master oscillator, *MO*, is crystal-tuned for 120 kc/s. Its frequency accuracy is determined by the crystal temperature coefficient, which is only $3 \cdot 10^{-6}$ per °C. This great stability has been attained by cutting and grinding the crystal in such a way that its different surfaces are oriented in a specific relation to the natural axis of the crystal.

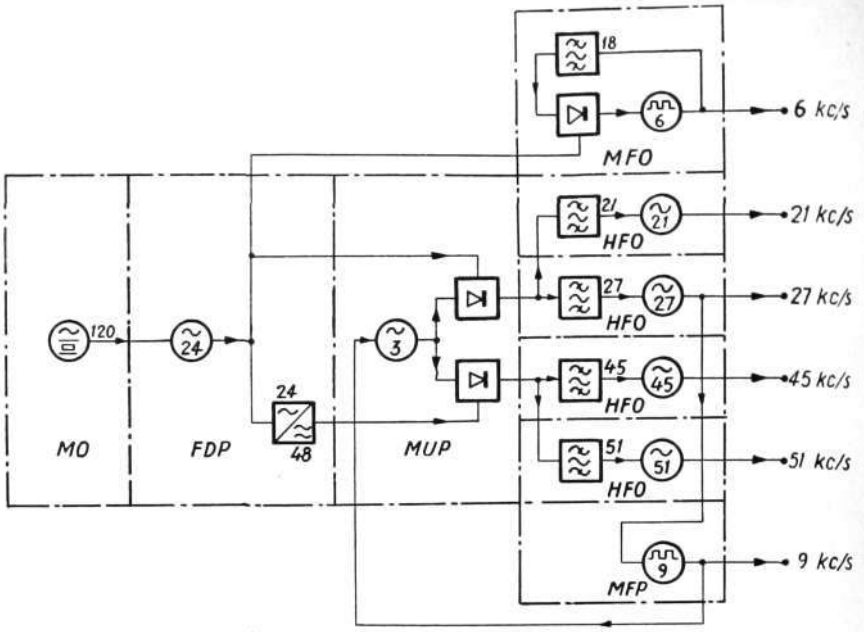


Fig. 19 X 6065
Schematic of oscillating equipment

FDP oscillator for 24 kc/s with frequency-doubling
HFO oscillators for 21, 27, 45 and 51 kc/s
MFO oscillator for 9 kc/s
MO quartz crystal tuned oscillator for 120 kc/s
MUP oscillator for 3 kc/s

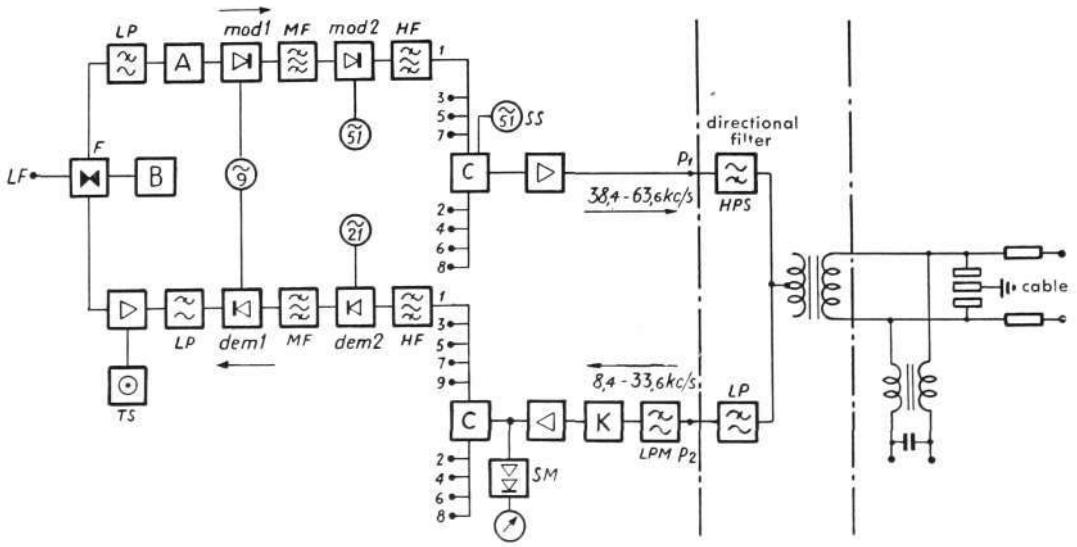
The oscillator equipment is designed for a capacity that can supply a considerable number of 8-channel systems with carrier power for modulators and demodulators. In order to decrease the risk for failure in operation caused by fault in the carrier oscillators, which would affect a considerable number of circuits, each oscillator is equipped with a stand-by unit and arranged so that at a failure due to fault in a working unit, the stand-by unit is automatically switched in. The output of the working oscillator is rectified and the produced D. C. voltage applies a high negative grid bias to the valve of the spare unit preventing this from oscillating. As soon as the A. C. output of the working unit fails, the blocking bias on the valve of the spare unit is removed and the spare unit practically starts operating immediately. The time it takes to get the spare unit into operation is about 0.3 ms. This time is short enough to allow V. F. telegraphy to be transmitted over this system without risks of loosing a part of a character at the change-over.

Fig. 20 X 7377
Simplified schematic of terminal

A volume limiter
B balance
CF compensating filter
DEM 1, DEM 2 demodulators
F four-wire termination
HF high frequency filter
HPS high-pass filter
K equalizer
LF voice frequency,
LP, LPM low-pass filters
MF intermediate frequency filter
MOD 1, MOD 2 modulators
SM pilot receiver
TS V. F. ring signal auxiliary unit

Terminal Equipment

Fig. 20 shows a simplified schematic of one terminal of the 8-channel system. For the sake of clearness, only the filter equipment of one channel is shown. The schematic shows how the system is layed out when it is connected for



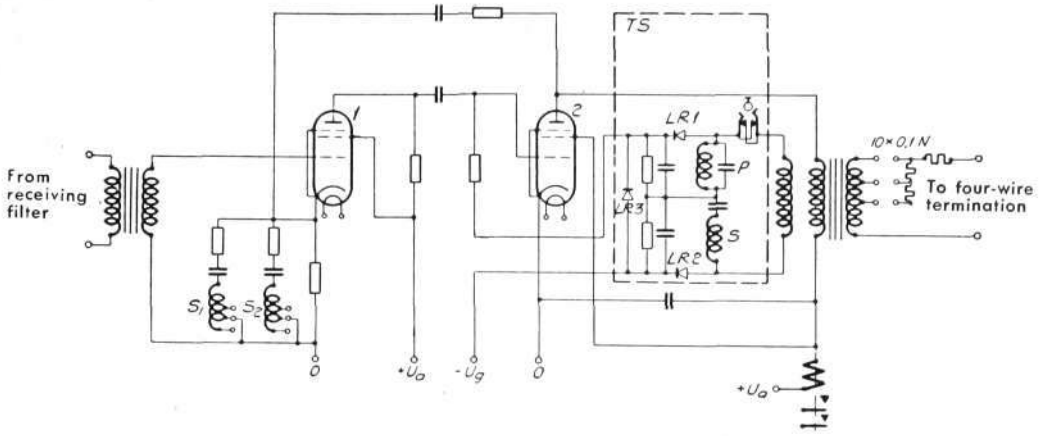


Fig. 21 X 7374
Schematic of V. F. amplifier with auxiliary unit

LR 1, LR 2, LR 3 rectifiers
P parallel resonant circuit
S_1, S_2 series resonant circuits
TS V. F. ring signal auxiliary unit

two-wire operation on a cable. At two-wire operation the directional filters are omitted and two cable pairs are connected to the points P_1 and P_2 respectively.

The ringing over the system is done with 500 c/s. The V. F. ring signal receiver is combined with the V. F. amplifier into one unit. In earlier designs the V. F. amplifier employed two valves and to this a separate V. F. ring signal receiver also employing two valves was connected. In the new design the V. F. ringing auxiliary unit has been combined with the V. F. amplifier retaining in total the same number of valves as the latter in itself. Hereby a considerable saving both in material and space was attained, and at the same time the wiring in the station was simplified a good deal.

The circuit schematic of the new V. F. amplifier with auxiliary unit is shown in Fig. 21.

For the sake of clearness the schematic is simplified. Furthermore the four-wire termination and the relays for relaying the incoming 20 c/s ring signal to 500 c/s outgoing ring signal and vice versa are not shown in this schematic. These elements are actually combined into one unit, see Fig. 22, which may be omitted, if the circuit is to be passed further as four-wire connected.

The amplifier is, as seen in the schematic, negative feedback coupled. The feedback circuit includes two series resonant circuits S_1 and S_2, by which the amplification can be raised (by lowering the feedback voltage) at two frequencies, which are chosen so that the attenuation increase at the edges of the transmitted band is compensated. The V. F. ring signal auxiliary unit *TS*, see Fig. 23, is connected to one winding of the output transformer. It is composed of the known combination of parallel and series circuits tuned for 500 c/s with included rectifiers. At a ring signal the voltage over the parallel

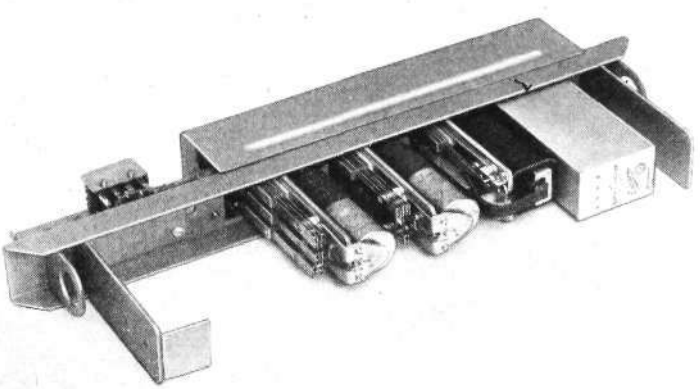


Fig. 22 X 6055
Relay unit for V. F. ring signal auxiliary unit

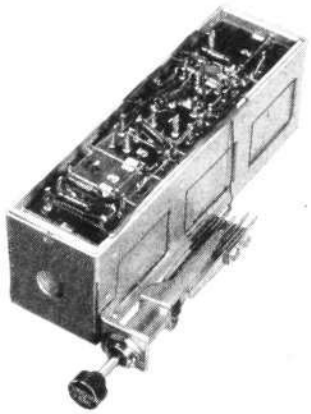


Fig. 23 X 4814
Ring signal auxiliary unit for V. F. ring signal receiver

circuit P is rectified by rectifier $LR1$ and the negative grid bias on valve 2 is decreased, whereby the anode current is increased and the relay in the anode circuit operates making another relay in the relay unit to operate, which connects 20 c/s ringing current towards the exchange. While conversations go on, the speach currents, which are composed of currents of different frequencies, will chiefly produce voltages over the series circuit. After rectification the attained D. C. voltage is given such a polarity that is reversed to the voltage from the parallel circuit. For preventing the anode current to decrease at speach rectifier $LR3$ is so arranged that it short-circuits the affect of these currents in the grid circuit. The grid bias can then be changed only in the positive direction but, to be noticed, only when pure 500 c/s current enters the V. F. ring signal auxiliary unit.

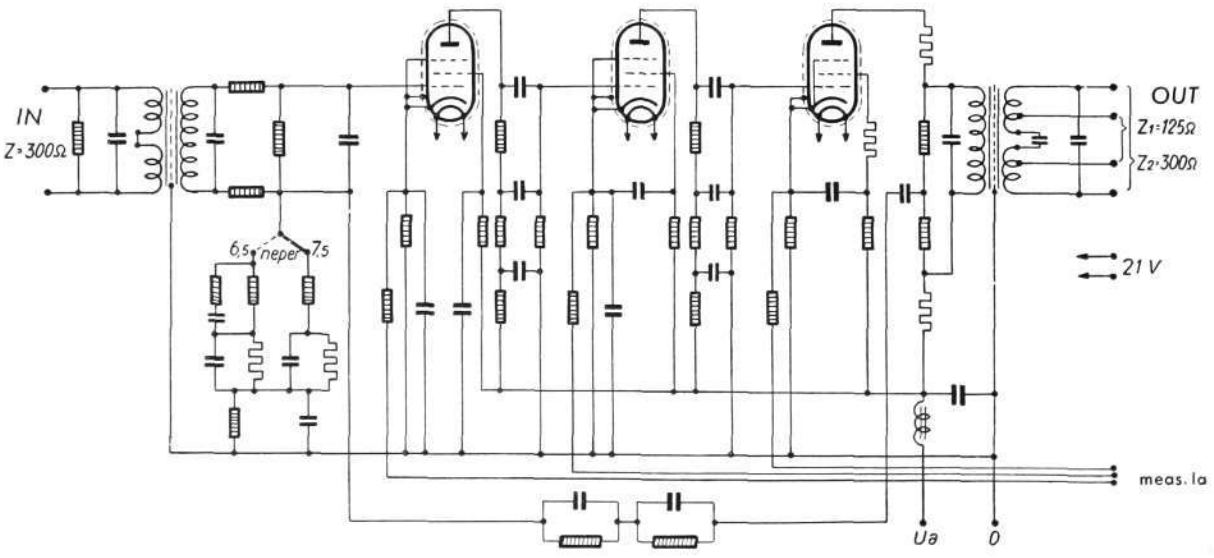
The ring relay also functions as anode alarm relay. It is namely built as a two-step relay where the first operated position, held by the normal anode current, only holds the contacts broken, which give alarm for anode voltage failure. First at a ring signal when the anode current has increased above a certain value the contacts for passing the signal are operated.

The High Frequency Amplifier

The amplifiers for the eight channels in each direction of transmission are of the same type in the terminal as well as in the intermediate repeater. Furthermore this type of amplifier is used in the 12-, 16- as well the 18-channel systems. Fig. 24 shows a circuit schematic of the amplifier. The amplifiers can be connected for a gain of either 6.5 or 7.5 nepers. The higher gain is of course used for the upper frequency group. By using negative feedback coupling these amplifiers can be designed to meet the very high requirements that must be raised as regards freedom from noise, stability and low intermodulation if carrier systems of this type at all can be built for offering satisfactory circuits. The principle of the feedback is well known through earlier publications by different authors and is, therefore, not discussed here.

An important matter will, however, be mentioned, namely the effect of the feedback upon the valve noise. As already mentioned, the noise level is entirely determining the length of the repeater sections and it may then be of interest to investigate if the amplifiers themselves add to the resulting noise level of the circuit.

Fig. 24 X 7576
Schematic of negative feedback-coupled amplifier



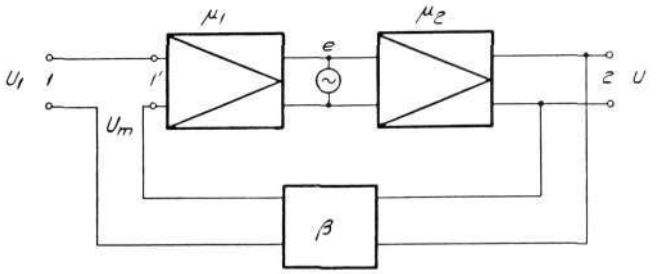


Fig. 25 X 6056
Negative feedback-coupled amplifier with a disturbing voltage e

Fig. 25 shows the schematic of a negative feedback coupled amplifier, within which a disturbing voltage e is imagined to appear at a point that generically is supposed to have a gain μ_1 from the input terminals 1' and a gain μ_2 towards the output terminals, and hence follows that

$$\mu_1 \cdot \mu_2 = \mu$$

is the gain without negative feedback.

According to Fig. 25 the negative feedback is coupled through a passive, linear quadripole in such a way that

$$[(U_1 - U_m) \cdot \mu_1 + e]\,\mu_2 = U$$

where $U_m = \beta \cdot U$

Hence is obtained

$$U = \frac{U_1 \cdot \mu_1 \mu_2}{1 + \mu_1 \mu_2 \beta} + \frac{e \cdot \mu_2}{1 + \mu_1 \mu_2 \beta} = U_2 + U_s \quad \ldots\ldots\ldots \quad (1)$$

where

$$U_2 = \frac{U_1 \cdot \mu_1 \mu_2}{1 + \mu_1 \mu_2 \cdot \beta} \text{ is the signal voltage} \quad \ldots\ldots\ldots \quad (2)$$

and

$$U_s = \frac{e\,\mu_2}{1 + \mu_1 \mu_2 \beta} \text{ is the disturbing voltage} \quad \ldots\ldots\ldots \quad (3)$$

For the amplifiers applies

$$\mu\beta = 239 \gg 1$$

$$\therefore U_s \cong \frac{e \cdot \mu_2}{\mu \beta} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (4)$$

According to equation (2) and (3) is

$$\frac{U_s}{U_2} = \frac{e}{U_1 \cdot \mu_1} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (5)$$

Equation (5) gives that the relation, disturbance versus signal, will be greater the smaller μ_1 is, *i. e.* the nearer to the input side of the amplifier the disturbance appears. If it appears in the anode circuit of the output valve $\mu_2 = 1$ and one gets according to equation (4)

$$U_s = \frac{e}{\mu \beta}$$

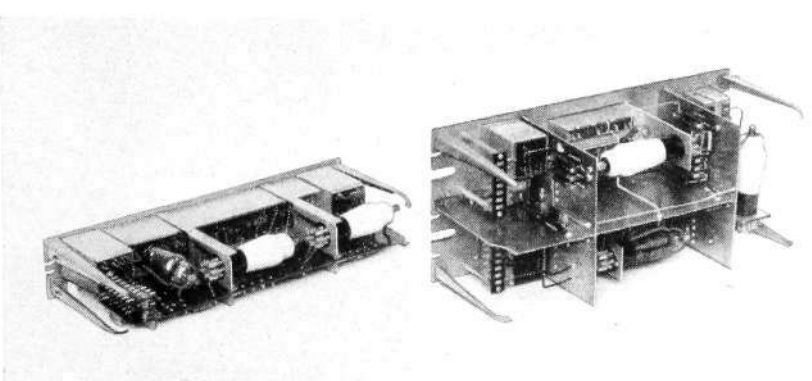


Fig. 26 X 6057
New and old design of negative feedback-coupled amplifier

showing that a reduction in interference is obtained, which is proportional to the negative feedback coupling factor $\frac{1}{\mu\beta}$, *i. e.* in this case $\frac{1}{239}$ of the value without negative feedback.

A reduction of the disturbing voltage is, however, only obtained, as seen by the term for U , if it appears at such a point of the amplifier that

$$u_2 \leqq \mu\beta$$

if e is the valve noise that appears in the anode circuit of the first valve

$$e = 0.56 \cdot 10^{-9} \sqrt{I_a \cdot f} \cdot R_a \, V$$

where I_a = mean value of anode current in A

f = band width in c/s within which the valve noise is effective

R_a = anode load in ohms

One finds in this case that for $f = 1000$ c/s

$$U_s \cong 24 \mu V$$

which is equivalent in level to — 10.4 nepers on the output side of the amplifier and — 16.9 nepers on the input side. This latter figure is to be compared with the resistance noise, which according to the foregoing was — 16.2 nepers. The effective noise level will thus through the addition from the amplifier be changed about 0.1 neper to — 16.1 nepers.

One may consequently with good reason consider the amplifiers not to any essential extent affect the resulting noise level but that this is determined by the resistance noise.

Supervisory Equipment

Comprehensive work has been put down to make the supervision of the system, especially the unattended repeater stations, as effective as possible without employing too complicated supervisory arrangements.

The demands are on the whole the following:

1. Fault in an unattended station should be indicated at the main station in such a way that the attendence staff from the indication signal can determine if the fault requires immediate attention or not.

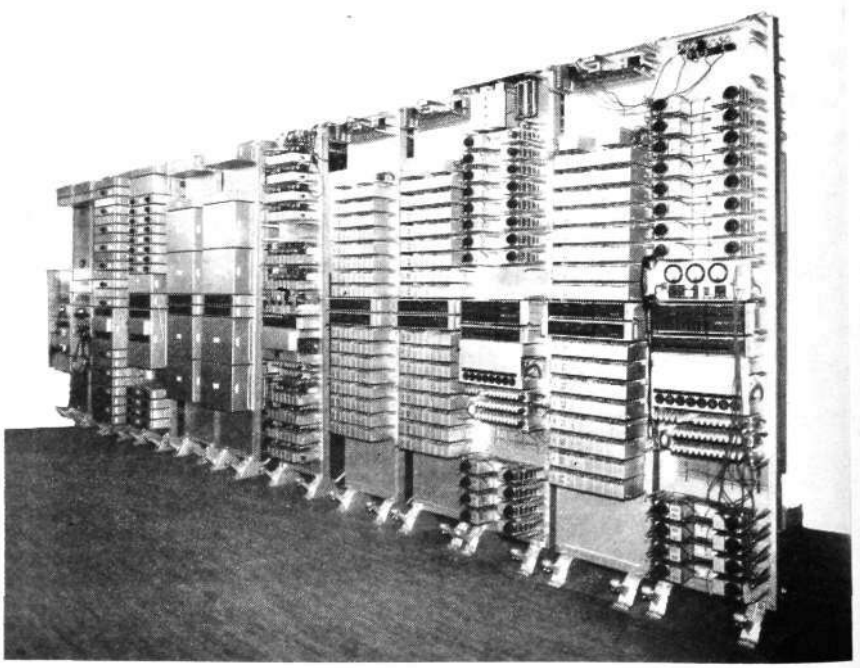


Fig. 27 X 6058
Terminal equipment for Stockholm being tested

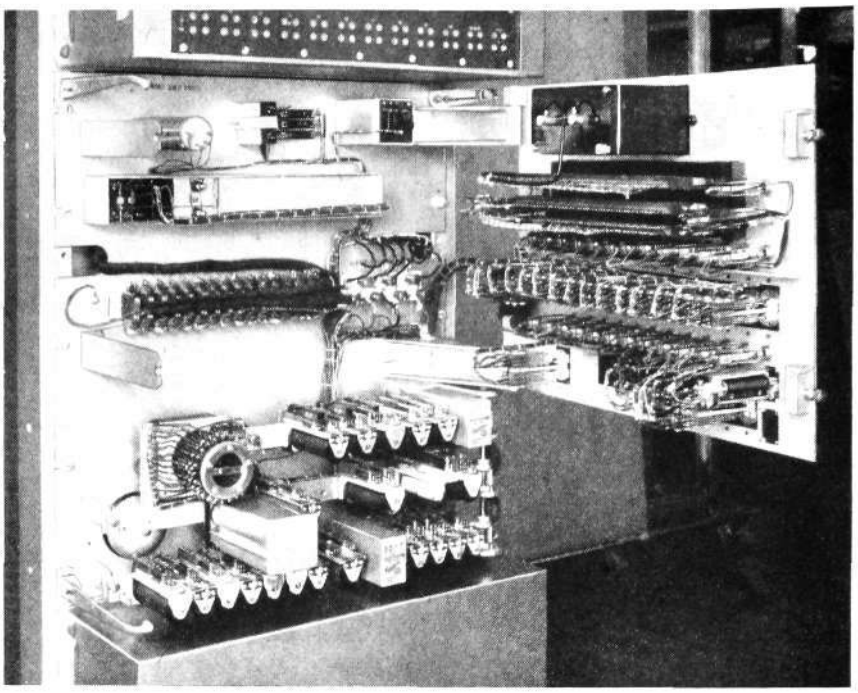


Fig. 28
Remote control equipment

X 6059

2. The attendence staff shall from the main station be able to obtain certain important data about the unattended station.

3. There ought to exist means for switching in a spare amplifier in an unattended station from the main station.

This remote control equipment, which is intended to meet above mentioned demands, the appearance of which Fig. 28 gives an idea, has in a general outline the following principle design.

The indication signals are transmitted on the same pair in the cable as the 8-channel system is working on. By means of low-pass filters at each end of the cable, D. C. currents or D. C. impulses can be transmitted without disturbing the carrier circuit.

Fault indications are transmitted with D. C. currents through relays, which are directly connected to certain pairs in the cable. Alarm signals are given with individual marking through signal lamps for a total of 13 different kinds of faults in the sub-station, for example power supply failure, fault on spare equipment, blown fuses, failing heater, anode or relay power. A ceiling thermostate is also mounted in the station and included in this alarm system.

The measurement of the output level of the amplifiers is arranged by remote control. From the end terminals a pilot is transmitted, which in the lower group has a frequency of 21 kc/s and in the upper group 51 kc/s. This pilot normally has a level of — 0.5 neper on the output side of the amplifiers.

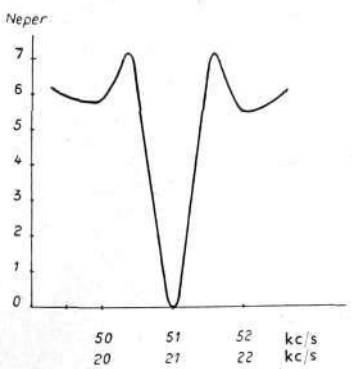


Fig. 29
Selectivity of pilot receiver

X 4915

By means of selectors a pilot receiver can be connected to the output side to any of the 40 amplifiers in the unattended repeater station. This pilot receiver, which is of a very high selectivity, see Fig. 29, is only affected by the two pilots 21 or 51 kc/s without being disturbed by the conversations in progress neither in nearby channels nor others. In the pilot receiver the pilot is amplified and rectified and the resulting D. C. current is admitted through the cable to an instrument at the controlling station.

With the same instrument the operating voltages 21 V ~, 24 V = and 85 V = are measured.

Power Supply Equipment for the Unattended Repeater Stations

The power supply of the unattended stations are in the main arranged in the following way. The ordinary working power source is of course the local power mains, which supply 380 V three-phase A. C. As reserve power serves a diesel engine driven generator delivering the required voltage. The change-over to the reserve equipment takes place automatically, at which the diesel engine is started by a 12 V battery, which ordinarily is held fully charged by a voltage-regulated rectifier.

For working the carrier equipment for instance twenty 8-channel systems, is required:

filament heating power	21 V~, 40 A
anode power	85 V=, 1.1 A
alarm relay power	24 V=, 4 A

The heater current is taken directly from the mains through a transformer and regulating equipment. The anode voltage is obtained from a voltage-regulated rectifier. The relay voltage is obtained in a similar way as the anode voltage.

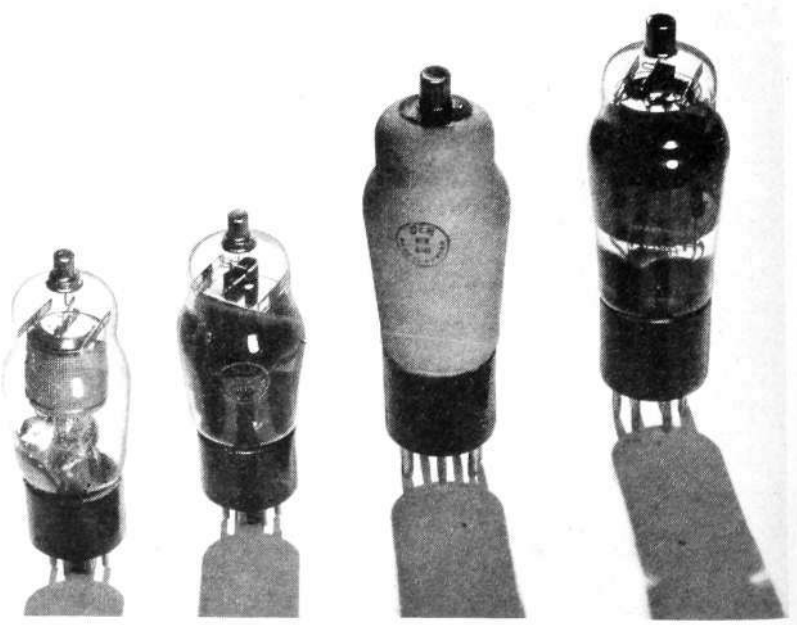
At mains failure in case of fault on the reserve equipment, a second reserve is available in form of two 11 cell batteries for 288 Ah reckoned to last 4 h each, during which time the staff, called by the alarm circuits, is expected to clear the fault on the reserve equipment, if the mains failure is of a long duration. At the same time a converter 24 V = /85 V = delivering 85 V anode voltage is connected to the battery. The two reserve batteries are held fully charged as long as the mains voltage is present.

The reserve battery is connected immediately for heater supply at mains failure but is disconnected when the diesel engine has started and the generator delivers the right voltage. If the diesel engine does not start after a certain time, its starting battery is disconnected and alarm is sent to the attended station. The power supply equipment is delivered by ASEA.

Types of Valves

Fig. 30 shows the different types of valves used in the 8-channel system. There are four types all pentodes with indirectly heated filaments. The four valves are from the left

RTR 4141, RTR 4142, RTR 4341 and RTR 4342.



X 6060

Fig. 30
Types of valves used in 8-channel system

The two latter valves work on 21 V heater voltage with a heater current of 0.28 and 0.33 A respectively. These two valves are used in the negative coupled high frequency amplifiers, while the other two are employed by the V. F. amplifiers and the oscillators. RTR 4141 and RTR 4341 are chiefly to consider as high frequency pentodes, while RTR 4142 and RTR 4342 are output pentodes.

The valves are manufactured by AB Svenska Elektronrör (SER), a valve factory associated to LM Ericsson.

Measuring Results

When the system was installed, some measurements were made on the completed circuits.

Far-End Crosstalk

Table I shows the far-end crosstalk (écart diaphonique) between the different channels of the same system.

Table 1. Measured values in nepers of the far-end crosstalk between channels of the same system

Disturbing Channel	Disturbed Channel							
	1	2	3	4	5	6	7	8
1	—	7.6	—	—	—	—	—	—
2	8.0	—	7.2	—	—	—	—	—
3	—	7.2	—	8.0	—	—	—	—
4	—	—	7.8	—	7.5	—	—	—
5	—	—	—	7.3	—	8.0	—	—
6	—	—	—	—	7.7	—	7.5	—
7	—	—	—	—	—	7.4	—	7.7
8	—	—	—	—	—	—	7.6	—

Fig. 31 shows the over-all characteristics of one wide and one narrow channel of the 8-channel system as well as one old V. F. circuit of the Stockholm—Gothenburg cable.

To test the adaptability of the system on long distances a circuit was connected, whose length was 37 times back and forth Stockholm—Gothenburg, which is 20000 km or one and a half time around the earth. The total cable loss was 2900 nepers and the over-all loss was adjusted to 1 neper. Owing to the fact that different frequency bands are used for the two directions of transmission, the circuit could not be established by high frequency joining but had to be joined on the V. F. side. This way of connecting gives a phase distortion caused by the filters of the terminals, which normally does not exist on a circuit of this length.

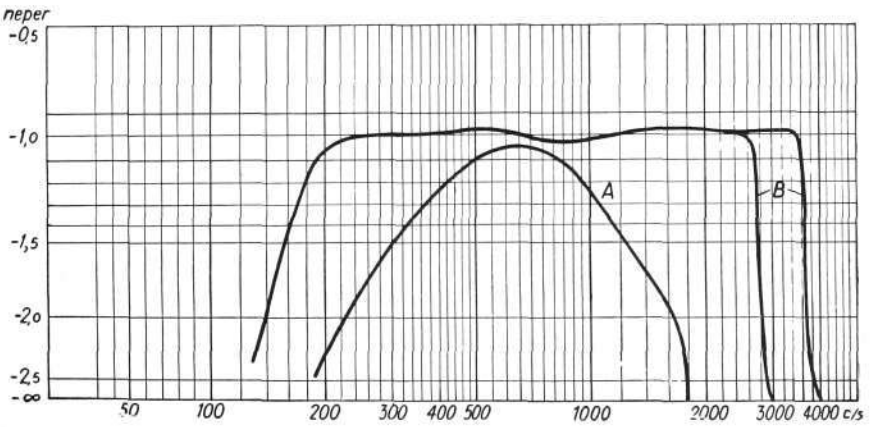


Fig. 31 X 6064
Over-all frequency characteristics of distance Stockholm—Gothenburg
A old circuits
B 8-channel system circuits

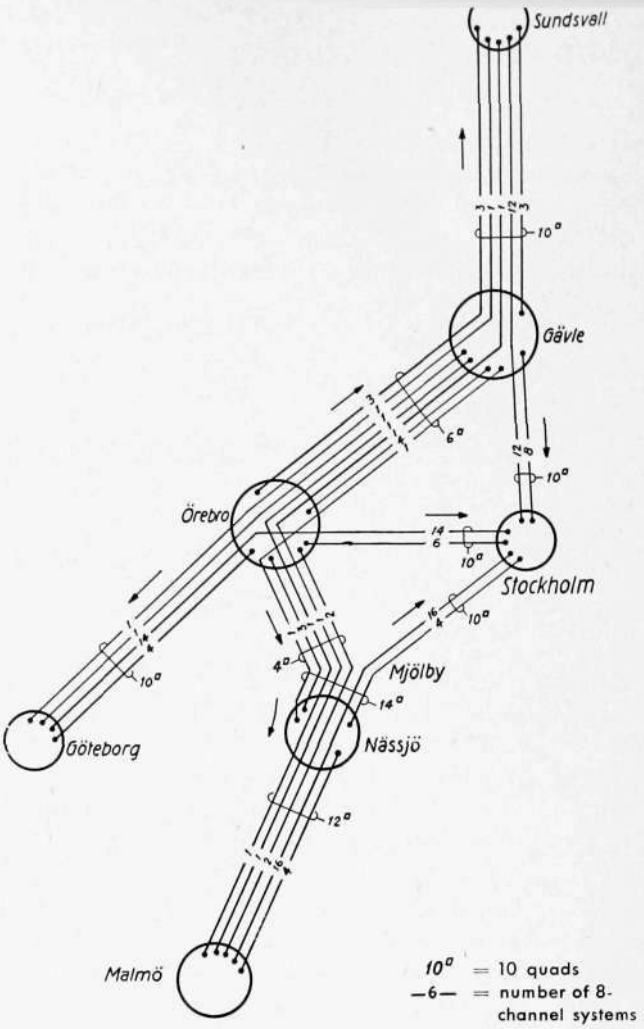


Fig. 32 X 6063
The Telegraph Administration installation plans for 8-channel systems

Despite the phase distortion, conversation could go on without difficulty. The contribution in propagation time of the cable amounts to about 100 ms. The filters of the terminals contribute at the mid-frequency with about 50 ms, which nearer to the cut-off frequencies is increased, however, to about 250 ms. It may then be said that the connected circuit as regards the propagation time can be equalled to a cable circuit of 30000 km but that it on account of the way of joining-up, which never can be equalled in reality, was inferior to what it would have been on a normally arranged circuit of this length. At last it may be mentioned that 185 modulations and demodulations took place in each one of the directions of speach of the circuit.

The Telegraph Administration Installation Plans for 8-Channel Systems

The map shown in Fig. 32 gives the extent of the program, which the Telegraph Administration plans for the next year as to installing 8-channel systems on the cable network. Ten systems in the plan are installed on the distance Stockholm—Gothenburg and 10 systems are being installed on the distance Stockholm—Sundsvall. An addition to make a total of 20 systems on the distance Stockholm—Gothenburg is ordered, besides which the unloading of the distance Stockholm—Malmö will be started in the summer 1945.

When all this work is finished, a total of about 300000 circuit kilometers is constructed according to the 8-channel system principle in Sweden. During the same time also 12- and 18-channel systems will be installed, whereby the number of circuit-kilometers obtained by means of LM Ericsson multi-channel systems on unloaded cables will amount to 350000, which nearly is equal to the half of the existing Swedish trunk network.

Portable Exchange Tester for Automatic Telephone Exchanges

B BJUREL, ROYAL BOARD OF TELEGRAPHS, STOCKHOLM

U.D.C. 621.395.66

Rational maintenance of automatic telephone exchanges requires labour-soving and reliable testing equipment. A portable exchange tester which allows of automatic testing of the exchanges has been developed by Telefonaktiebolaget LM Ericsson in collaboration with the Swedish Royal Board of Telegraphs. The exchange tester, which meets the highest demands for reliability, can be used for all standard telephone systems.

Included in the work of maintenance occurring at automatic telephone exchanges is routine testing of connecting devices and traffic routes for the identification of those faults which are not automatically marked by existing alarm equipment. As these routine testings represent an appreciable part of the maintenance costs, it is desirable that the routine testing work is cheapened as far as possible with the aid of effective automatic testing devices. For this purpose a portable automatic exchange tester has been worked out by Telefonaktiebolaget LM Ericsson in collaboration with the Swedish Royal Board of Telegraphs.

In developing the exchange tester the object has been to produce a testing device which can establish and check normal connections between local subscriber numbers, trunk breaking of local call connections and calls to outside exchanges. The testing device should work automatically, be easy to operate and have great reliability.

The result of these efforts has been an exchange tester with the following properties:

Testing Facilities

The exchange tester provides for the following four types of test:

1. call to disengaged subscriber numbers in the exchange itself
2. call to busy subscriber numbers in the exchange itself
3. trunk breaking of local call connections
4. call connections with other exchanges

For the three first tests there must be test numbers, corresponding both to the calling subscriber (A-subscriber) and to the called subscriber (B-subscriber) available in the exchange concerned. In the fourth test the B-subscriber is represented by an automatic answering device at the other exchange. The tester needs only to be connected to the test numbers, set for the required type of test and set going, after which it works automatically. When a fault is encountered the tester stops and emits an alarm signal.

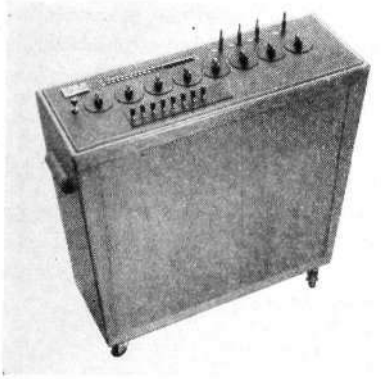


Fig. 1 X 4346
External view of LM Ericsson's new exchange tester

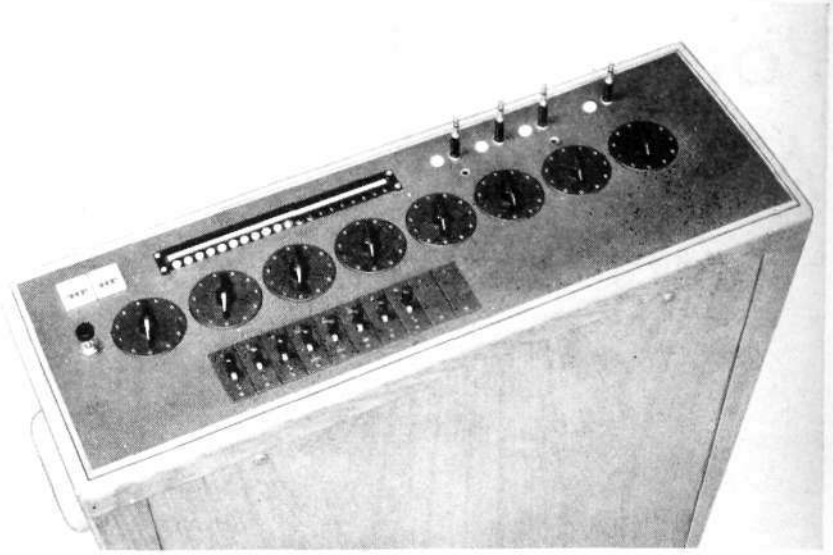


Fig. 2 X 6080
Control devices on the exchange tester

For entirely automatic test the connecting devices are selected at random. If in special cases it is desired to test certain definite devices or rapidly to test right through a whole group of devices, it is possible to direct the tester by progressivly blocking the devices.

Electrical Construction

The connecting parts comprised in the exchange tester consist in the main of some forty telephone relays, a voice frequency generator and a voice frequency receiver. The relays are fitted with twin contacts, thus ensuring great reliability. The diagram is drawn on the basis that the tester shall be able to make call connections in the same way as an ordinary subscriber. There is therefore included in the equipment a chain of relays for transmitting the figures set on the exchange tester's figure knobs and chains of relays for recording all the signals which during the establishment of the connection go out to the calling and called test wires respectively. The voice frequency generator and the voice frequency receiver have the duty among other things to check a connection established in respect of transmission.

Mechanical Construction

In designing the tester special efforts have been made to bring down the work of attendance as much as possible. This work is largely confined to connecting the tester to the reserved test numbers, setting up a desired figure combination on a number of figure knobs and selecting the desired type of test by means of switches.

The broad lines of the exchanges tester's mechanical construction may be seen from Fig. 1 and 2. All relay equipment together with a voice frequency receiver and a voice frequency generator have been built in to a truck. The dimensions of this truck are such that it can easily be wheeled in the passages between the rows of racks in the automatic exchanges.

The control devices are, as may be seen from Fig. 2, easily accessible on the top of the truck. The control devices of the tester consists of figure knobs, switches, connecting plugs with cords, call meters and an illuminated signal board.

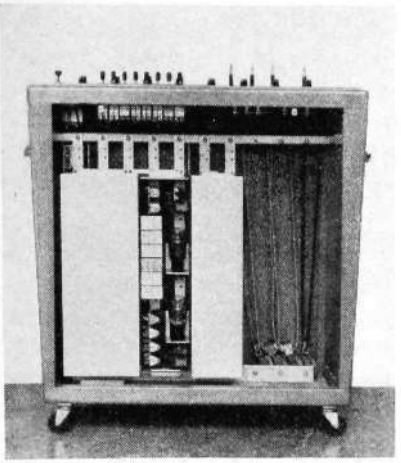


Fig. 3 X 6019
Exchange tester with front removed

Making the Tests

The testing process for the four different tests are briefly the following:

1. Call to Disengaged Subscriber Numbers in the Exchange itself

After the B-number has been set up on the exchange tester figure knobs and the type of tests indicated by the switches, the tester is started and the automatic process of testing begins.

The first stage is the calling of the exchange in normal manner over one of the test wires. The voice frequency receiver is then connected to this wire to record the answering tone. When the answering tone has been received the B-number set up is transmitted automatically.

The next stage in the testing deals with checking the ringing up process. For this the tester checks that ringing tone goes out to the A-side and ringing signal to the B-side. While checking the ringing process the exchange tester connects an artificial load to the B-side. This load is equivalent to the largest number of bells permissible for the subscriber and is intended to check that no unauthorised signal breaking takes place. After the process of ringing the appropriate signal breaking, current feed and speech connection are checked.

Finally the connection is taken down. In conjunction with the disconnecting, check is made that call meter signal comes in and that disconnection really takes place with a certain margin of resistance inserted in the A and B loops.

While testing is proceeding the different phases of the process can be followed on the illuminated signal board. In case of fault in any of the phases of connection the tester stops and emits alarm signals.

2. Call to Busy Subscriber Numbers in the Exchange itself

This test is identical with the foregoing up to and including the sending of figures. After the figures have been sent the voice frequency receiver is again connected on the A side to check the busy tone. The taking down of the connection is checked in the same way as with the previous test. However, the call meter signals should not come in this case.

For this test, calls can either be made to the test wire over which the exchange tester calls the exchange or to a separate busy marked number. For different A and B numbers the exchange tester allows of a margin testing of the test relays of the finders and the final selectors.

3. Trunk Breaking of Local Call Connections

The trunk breaking test is intended to check that a local call marked connection, which is subjected to trunk breaking via the finder or the final selector, is really and effectively broken. The test proceeds in the same manner as tests with disengaged subscriber numbers up to and including the checking of the current feed. The connection is then broken for trunk via the finder or the final selector. Execution of the breaking of the speech connection is recorded by the voice frequency receiver which via the speaking route is connected to the voice frequency generator.

In the trunk breaking test, the test relays of the finders and final selectors are tested for margin.

4. Call Connections with other Exchanges

To facilitate supervision of the operating reliability in an automatic network the exchange tester has been given the possibility of also establishing connections with other automatised exchanges. As the B numbers in this case are not located in the exchange itself, test numbers are arranged provided with automatic answering devices at the called exchanges.

To enable the establishing of connections to other exchanges the tester allows of the transmission of all combinations of figures that occur in the Swedish telephone network. Thus up to eight figures of any kind can be sent out. For long distance traffic these can moreover be preceeded by a zero. The tester can wait for answering tone after the sending of two, three or four figures.

The answering device at the called exchange answers the call by a special tone code that is recorded by the exchange tester.

After each faultless connecting the tester checks in conjunction with disconnecting that call meter signal comes in.

Catalogue Numbers on the ABC System

G GRÖNWALL, TELEFONAKTIEBOLAGET LM ERICSSON, STOCKHOLM

U.D.C. 651.533.25

In studying LM Ericsson's current catalogues it will be found that most of the catalogue numbers are made up of three letters and four figures, e. g., RBM 1404. These designations are based on a classification system introduced in conjunction with the standardisation of LM Ericsson's products, known as the ABC system, the make-up and application of which will be briefly described here.

The classification, which constitutes an important feature of the standardisation of the products, is based on sorting and bringing together products that are closely related in construction and function into main groups and groups, classes and types subordinate to them, in such a manner that the relationship becomes the more intimate the further the dividing up is taken.

The first division is done into *main groups*, as they are called in the language of classification, one of which comprises telephone switchboards, another telephone instruments, a third line and fuse material and so on. Each main group is designated by a letter.

Thus the whole of the current production is divided into the following main groups:

A Telephone switchboards. Party-line and selective calling equipments.
B Racks. Relay sets. Material for current feed etc.
D Telephone instruments. Telegraph instruments.
J Traffic signalling material.
K Tele-signalling material.
L Tools.
M Material and moulded products.
N Line and fuse material. Erecting material.
R Assembled construction components such as relays, dials, switches, selectors etc.
S Standard parts such as screws, pins, washers, nuts, cable-shoes etc.
T Cable. Cords. Conductor wire.
V Electricity meters. Electricity test instruments.
Z Transmission technical material.

The letters *C, E, F, G, H, O, P, U* and *Y* are available for the designation of fresh main groups, the total number of which when the system is fully utilised may then go up to 22. The letters *I, Q* and *W* may not be used as they can lead to confusion. The Swedish letters *Å, Ä* and *Ö* have not been included as they do not occur in the international alphabet.

Each main group is then divided into *groups*, which are designated by two letters. The following examples of group division in a main group may be given:

NA Network systems.
NB Main distribution frames. Cable cabinets. Cable racks etc.
NC Distribution boxes. Fuse boxes.
ND Jointing sleeves. Jointing pipes. Terminal sleeves etc.

Fig. 1. Division into groups and classes for main group D (telephone and telegraph instruments) on L M Ericsson's ABC system

First two letters	Meaning	Third letter: A	B	C	D	E	F	G	H	K	L	M	N	P	R	S	T	V	Y
		Special points				Table instruments						Wall instruments							
						Bakelite case Beeston's large			Bakelite case: standard	Bakelite case: small	Sheet metal case		Bakelite case: standard	Bakelite case: small	Sheet metal case	Wood frame	Cast-iron frame		
DA	For connection to L.B. systems								Generator instruments		Generator instr. Interm. station with generator signalling		Generator instruments			Generator instruments	Generator instruments Watertight	Extension switchboard	
DB	For connection to manual and automatic C.B. systems								Standard 2-line instr. Interm. and terminal posts	Sub-instr. and instr. with creak-buzzer			Standard		Sub-instr. and instr. with creak-buzzer		Watertight		
DC																			
DE	Instruments for local telephone plants (D.C. signalling)						Rapid telephone		Selector intercom. Manager's telephone instruments	Extension instruments Instruments for automatic switchboards				Domestic telephones. Hotel telephones. Dwelling instruments	Extension instruments Instruments for automatic switchboards				
DF																			
DG	*Special telephone* instruments					*Enquiry* instruments Instr. for fire alarm cabinet loops			*Instruments* for fire alarm systems							*Ship's instruments*	*Ship's instruments*		
DH	Instruments for selective calling and party lines					Instruments for selective calling lines			Instruments for selective calling lines	Instruments for selective calling lines						Instruments for selective calling lines	Instruments for selective calling lines		Switching instruments for line sections
DK																			
DL																			
DM	Coinbox instruments	Coinbox instruments			Coinbox for coinbox instruments														
DN																			
DP	Portable instruments	In bakelite case	In wood case	Handset with dial in case															
DR																			
DS																			
DT	Telegraph instruments																		
DV																			
DY																			Accessories for telephone instruments

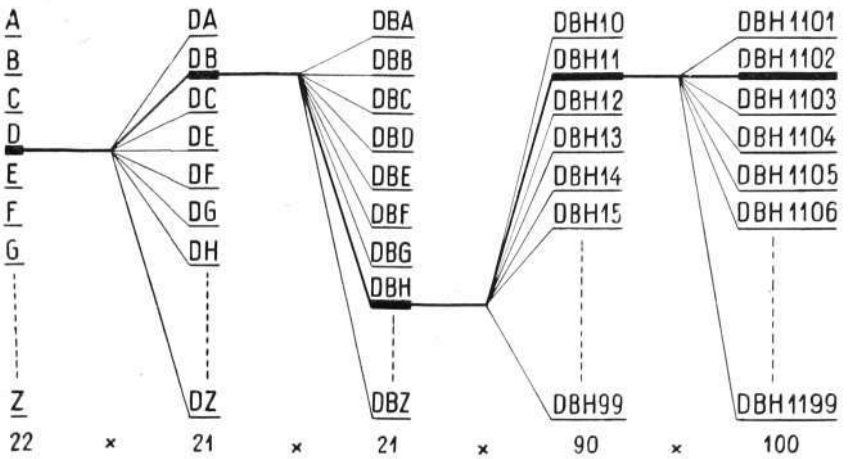


Fig. 2 X 6079
Presentation in diagram of L M Ericsson's classification system

The next stage in the classification is called *class* and this is designated by three letters, *e. g., ABC.* It is from this that the name ABC system has been derived.

The class and group divisions in the main group *D* are shown in Fig. 1. In the division into groups the main stress has been laid on the function, which in this case, however, also has its influence on the constructive execution. The division into classes has been based on the different shaping of the instrument's frame and outer casing, that is a purely constructive division.

A class is divided up into *types,* and the type is designated by a two-figure (sometimes a three-figure) number from 10 to 99 being added to the class, e. g., *ABC 12.*

Figuratively speaking the classification can be compared to the division of humanity into races, peoples, relatives and families. The type represents the family in the ABC system and it may comprise a greater or smaller number of individuals. Each such individual or *article* is designated by the type number with the addition of two (sometimes three) figures, *e. g., DBH 1102.* The whole chain of classification for this number will appear as follows and it is also illustrated by Fig. 2:

Main group	*D*	Telephone instrument.
Group	*DB*	Telephone instrument, C. B.
Class	*DBH*	Telephone instrument C. B. Table instrument in standard bakelite case.
Type	*DBH 11*	Telephone instrument C. B. Table instrument in standard bakelite case. Ordinary subscriber instrument with dial.
Article	*DBH 1102*	Telephone instrument C. B. Table instrument in standard bakelite case. Ordinary subscriber instrument with dial. In mahogany colour and connected for LME's system.

The article numbers made up on the ABC system, which are now also used as catalogue numbers, are quite distinctive and are employed also internally at LME's on drawings, orders and specifications.

The classification on the ABC system, as may be seen from the main groups listed above, covers the whole chain of development from material and moulded products *(M),* standard components *(S)* and assembled elements of design *(R)* to the complete independent designs. The question whether all products are to be classified on the ABC system can, at least at the present stage, be

answered in the negative. Only those designs which from the standpoints of systematisation and standardisation are useful to classify will be incorporated in the ABC system. Other products receive six-figure numbers, taken out in running order. Consequently there may be found in our catalogues, side by side with the ABC designations, actual drawing numbers which have been raised to the rank of catalogue numbers, such as 209195 = gong support.

With four-figure numbers there are in the ABC system $22 \times 21 \times 21 \times 90 \times \times 100 = 87318000$ possibilities for individual articles. Naturally in practice only a very small fraction of these numbers will be utilised, but the system must be of such a nature that it is possible to build on any branch whatever with fresh numbers. For example, it may be stated that in the class RCA »wound rolls», on account of the great number of variants that can arise, it has been necessary to adopt 6-figure numbers, *e. g.,* RCA 203226.

The decision to introduce the ABC designations as catalogue numbers was taken as far back as 1937. On account of the enlargement of the manufacturing programme to comprise ever more domains of technology, the capacity of the catalogue system then existing with two letters followed by figures was found to be too small. As the ABC system with its large capacity was already in considerable employment at that time for internal designations of the standardised productions, there was available almost as a gift a new system for catalogue designations.

The ABC system can also be utilised by other undertakings belonging to the LM Ericsson group. By adding to the three letters designating the class a fourth letter representing the undertaking's code letter the possibilities of the system are increased, so that each undertaking on the basis of the framework drawn up by LME can classify and designate products in the main groups or, in other words, the kinds of goods for which the system is designed. For LM Ericsson, Helsingfors, which has the code letter H, the class designation for DBK will then be DBKH and the individual article will, for example receive the number DBKH 1367. These designations, however, are only used for products manufactured in Finland, while the instruments normally imported from Sweden are designated by the normal three-letter designations.

Ericsson Technics

Ericsson Technics No 44

Conny Palm: Intensitätsschwankungen im Fernsprechverkehr
Untersuchungen über die Darstellung auf Fernsprechverkehrsprobleme anwendbarer stochastischer Prozesse

The determination of the suitable number of lines and selectors so important for the financial yield and uninterrupted functioning of telephone plants, must often owing to lack of experience directly applicable to the various individual cases, be based on results derived from theoretical investigation. In view of the general character of telephone traffic the theories presented for this purpose must be drawn up in close connection with the methods of probability calculation, for which in the first place the theories for what are known as Stochastic processes have proved of importance.

The definite Stochastic process has now been laid down as basis for theoretic investigations hitherto carried out respecting telephone traffic problems, this process corresponding to what the technicians designate as pure chance traffic. Nevertheless it has gradually been realised that in this way there are not obtained the possibilities regarding tendencies that are necessary for a satisfactory reproduction of actual traffic conditions in telephone plants. In the present study an attempt is made arrive at a more reliable basis for describing telephone traffic, by observing more general Stochastic processes than those corresponding to pure chance traffic.

In the first part of the paper there are worked out theories for general Stochastic processes of such a nature that they may be employed for describing the properties of telephone traffic. Chapters 3 and 4 partly contain applications to some special problems falling rather outside the scope of the work, but which have been included as they seem to provide valuable facilities for the treatment of problems hitherto unsolved having pure chance traffic as point of departure.

The author goes on to give closer investigation to a special Stochastic process, constituting a modification of the definite process and based on an assumption of what is called sluggish intensity variations. Starting out from this, which appears particularly suitable for a description consistent with facts of the properties of telephone traffic, the mathematic expressions for traffic conditions will be relatively simple. It is found in conjunction with this that there exists an intimate connection with the conditions already well investigated of pure chance traffic, so that these latter continue to be of the greatest significance for investigations of traffic problems.

In chapter 7 it is shown that the results obtained on the basis of sluggish intensity variations with insignificant changes may be applied also to rapid variations, so that the utility of the theories presented increases appreciably in practice. In chapter 8, which assumes a central position in the theoretical part of the work, there is given on the foundation of the intensity variations a systematic treatment of the banking up problems, which are of the utmost importance for many applications. From these investigations emerges a fundamental term, traffic classes, and by study of these there is obtained finally a standard form for describing telephone traffic. By means of this standard form, the mathematical relations of which are thorougly discussed, the traffic properties are completely expressed by two magnitudes, the traffic amount A and the class parameter η_0. Thus, through characterising the traffic by two magnitudes instead of by the traffic amount alone, as was formerly customary, very valuable possibilities are obtained of taking into account the peculiarities of different traffics.

In conclusion the last part of the work gives an account of a number of measurements made in recent years in conjunction with the building up of the theories presented. These have been chiefly designed to verify the fundamental hypothesis of the traffic's description from the intensity variations and to investigate the utility of the above-named standard form in the treatment of traffic problems arising in practice. Following an investigation in chapter 10 of suitable principles for the carrying out of such measurements, a thorough description is given in chapter 11 of the specially designed measuring apparatus employed. The very comprehensive measurements carried out with these apparatus have constituted a part of the research work on telephony traffic questions carried out jointly during the past six years by the Royal Swedish Board of Telegraphs and Telefonaktiebolaget LM Ericsson. The measurement results, dealt with in detail in the last chapter, give rise to very good hopes that the theories advanced will be of great importance for the treatment of traffic problems in practice. Thus it has been shown that it is possible with the aid of the above-mentioned standard form to compute with the greatest accuracy the blockings arising, which in general have been found to be 5 to 10 times larger than could be computed previously from the then known formulae for purely random traffic. In this way telephone technicians engaged on practical work have been given good facilities for carrying out the dimensioning of line and selector groups with considerably greater certainty than before.

Ericsson Technics No 45

Carl-Georg Aurell: Contribution to the Theory of Telephone Cables with Twisted Conductor Groups

The theory of telephone cables with twisted conductor groups can for low frequences be built up along the same guiding lines as for a system of parallel homogeneous conductors. For this reason there is first gone through the theory for the latter case, assuming sinus form for tensions and currents and purely transversal connections between the conductors, the line constants being taken as known. The deviations from the properties of the homogeneous line that may be expected when account is taken of the variation of the line constants along the line are computed for a couple of cases. In what follows the cable is assumed to possess connection impedances that are constant along the conductors and equal to the mean value of the connecting impedances computed from quasi-stationary state.

The transmission properties in such an idealised cable are investigated and the term »cyclical symmetrical group» is introduced. Explicit formulae are derived for propagation constants and characteristics for the different conductors in such a group. The results thus gained are applied to a couple of crosstalk problems.

The last chapter is devoted to computation of certain mean line constants for spiral shaped conductors. To begin with, there is treated the simple case where a spiral shaped pair is assumed to be free in space. The influence of the rise on propagation velocity and characteristic is shown. Further there is computed the mean value of the mutual inductance between spiral shaped conductors lying separately over a flat surface. The last chapter is given up to certain observations respecting the capacitative conditions in cables.

In this work no attempt is made to compute the different forms of losses which occur in a cable, but these are assumed to be known in those cases where they are to be found in the formulae.

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Change-over at Helsingborg

U.D.C. 621.395.343 (485)

The change-over of a manuel telephone exchange to automatic operation is, of course, a purely technical process. Nevertheless it comprises, right in the midst of the comprehensive technical process, many features also of purely general human interest — episodes mainly of psychological nature due to the telephone subscribers' own reaction in face of the new method of operation. When the automatic exchange in Helsingborg supplied by L M Ericsson was connected up on 29th December, 1940, a journalist was invited by L M Ericsson to describe, chiefly from this latter angle, the change-over from manuel to automatic operation, and it is his impressions of an important event in the history of Helsingborg's communications that will be found below.

The nineteen twenties, now rather discredited, were nevertheless among the foremost years in the history of telephony, then some fifty years old. It was not only the era of technical discoveries but also the period of big expansion, when old telephone countries saw their subscriber numbers many times doubled and lands beyond the seas or on the periphery of Europe became endowed with up-to-date telephone networks that could link up with the many-branched networks of Western nations. About that time, or a little earlier automatic connection had attained such a high degree of perfection that it could emerge from the laboratory and be entrusted with its responsible mission in everyday life.

How many automatic systems have been produced since the time when it was first possible to talk of a telephone network in the real sense? There is probably nobody at present who can say with any certainty. The problem of replacing the routine movements and strictly limited train of thought of the telephone operator by relays and machine parts was already at the beginning exercising the minds of the most intelligent of the pioneers in the very infancy of telephony. The more traffic increased and demanded an ever more specialised distribution of work among the operating staff, the more persistent became the idea of finding a machine to take their place. Many systems were developed in the course of years, a number of them were put into service, but all were rejected because of their lack of reliability under actual traffic conditions.

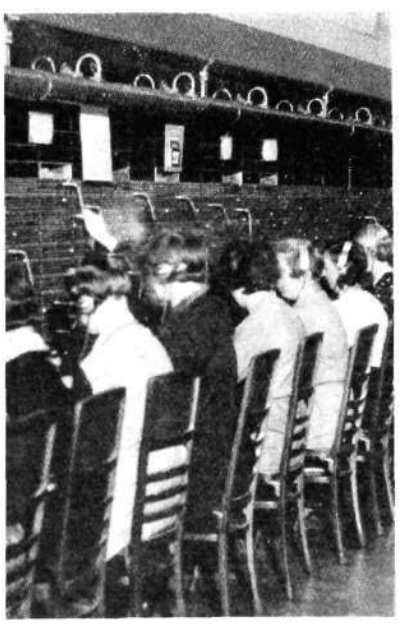


Fig. 1 X 4069
The problem of replacing the operator's routine movements by machinery is one that early attracted the attention of pioneers in telephony

It fell to LM Ericsson, after many decades devoted to the work of development, to be among the first of telephone producing companies in the world to produce a machine system of such reliability, flexibility and capacity of expansion that it could not only replace manual operation economically but in addition surpassed technically the improvements that the collective experience of constantly expanding traffic had brought about in the manual system. In the twenty years that have elapsed since then, something like one and a quarter million telephone instruments have been connected to Ericsson's automatic exchanges, installed in about thirty countries, in all parts of the world and all kinds of climates. When it is considered in what confused economic and financial conditions this expansion has taken place, one begins to get a proper idea of the technical ingenuity with which LM Ericsson solved the heart of the problem of automatisation and of the financial advantages of the system. To have been able in a decade like the 1930s to have sold nearly 600 000 telephones and built automatic exchanges for them without having resort to cruisers, political loans and similar means which are associated with big international business, one must simply trust to the absolute superiority of the product both technically and economically. It was a brilliant development as long as it lasted. But then came the war to make a small nation's contribution to international cultural work more difficult.

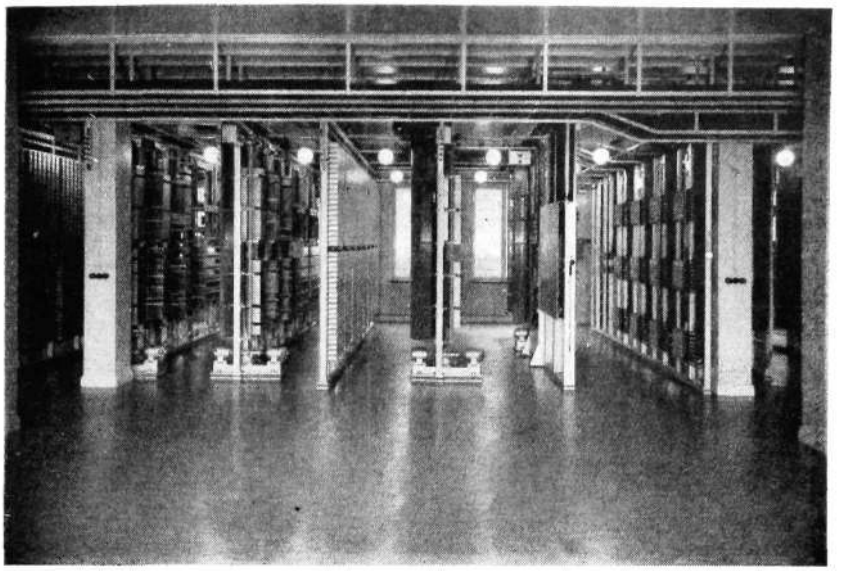


Fig. 2 X 3752
The big airy hall was empty of life

Nevertheless, despite the war and the impenetrable veil that hides the future economic life of the nation, there has continued in the Swedish telephone service that technical progress which in due course will make all telephones in Sweden completely automatised, in cities and towns and in rural districts. When the Swedish Telephone Administration's programme for countrywide automatisation is completed every subscriber will have constantly at his disposal, all hours of the day and night, very much greater connection facilities than he possesses at present, until finally the telephone dial will make him master of his country's entire telephone network — practically speaking.

Over 50 % of the larger towns are already hundred percent automatised. The same is the case with a number of medium-sized towns, many of which have been linked automatically with network groups with rural exchanges in the areas surrounding them. In this nation-wide reshaping of the country's telephone network LM Ericsson has so far contributed to the equipment of the main exchanges, while the Telegraph Administrations own automatic switchboards have been installed at the rural exchanges. Towns such as Borås, Norrköping, Uddevalla, Örebro and others have been fully automatised in recent years with LM Ericsson's 500-line selectors and at the end of 1940 Helsingborg's new automatic exchange was taken into service.

The change-over of a manual telephone exchange to automatic operation is always a unique technical event without direct equivalent in modern machine practice. A shipbuilder, for example, may feel himself a little out of his depth among the notabilities at the launching, but he has no fear that his ship will float when it glides into the water, nor has he any great worry that it will not successfully pass its final test. For he has worked to wellknown laws and tested experience — if he knows his job he needs fear no disagreeable surprises. The aircraft designer has now reached the stage of working on firm mathematical foundations and he can sleep soundly at nights in full confidence that the wings of his latest construction will not fall off during the power dives of tomorrow's tests.

A telephone engineer responsible for the design — or one may say the composition — of an automatic exchange is in quite another situation, even though he does work with welltried components, scientifically computed and carefully tried out both in the laboratory and in operation, yet he can never say with certainty what will happen when the exchange is put into service. He may have spent many months testing each relay and each circuit and every imaginable combination of selector setting, but the change-over is still a step in the dark for him. He can only be certain of one thing — when one fine morning the plugs are pulled out of the distribution frame and the new apparatus is suddenly set going, then some mischief will be afoot.

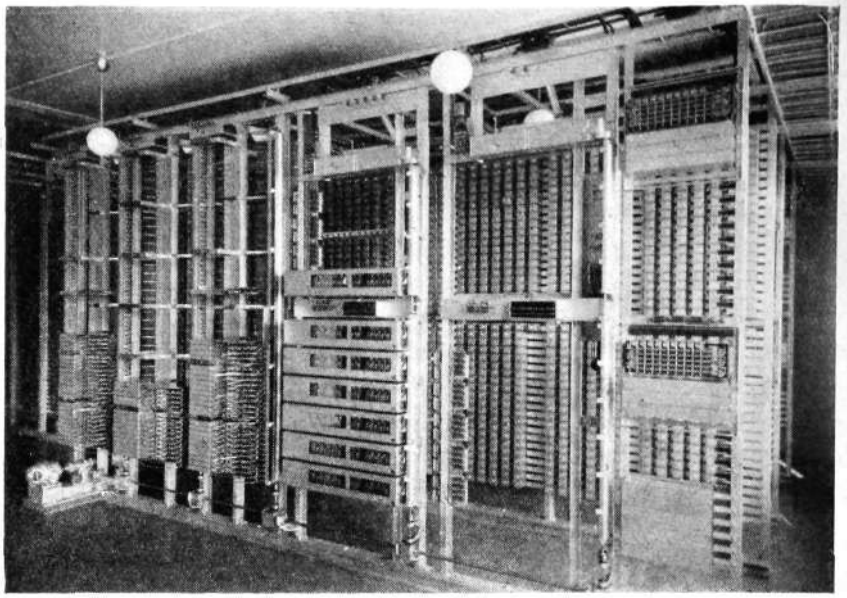


Fig. 3 X 5753
The floodlight from the ceiling streamed down on columns of gleaming aluminium apparatus racks

He may curse the fact or, if he be chastened and toughened by many a similar change-over, philosophically bow to the inevitable and even find interest in wondering what will be the new variation of cussedness that will arise this time. From the moment he puts his work into the hands of the public he can do nothing about it, but hope he stands well with Providence.

That is the difference between the work of the automatic telephone engineer and the contributions of his colleagues in other branches of technology. All are imbued with the same spirit — if it can be said that a technician ever does ponder on the future results of his work — to serve progress and in that way be a joy to the human race. Even the bomber designer would, had he time, produce a decent explanation of how the child of his brain in the long run will help the coming of a better world. But while the shipbuilder puts his construction in the hands of an experienced skipper and a chief engineer skilled in machines, and an aircraft designer will allow nobody but a tried test pilot to go near his new product, the telephone engineer hands over a complicated machinery to the tender mercies of thousands who, in his eyes at the moment of connecting over, have only one thing in common: a more or less complete ignorance of how his sensitive apparatus should be used.

The first hours and days after an automatisation has been put into service should provide a splendid opportunity for a social research worker to obtain a measurable conception of the collective reaction of a community to the new and unfamiliar, while at the same time he could obtain some measure of its level of intelligence. Instead of experimenting with mice in a cage he would have at his disposal human material carefully segregated, which is suddenly compelled without previous experience to execute a series of simple operations. How they succeed or fail in this elementary intelligence test is revealed objectively and ruthlessly by the pitiless demand of the automatic system that these operations shall be performed correctly.



Fig. 4 X 4120
Now all available hands began to pull out the plugs in the old distribution frames

There was no social research worker at hand when Helsingborg's new automatic station was set going and the learned paper on »Measurement results of community intelligence and examples of collective conduct based on them, observed during the change over to automatic operation of the telephone exchange of a mediumsized Swedish town, mainly middleclass in character» will remain unwritten until the world again has leisure to deal with such matters. Instead there were automatic technical engineers — heartily glad to be finished with a lengthy job — and traffic men, nervously wondering what the immediate future had in store and how the professional grumbler could best be silenced. There were also the high officials of the Swedish Roval Board of Telegraphs

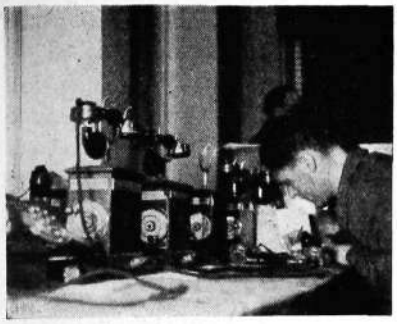


Fig. 5 X 4121
Fifteen minutes later Helsingborg as regards telephony was a dead town
but as a precaution these battery instruments maintained contact with the outer world

watching with lynx eyes that the Swedish State and Crown got full value for money, together with leading men of LM Ericsson to see that the representatives of the Crown were satisfied.

The time was five o'clock in the morning on the 29th day of December in the year of Grace 1940 and a bitter wind threatening snow swept across the Sound from a blacked out Denmark, whining in melancholy fashion round the air-raid shelters on Storgatan, where the street lamp lights were mirrored in the dark depths of windows. It was a Sunday and several hours had still to go before any sign of life would be apparent from sleeping Helsingborg's 60000 inhabitants and 8000 telephone subscribers. It was an ideal morning for a critical operation like a telephone change-over.

In the apparatus room of the newly constructed telephone exchange the flood light from the ceiling streamed down on the sparse columns of gleaming aluminium racks. The large airy hall was empty of life and for the last time there reigned complete silence, rather accentuated by the scarcely noticeable drone of softly revolving motors and well journalled shafts.

If on this Sunday morning the apparatus room was symbolically empty of human labour, there were so many more people elsewhere in the telephone building. In a crowded little triangular room where the old manual distribution frames after continual additions covering thirty years had taken up every bit of space and seemed even to have crowded out the air, a flock of early rising fitters jostled each other waiting for the magic hour. In a room below, in front of the test desk and in immediate vicinity of the new distribution frame, a line superintendent had mustered his men. In the operator's hall a buxom Scanian operator kept the last turn of duty on the manual position, now reaching its final hours of service.

The district line superintendent made a last check of his staff before giving on the stroke of five the order which meant the definite liquidation of the old manual exchange. Some twenty hands immediately became busy on the horizontal side of the manual main distribution frame. Cut-off plugs, placed in readiness in the line jacks, were rammed home and line after line was broken between the distribution frames and the outer world. Fifteen minutes later Helsingborg from the telephone standpoint was a dead town. The next few minutes in the change-over process might be well utilised by a talented detective story writer. Now could murder be committed, banks robbed, invasion attempted and fifth columnists play their finest cards, with all the best chances of gaining those first precious minutes which it is said are of such extreme importance for such undertakings.

Of course, no such activities were attempted in Helsingborg during the few minutes when the community's nerve centre was amputated. The town went on sleeping peacefully while the line superintendent's fitters hastened downstairs to the new frame already joined to the incoming cables. Here those busy hands hurried to pull out the cut-off plugs which up to now had separated the automatic exchange from the subscribers, and line after line was linked to the distribution machinery. By 5.40 a. m. all subscribers were connected with the automatic exchange. Theoretically Helsingborg's new exchange had been put into operation, but the most critical hours of its life were still shrouded in the unknown future.



Fig. 6 X 4118
The cut-off plugs were rammed home in the new distribution frame

The great silence in the apparatus hall had been immediately broken. As line after line was connected with the multiples, finders in the different groups woke to life and the clicking of relays, geared rods and wipers showed that the machine had begun to react to impulses from outside. These first signs of life were, however, only the newborn infant's protests against the troubles of life, as hysterically fumbling finders and frantic red signal lights were evidence that the electrical conditions on the lines making this tumult were not to the liking of the machine. The causes of the finders' conduct, not quite

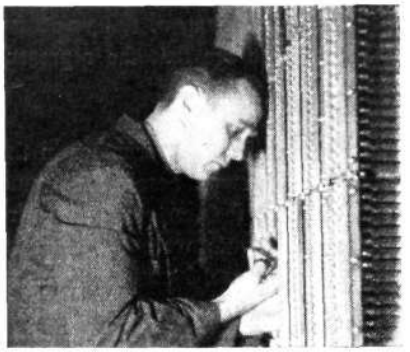


Fig. 7 X 4119
The inevitable line faults in conjunction with switching over are dealt with

unanticipated, were quickly localised to the old main distribution frame, where a number of lines had been shortcircuited instead of being broken when the plugs were rammed home. By 5.45 a. m. line faults in the distribution had reached a culmination of 46, but from then on they were rapidly eliminated and by 6.12 a. m. there were but twelve left. A total of 68 subscriber errors were recorded by the machine and were put right before grey dawn crept in on the town.

The first legitimate calls, automatically established, to traverse the circuit labyrinths occurred before the exchange change over was entirely finished. A Helsingborger who had ordered telephone waking was called from his sleep automatically at 5.30 a. m. and some minutes earlier the very first call had been recorded from a public coinbox instrument somewhere in the town. It may have been a good omen or not, but unconfirmed reports declare that this first call was concerned with the summoning of a midwife for somebody's firstborn.

The red lamps of the traffic supervisor's desk went out one after the other, as the registers were freed from the blocked subscriber lines and in the next few hours it was seldom that a lamp lit up to indicate that a register was busy routing a connection. No red alarm signals in the apparatus hall any longer gave evidence of fault demanding attention and the alarm boards of the premises were idle.

The first phase in the change-over had been passed. The inevitable line faults had been dealt with and in the subsequent twentyfour hours nothing but the light traffic of a Sunday was expected, with perhaps the addition of a certain percentage due to curiosity, sufficient to give the exchange apparatus a gradual and comfortable shaking up. The first real test need not be reckoned with until the following morning.

Then stepped in one of those many unknown and unforeseeable factors that always arise to upset the most careful prognostics for a switching over. At 8.45 a. m. the silence in the apparatus room exploded. In each subscriber group the registers clicked in time to incoming impulses, wipers clattered over their metal segments, halted an instant, were engaged in a gear wheel and were then driven irresistably over the gleaming mat of the multiple to stop suddenly at the called line. At the traffic desk the register lamps flashed in response to calls from all parts of the town, went out and were again lit. As the minutes went by the traffic grew more intense and in the apparatus room the clicking of the registers rose higher and higher. Twentyfour hours earlier than anticipated the new machinery was subjected to its first heavy traffic test. It was the first reaction of Helsingborg to the introduction of butter rationing, announced the previous evening, which led to this unexpected spurt of traffic.

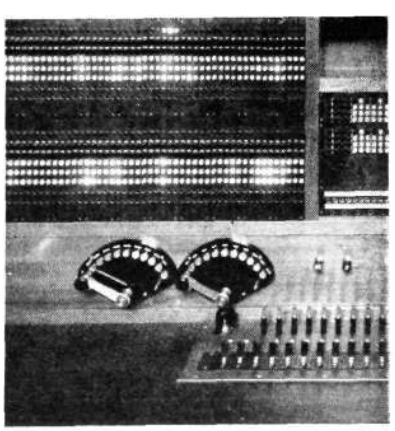


Fig. 8 X 4058
At the supervisor's desk register lamps flashed red

On Monday morning the god of trouble made his presence known in another way. At the same time as Helsingborg's traffic was automatised, automatic junction traffic had been introduced between the main exchange in Helsingborg and a number of the larger rural exchanges. Nevertheless most of the telephone exchanges in the Helsingborg area were still connected manually and the incoming traffic to the Helsingborg exchange from these rural exchanges was converted to semi-automatic when the main exchange changed over to automatic, in that the operator had to set up the called Helsingborg number on a keyset, after which connection was routed by the automatic devices in the usual way.

This resulted in a bottleneck on Monday morning. With the opening of business hours and the swelling flood of traffic, fewer and fewer registers became available to operators at the twenty or more positions of the order desk. The register lamps flashed red at the supervisor's desk and soon after nine o'clock practically all registers were occupied. An appreciable number of them were

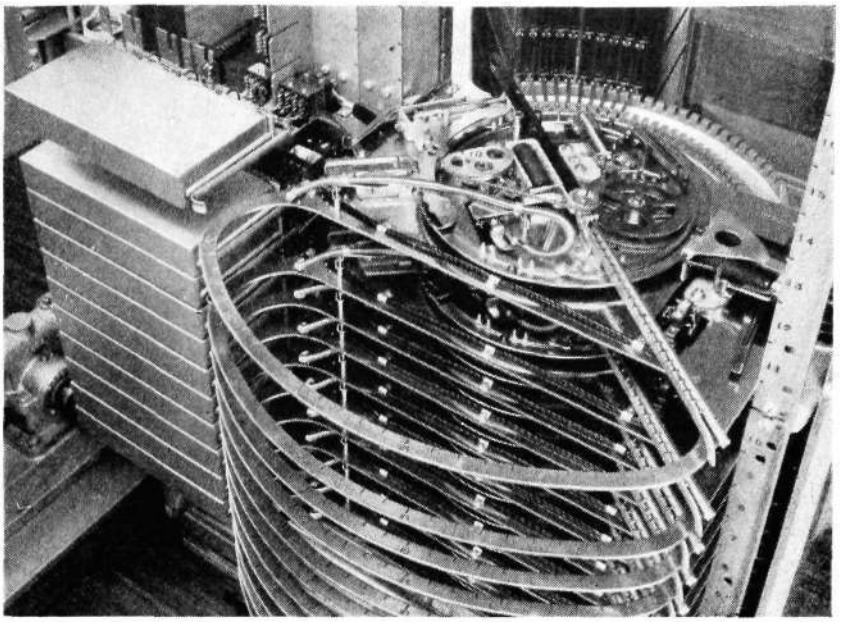


Fig. 9 X 5751
In each subscriber group the registers clicked in time to the impulses and the wipers climbed over their metal segments

blocked by straying subscribers, who went through the whole gamut of wrong dialling before finally after many attempts they managed to dial the wanted number right. By then, however, most of them had been piloted to their correct numbers by a couple of operators at the supervisor's desk, who were able to follow on a board the results of subscribers' first encounters with the dial.

While this schooling was going on the passage for the incoming rural traffic became more congested and finally it was entirely choked. The cord lines climbed along the desk and fifty pairs of lips repeated constantly the same monotonous phrase »The exchange is blocked».

In the next few hours the new exchange went through its first real crisis. Unaccustomed subscribers continued to hold up the automatic machinery with their faulty dialling, while traffic from the surrounding districts never ceased to flow in — but further than the order desk it could not get and no means to break the jam was at hand. All available junction lines and registers were in full occupation and immediately a connecting unit was clear of one call it was immediately taken up by another. The finders in the groups concerned seemed at first sight to be almost inactive: they moved rarely or not at all and if it had not been for the flashing alarm signals there would have been nothing to show that a traffic jam prevailed.

In these hectic hours Helsingborg telephone subscribers learned by experience the stern statistical laws that govern the traffic capacity of an automatic exchange. For even though careful calculation forms the basis for the number of connecting circuits and registers required for normal traffic, plus a not inconsiderable margin of safety, yet financial considerations set a limit to the number of these important — and expensive — apparatus. So when for some reason the traffic curve rears itself up and disappears above the limit which can statistically be regarded as constituting the talkativeness becoming to a community, the automatic exchange can only take note of it and make its protest by general alarm.

Towards the afternoon traffic shrank appreciably, the number of blocked registers due to faulty dialling began gradually to approach the normal and the crisis with rural traffic was blowing over. The new machinery had withstood the first heavy shock without revealing any inherent weaknesses and without any grave incidents occurring. But around the rural traffic group a couple of LM Ericsson engineers stood and pondered aloud whether, when all came to all, it would not be better to install some more connecting circuits. Obviously the people of Helsingborg district talk too much!

Economic Viewpoints on Rural Automatisation

C BERGLUND, TELEFONAKTIEBOLAGET LM ERICSSON, STOCKHOLM

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It is possible in an automatic system without any great expense to build up connections over several exchanges in series. In this way there is attained on rural automatisation an economical building up of the rural and trunk line networks and the rural automatisation therefore makes it economically possible to arrange traffic without waiting time and to improve the quality of the traffic and rationalise the line network, which sooner or later would be unavoidable. The normal method of debiting in manual systems is extremely uneconomical, but with rural automatisation automatic debiting can be introduced. It is then possible to apply either unit debiting or automatic ticketing, the former of the two methods being essentially more advantageous economically. With unattended automatic exchanges reliability of operation is of particularly great importance, in view of expense involved in sending out skilled staff for repairs. These questions, so important for rural automatisation, are the subject of observation in this article.

As there are now available considerable experience and comprehensive statistical material concerning operating costs for manual and automatic telephone exchanges, it should be fairly simple to arrive at a proper economic comparison between automatic and manual operation. It might be supposed that the economy of automatisation could be fairly well estimated merely by a comparison of the costs of interest and redemption for the expensive automatic equipments and the saving in cost of operators, appropriate adjustments being made for the changes arising with automatisation in respect of energy and maintenance costs. If it were only a matter of automatisation of local traffic in large exchanges, it is possible with such simple calculations to arrive at fairly correct results.

It is, however, necessary to take into consideration rural automatisation comprising the introduction of automatic switching for the telephone subscribers of rural districts and for traffic between the different communities. The calculations will then become very much more complicated. Especial difficulty arises in such calculations because the automatisation causes a regrouping of the junction circuits between the local networks and because the automatisation allows of more effective methods for call debiting, particularly for the short

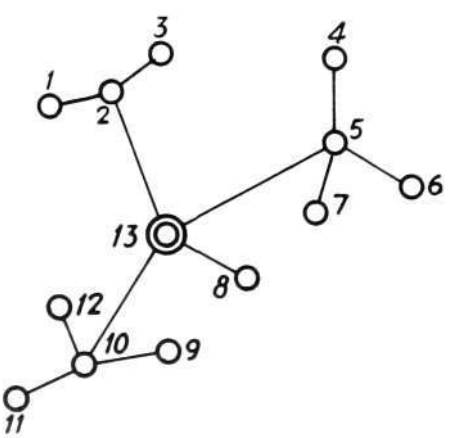


Fig. 1 X 5924
Line network in automatic system

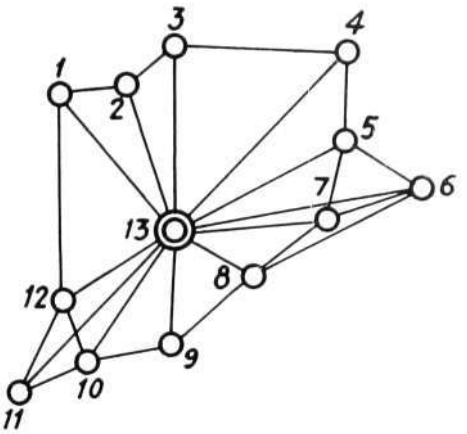


Fig. 2 X 5625
Line network in manual system

distance trunk traffic. When it is a question of small automatic switchboards in rural districts it is not possible as in the case of large exchanges to compute the maintenance costs on the basis of unit prices for various kinds of automatic equipment, as frequently the greatest expense is due to the transportation of skilled staff to the place.

These special circumstances, extremely important for the economy of rural automatisation, will be considered in this article. As local conditions, which strongly influence these factors, are very variable it is not possible to give any figures that are generally applicable, and the average figures which the author has sought to extract from statistics from various quarters should only be regarded as rough estimates. The points of view put forward may nevertheless be of value as foundation in computing actual cases and contribute to increased exchange of views in these interesting questions.

Junction Circuits

People are often heard to say that automatic systems require more junction circuits between different local networks than manual systems. Such a general statement, however, does great injustice to rural automatisation and it would be just as correct to say that rural automatisation saves such junction circuits. The occurrence of such dissimilar judgments may most easily be explained by an example:

Fig. 1 and 2 show one and the same network group, consisting of 13 local networks. The junction circuits between the local networks, however, are built up in different ways. Both with manual and with automatic systems it is desirable that the junction circuits are assembled in as large bunches as possible, as utilisation of each circuit is increased the more circuits there are at disposal when a connection is to be established. From this standpoint, therefore, the network lay-out of Fig. 1 is economically much superior to the network lay-out of Fig. 2. In manual systems, however, with a network lay-out as per Fig. 1, it would require the collaboration of five operators (in exchanges 3, 2, 13, 5 and 4) to couple up connections between exchanges 3 and 4. This will be far too cumbersome and uneconomical, in view of the high costs of operation. It therefore becomes a necessity to arrange direct junction circuits between the different local networks, *e. g.*, in the manner shown in Fig. 2. The line bunches will then naturally be small, and, to handle the necessary traffic, the arrangements for waiting traffic must be such that the operator receives orders for the calls and establishes them in turn as circuits become free. With automatic systems, however, it is possible at no great expense to build up circuits with selectors over a number of exchanges in series and consequently for such systems the network lay-out shown in Fig. 1 would be natural. On the other hand it is not suitable with automatic systems to arrange waiting time in order to augment the utilisation of the junction circuits.

It is usual on automatisation to change over from network lay-out as in Fig. 2 to the lay-out shown on Fig. 1. It depends on local conditions whether the lower degree of utilisation owing to the disappearance of waiting traffic will be counterbalanced by the change over to a more economical network lay-out with a decrease or increase in the total length of junction circuits arising from rural automatisation. As a rule it happens that on some stretches of line the number of junction circuits must be increased, while line material on other stretches is made available. Obviously such radical re-arrangement of the line network involves first costs, but it has been found in practice that re-arrangement of the lines to a surprisingly large extent requires only re-connecting. That this is the case is due to the fact that in actual conditions the line network is often fairly star-shaped, the lines being built along the high-ways. (For example, it is likely that a line between exchanges 4 and 13 actually goes past exchange 5.)

Moreover, it should not be forgotten that waiting traffic constitutes very great inconvenience for the subscribers. Their justified and constantly growing de-mand for more rapid facility of communication imposes in manual systems the building up of fresh junction circuits and, if it is desired to satisfy sub-scribers' desire for direct traffic, automatisation in actual fact means an appreciable saving of junction circuits.

In conjunction with automatisation, expense frequently arises because when re-arranging the circuits it is often preferred to change from aerial circuits to cable circuits. This is due to the desire to make the circuits as free from disturbance as possible and in this way improve their reliability and reduce maintenance costs. It is not automatisation in itself that is responsible for this outlay, but on the contrary it may be claimed that the automatisation leading to the assembly of the circuits in larger bunches enables a circuit network that is more reliable of operation and more favourable as regards maintenance to be realised in an economical way.

Rural automatisation, therefore, taking the long view, cannot as regards the lines be a doubtful investment but rather a splendid means of carrying out economically — in many cases with an appreciable direct yield — an im-provement in the quality of traffic and rationalisation of the circuit network that sooner or later would be unavoidable.

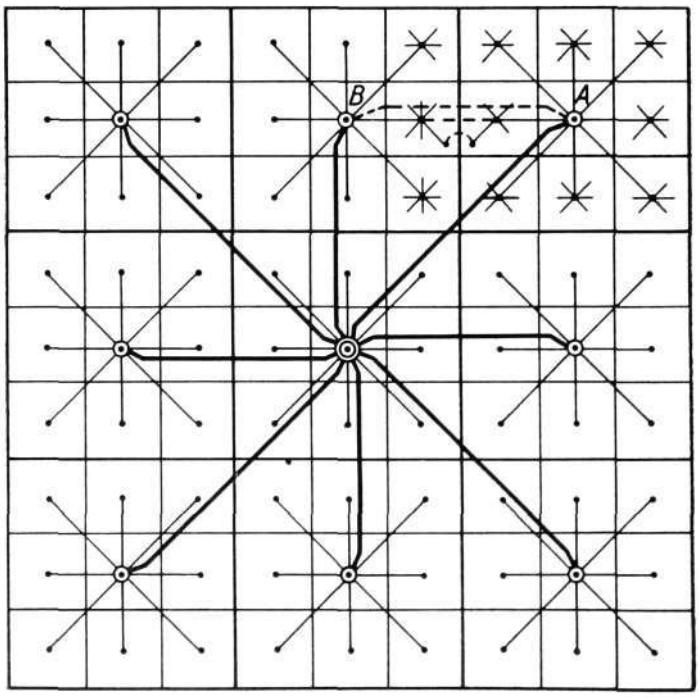


Fig. 3
Diagram of trunk circuit network

Rural automatisation applies not only to the traffic inside the network group concerned and its advantages are not wholly felt until the traffic between the different network groups has also been automatised. For the same reasons as apply to the circuit networks of the network groups, the circuits between the different network groups should as far as possible have a star-shaped lay-out. Fig. 3 shows such a lay-out in diagram. Each small square represents a network group with a central exchange. A number of such central exchanges in turn form a network, the central exchange of which forms with other such exchanges a superior network. If the country comprises still more network groups there is obtained a further superior network and finally the capitals of different countries may together form a world trunk network.

It may appear strange that a connection between, *e. g.*, the places *A* and *B*, situated fairly near to each other, should be set up over the long detour, yet this is most economical if the traffic between these two places is small. If, however, the traffic is considerable it may be right to arrange a direct circuit between those places, what might be called a cross circuit. Such cross circuits may be justified in various parts of the network and little doubt exists that cross circuits have considerably greater justification in the circuit networks of a higher order than in the network groups. Nevertheless it is practicable in rational planning of the trunk network to keep to the star-shaped network lay-out in each of the networks superior to each other and to regard the cross circuits as exceptions even though they occur to large extent.

The cross circuits have generally the disadvantage that the circuit bunches will be rather small with the result that the circuits in automatic or direct manual traffic will be poorly utilised. To remedy this, considerable attention is just now being given to the possibility of augmenting the utilisation of these circuits by *alternative routes*. This means that, in the example selected, with a cross circuit between *A* and *B*, the devices which have to select a circuit would first test to find if a direct junction circuit is unoccupied, but if this is not the case they route up the communication over the detour. In this manner it is possible to attain good utilisation of the lines in the cross circuits even though the circuit bunch is small. It may appear very tempting to make much use of the method with alternative routes. Theoretically it offers general prospects of utilising the lines well even if the circuit bunches are small. One could conceive of having the trunk network laid out in mesh form and allowing each communication to find a way over the circuits which happen to be free. However, unlimited employment of the method with alternative routes involves far too complicated connecting processes, but if the method is used with discretion it should constitute a valuable accessory in arriving at economical and effective automatisation of the long distance traffic.

Call Debiting

A point of very great importance, especially for the economy of short distance trunk traffic, is the method applied for debiting calls.

Appropriate call debiting should fulfil the following two main conditions:

1. the cost for the debiting of calls should be low
2. the charges for different classes of calls should correspond to the expense incurred.

On studying the normal debiting method in manual systems with recording on tickets, it will be found that usually it in no way fulfils these conditions. When this method is employed the service for calls will be extremely complicated and expensive, while the ticket and its passage through the organisation until the charge for call is paid involve considerable costs.

To estimate the cost for a 3 minute call over a 40 km trunk circuit the following values are assumed for an operator's working capacity for different kinds of operations:

	number operations per operator and hour	operator hours per call
local calls	200	1/200
trunk recording	50	1/50
outgoing trunk calls	50	1/50
incoming trunk calls	100	1/100

When each trunk call requires recording and both incoming and outgoing operation, the number of operator hours per trunk call will be $1/50 + 1/50 + 1/100 = 1/20$ and the operator work for a trunk call will then be 10 times as great as for a local call. If it is assumed that the operator expenses constitute 30 % of the total annual costs and if it is assumed that the cost per local call is 5 öre, we get:

operator cost per local call	1.5 öre
operator cost per trunk call	15 »

On the basis of this and of some other estimations we get the following table for the total cost of the trunk call:

cost for occupation of trunk circuit	10 öre
cost for local call	5 »
extra for trunk call	13.5 »
cost for ticket	5 »
total	33.5 öre

Obviously the cost for occupation of the trunk circuit depends on what kind of circuit is used and the utilisation that can be attained. The figure given of 10 öre is to be regarded as an estimated mean figure. In the cost for the ticket are comprised the cost of the paper itself together with all the work of sorting, bookkeeping and collecting the amount that is required.

It is usual to justify the comparatively high charges for trunk calls by their occupation of long and expensive trunk circuits. The above example, however, shows that this cost, even for a circuit as long as 40 km, constitutes less than one third of the total cost and that the most considerable part of the cost arises from the complicated work due to call debiting by recording.

Though the above figures are a rough estimation, it should be possible on the basis of them to establish that this method of debiting calls does not fulfil the condition that the cost of call debiting should be low.

The high expense of the debiting is probably the reason why for short distance trunk calls it is often considered that the charge for calls cannot be set so high that it fully represents the costs involved. Call charges below 30 öre per 3 min are therefore in themselves doubtful business. Nevertheless, it may seem expensive to the uninitiated telephone subscriber that simply the circumstance that the call is carried on over some tens of km should raise the charge to 30 öre per 3 min, while a local call of unlimited duration will as a rule cost him considerably less than 10 öre.

The short distance trunk call charges, unfavourable both for the subscriber and the telephone administration, are perhaps the most important reason for free traffic in Nordic countries being available even over quite considerable distances. In this way one escapes the high cost for call debiting and the subscriber gets cheaper calls. Nevertheless such calls will in

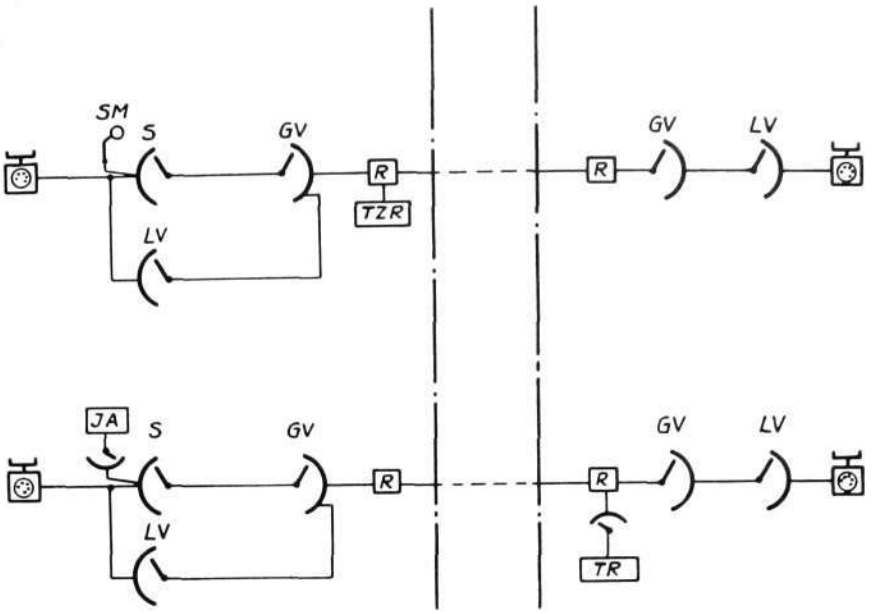


Fig. 4 X 5926
Diagram of automatic telephone exchanges with automatic debiting

Top: unit debiting; below: automatic ticketing
GV group selector
JA identifying device
LV line selector
R relay set
S line finder
SM call meter
TR printer recorder
TZR time zone meter

themselves involve quite appreciable loss to the telephone administration. To counterbalance this loss the system is adopted in some places of allowing a certain restricted amount of free traffic only against a higher subscription. The possibilities of applying such a system, however, are rather limited and such a tariff system cannot be quite fair as those who make many long distance free calls get them too cheap and those who have few such calls pay too much for them.

Whatever form of tariff is selected it is hardly possible to avoid call debiting with ordinary manual systems failing to fulfil the two conditions stated above, namely that the charges should correspond to the costs involved.

It has therefore been shown that the current methods for debiting short distance trunk calls do not with ordinary manual systems fulfil the two fundamental conditions for appropriate call debiting. It is natural to wonder if there is not some good method to get away from this inconvenience. The reply to this is an unhesitating »Automatisation».

The methods available are chiefly two: *unit debiting* and *automatic ticketing* (see Fig. 4).

Unit debiting means that both local and trunk calls are recorded on the calling subscriber's call meter. The number of units recorded is, for trunk calls, dependent on the duration of call and the distance between those speaking. For a trunk call there is connected in to the junction circuit a time zone meter *TZR* which during the call transmits to the call meter *SM* a number of impulses corresponding to the rate it is set for and the duration of the call.

For *automatic ticketing* there is connected in a printer recorder *TR* which automatically makes out a ticket. The called subscriber's number is recorded in the printer recorder at the same time as the impulses select the correcting devices. The calling subscriber's number is transmitted to the printer recorder by special identification devices *IA* which are installed at the automatic exchanges and send out impulses to the printer recorder. In addition there are connected in devices which take care of the printing of the cost of the call, the time of the call and the printer recorder's number.

Through unit debiting, the high cost for manual operation and tickets is saved but instead there comes to cost of time zone meters. The system can be so designed that the last named cost reckoned per call will be low.

If automatic ticketing is employed the costs of the ticket, which have been estimated at 5 öre, are not avoided. In addition the costs of printer recorder,

identification devices etc. have to be reckoned with and these would be appreciably higher than for time zone meters. For this reason automatic ticketing as regards economy is much inferior to unit debiting. Nevertheless, automatic ticketing has one advantage, namely that the subscriber can receive with the account a specification of the calls debited. However, so long as it is not a question of particularly high charges it need hardly be feared that the subscriber will insist on receiving specifications of calls, but will be content to have the call charges comprised in a single total along with the charge for the local calls, which would be the result of the introduction of unit debiting.

The question will then be how high the call charges to be debited without specification may be. Experience in Holland and Switzerland shows that even quite high charges can be unit debited. In these countries unit debiting was used even before the war for call charges up to 85 and 92 öre per 3 min respectively.

If to begin with one is content with unit debiting for charges up to 50 or 60 öre per 3 min., then in some of the Northern countries calls over stretches up to about 200 km would be covered. There would then be comparatively few calls left for which automatic ticketing would come into question. If the outlays for printing recorders, identifying devices etc. were only to fall on these calls the cost of them per call would be considerable and it is probable that it would be more economical to retain manual operation at a small number of trunk exchanges. In that case, however, they should be so arranged that only one operator needs to handle the switching. If keysets are used for dialling there is obtained almost as rapid an establishment of the connection as with complete automatisation and the operator cost would probably be lower than the expense which would arise with automatic ticketing.

Nor should it be forgotten that modern technical inventions in the domain of long distance telephony have provided facilities for appreciably cheaper long distance communications than previously and there is therefore reason to anticipate that even the long distance calls will in the future be available for low charges. Perhaps when general automatisation of the whole traffic of the country is to be carried out things will have progressed so far that the charges even for the longest communications within the country can be unit debited. Should such be the case the rather expensive adaptation for automatic ticketing will for this reason also be an unnecessary complication and a capital investment entirely thrown away.

Another argument advanced in favour of the automatic ticketing is that the time zone meters would be far too complicated if they also had to take care of the debiting of the long distance communications. For the designs hitherto available for time zone meters this argument is justified to a certain extent. Nevertheless, it is possible by working on new principles to arrive at simple time zone meters which meet reasonable demands for the debiting of long distance communications as well.

With manual operation it is usual to fix the rates per 3 minute period. This is connected with the necessity that the operator dealing with the call should not be burdened with or allowed more frequently than each third minute the trouble of checking whether the call is still going on and is to continue. With automatic debiting this consideration no longer applies and the intervals of time may be allowed to vary, there being fixed instead a unit for the charge which can be simply recorded as a step on the calling subscriber's call meter. This way of debiting, employed in the Swedish rural automatisation, must be acknowledged as more correct and more fair and it gives the subscribers access to cheap short distance trunk calls, while at the same time it has the advantage that the technical arrangements will be simpler.

An example of rates with this method of debiting is given below:

					cost per call of 3 min.
local rate	5 öre	unlimited	time		5 öre
trunk rate 1, up to 10 km,	5 »	per 3	min.		5 »
trunk rate 2, 10—20 km,	5 »	» 1.5	min.		10 »
trunk rate 3, 20—50 km,	5 »	» 30	sec.		30 »
trunk rate 4, 50—100 km,	5 »	» 20	»		45 »
trunk rate 5, 100—200 km,	5 »	» 15	»		60 »

When the tariff has been fixed it is a question of adapting the automatic debiting devices so that, without being too complicated, they fulfil as closely as possible the rate conditions required. The following article on call debiting »*Call debiting and numbering for automatic telephone traffic*», indicates a method by which it is possible to arrive at simple time zone meters without deviating too much from the principles for distance debiting. This method would mean in the example here given that calls between exchanges within 10 and 20 km distance from each other would be debited exactly in conformity with the tariff set up, but exchanges at more than 20 km distance are debited at the 20 km rate, if the calling and called exchanges belong to the same network group, and according to the distance to the called network group central exchange if they belong to different network groups. If unified numbering is employed inside the network group but each network group has routing numbers from the series 011—099, to be dialled before the subscriber number for traffic between the network groups, and if the above rates are applied, it should be possible to confine the requisite material for a time zone meter to a couple of simple selectors with a single direction of movement, a time relay and a few ordinary relays.

A time zone meter constructed in this way will be quite a simple and cheap device. It is especially for the small rural exchanges that the price for the time zone meters is of great importance. At such exchanges, however, discriminating selectors are most often required to determine whether the switching shall remain in the exchange and, if needed, to enable the blocking of certain instruments for certain kinds of traffic and to meet other special requirements. As the time zone meters can serve these purposes as well, the extra costs due to the debiting devices will be quite small.

A comparison between the cost as estimated above with manual systems and the cost with automatic systems for a 3 minute call over a 40 km trunk circuit will give a good picture of the great influence on economy of the unit debiting. To estimate the cost with automatic systems it is assumed that the automatic exchange cost including maintenance constitutes 25 % of the total annual costs. Though the cost for a local call with automatic systems is usually smaller than with manual systems, it is here assumed that even with automatic systems this cost is 5 öre. The automatic exchange cost inclusive of maintenance thus constitutes $0.25 \cdot 5 = 1.25$ öre. As a trunk call occupies connecting devices both at the outgoing and the incoming exchange, relay sets belonging to the junction circuits and the above mentioned time zone meters, the automatic exchange cost per call is higher for a trunk call than for a local call and is here intimated at 3 öre. A comparison between the costs for 3 minute call over 40 km trunk circuit employing manual and automatic systems will give the following results:

	when employing	
	manual system öre	automatic system öre
cost for occupation of trunk circuit	10	10
cost for local call	5	5
supplement for trunk call	13.5	1.75
cost for ticket	5	—
altogether	33.5	16.75

Thus in this example the cost for the trunk call with manual system will be twice as high as with automatic system.

Assuming a rural exchange with 50 % outgoing traffic which on the average is made up of 3 minute calls over 40 km trunk circuit, the saving on automatisation can easily be computed in the following manner:

	when employing	
	manual system öre	automatic system öre
local call	5	5
outgoing call	33.5	16.75
altogether	38.5	21.75

saving by automatisation $\frac{38.5-21.75}{38.5} = 43\ \%$

As the whole automatic exchange cost exclusive of maintenance is about 20 %, in this case the saving through automatisation will be so great that it will suffice to pay for the whole annual cost for two further equally large rural exchanges.

The example selected, however, is hardly typical of conditions in the Northern countries, as usually an appreciable part of the outgoing traffic from a rural exchange with manual system is made up of free traffic. To illustrate what might be the economic results of the introduction of unit debiting for rural exchanges with large outgoing free traffic, we therefore take as another example a rural station with 50 % local calls, 25 % 10 km calls and 25 % 20 km calls. It is assumed that with manual system 10 and 20 km calls are free calls, while with automatisation and the introduction of unit debiting the calls are debited at the rate given above, *i. e.* 10 km calls at a unit per 3 min and 20 km calls at a unit per 1.5 min. An investigation in Sweden has shown that the long distance free calls are of very long duration and it is therefore assumed that the number of 3 min periods is twice the number of calls. Further it is assumed that the mean call frequency amounts to 1200 calls per subscriber and year and that the subscription amounts to 50 kr per year + 5 öre per local call. We thus obtain the following calculated results through automatisation:

	when employing	
	manual system kr	automatic system kr
Outlay per trunk call		
cost for occupation of trunk circuit	0.04	0.04
cost for local call	0.05	0.05
supplement for trunk call	0.04	0.0175
altogether	0.13	0.1075
Income per subscriber		
fixed charge	50	50
income local calls	30	30
income from 10 km calls	15	20
income from 20 km calls	15	60
altogether	110	170

decrease of outlay on automatisation $\frac{13+5-10.75+5}{13+5} = 12.5\ \%$

increase of income on automatisation $\frac{170-110}{110} = 54\%$

This example, too, shows very good economic yield from automatisation. Nevertheless, the example is rather constructed, as the introduction of unit charge for 3 min and 1.5 min for 10 and 20 km calls would probably lead to a shortening of these calls, and the income would therefore not come fully up to the estimated 170 kr per subscriber. On the other hand, such a decrease in the duration of calls is desirable to reduce the occupation of the junction circuits.

In this example it is not the automatisation which produces the greatest part of the economic gain but the increase in rates arising from the introduction of the stated rates for 10 and 20 km calls. It is, however, the automatisation which makes possible the introduction of such flexible rate increase as may well from the subscriber's standpoint be regarded as fairly just and reasonable. As even after increase of rates the subscriber can get both 10 and 20 km calls for local call charge, if they are not of longer duration than a fairly normal local call, it should not be altogether out of the question that such a rate can be brought in without overmuch protest from the subscribers. In any case, the example is illustrative of the large profits that can arise from the introduction of unit debiting.

Reliability and Maintenance

To provide some basis for judging the importance of maintenance costs we shall give here only some points of view from the automatic systems that have been selected in Sweden.

Large exchanges in Sweden have with a couple of exceptions been constructed on the LM Ericsson system with 500-line selectors. The experience of operation with this system has been extremely good and the maintenance costs, closely analysed in Ericsson Review No 3, 1937, must be regarded as remarkably low. In general visitors from telephone administrations in various parts of the world have been surprised to find such small staffs required for maintenance. The number of faults remedied in the Swedish exchanges is at present on an average 2 faults per 100000 connections, of which about half or 1 fault per 100000 connections has consisted of contact faults. This is equivalent to about 1 fault per day at an exchange for 10000 subscribers with normal traffic. Now it is obvious that a relationship prevails between the number of faults and the maintenance seeing that when many faults occur it is possible to reduce them by increased maintenance. For example, if many faults arise in the selector contacts they could probably be reduced by cleaning the selectors more often. In Sweden the periods for cleaning selectors vary somewhat for different exchanges, it being done at some places each year and at others every other year.

At the large exchanges there is always skilled staff available to remedy any faults and the costs for this therefore will not be so heavy. The problem will therefore largely be to see that the fault percentage is safely kept under a fixed figure and the cost in maintenance to keep to this figure will be the economic criterion of the system's reliability of operation.

With rural exchanges it is quite a different matter. For their economic working it is most essential that permanent supervision can be avoided. To remedy a trouble at an unattended exchange will often be quite expensive as it is necessary to despatch skilled staff to the exchange. It is thus of great economic importance, particularly for the small exchanges, that cleaning and other maintenance can be done seldom, not only because cleaning in itself is expensive but also for the reason that in dusting contacts and other cleaning the dust is disturbed and the risk for temporary contact disturbance is in fact particularly great immediately after overhaul of an automatic exchange. There is especially good reason, therefore, to require rural exchanges to be absolutely completely automatic, i. e., freedom from trouble and little maintenance.

This is reason why the small rural exchanges in Sweden are made with relays only and the related crossbar selectors. Only relay contacts occur in these selectors. Since the introduction of double contacts both for selectors and for all relays it is stated that the number of contact faults is only ½ contact fault per 1 million connections. This means that, at a rural exchange for 100 subscribers with normal traffic, a contact fault occurs on the average only once every tenth year. As the movement of the selector consists only of the relay operation it is not exposed to any wear and requires practically no maintenance. From these points of view the selector is both theoretically and practically superior to rotary selectors with step-by-step mechanism or machine drive, otherwise usually used at small rural exchanges, and it may be declared that up to now no other selector has appeared with such good operating properties. It is evident, however, that such a selector must be somewhat more expensive to buy, but if it is considered that the cost of the whole of the automatic equipment constitutes little more than 20 % of the total annual cost and if one appreciates the great importance of absolute reliability of operation for rural exchanges, it must be admitted that the choice of this system is well justified.

The operating results from the first rural automatisation on a large scale in Sweden, in the Borås region, consisting of 3 main exchanges and about 90 rural exchanges, have been very satisfactory and after rural automatisation is introduced more generally throughout Sweden and all experience with the exchanges built has been noted, the rural automatisation system selected should with certainty allow of very economical and rational operation.

When rural exchanges are made on these or similar principles the maintenance costs even for the small automatic rural exchanges need not be of an order of magnitude other than for ordinary manual exchanges and will constitute only a small percentage of the total annual costs.

Call Debiting and Numbering for Automatic Telephone Traffic

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The automatisation of telephone traffic for zone and trunk traffic has increased the demands of unified planning, both because the place names must be replaced by figures and because it must be possible to record automatically the charges for zone calls.

One of the advantages of automatisation is that it makes possible a debiting of zone calls that is both economical and just. In manual telephone operation the service costs are large, especially if the calls have to be noted. Moreover, the handling of the call tickets involves appreciable cost and this, particularly for the short distance calls, will be disproportionally high in relation to the charges that can be made for the calls.

The possibilties for economic debiting of telephone calls however depend on the numbering system which in order to suit the public service must be so designed that the necessary instructions and routing figures will not be troublesome.

By automatisation of telephone traffic which comprises local traffic as well as zone and trunk traffic, it would perhaps appear rational to number all the subscribers in the country in one single big number series and fix only one rate for calls, irrespective of the distance between those speaking. A unified numbering for all subscribers who are to be connected automatically to each other is always necessary, but the technical devices require a distribution of the number series to conform to local conditions, whereby it is found advisable from several points of view not to include all the figures in the subscribers complete number when setting up connections between subscribers who belong to the same local net. Junction lines between exchanges, moreover, represent a very large part of the cost of a telephone system, therefore wasteful occupation of these lines must be prevented and this is best done by introducing special charges for zone calls.

The charges for the calls should as far as possible correspond to the administration's costs, therefore it seems to be necessary to introduce a number of rates based on the length of line. In this respect, however, it is not possible to use the line length as a direct measurement in such a way that a telephone call will cost so and so much per km of line. The cable routes inside a telephone network can be arranged in many ways and often exchanges are connected in such a way that a large part of their outgoing connections are carried over considerable detours. A rate directly based on the length of line would therefore be unreasonable and obviously unjust. Even with manual telephone traffic a geographical distance between the telephone exchanges to which the speakers are connected was used as basis for determining call rates. With automatic telephone traffic direct lines between the exchanges occur to a much less extent than in manual traffic, so that debiting according to geographical distance is more required by circumstances after the automatisation of the telephone traffic than before.

In manual telephone operations the service costs are large, particularly if the calls are to be noted. Moreover, the handling of the call tickets — sorting, entering, collecting the charges etc. — represent considerable expense. To ensure that zone calls bring in a reasonable return to the telephone

administration the charges for manual operation of short zone calls must therefore be relatively high. To bring down the service costs, noting the calls has sometimes been dispensed with and the subscribers have been allowed to have short-route zone calls without extra charge. The result of this can only be that the returns from zone traffic will be poor or the local rate must be raised. It happens, too, that free zone calls are only allowed against a higher subscription charge, but even this system is hardly satisfactory as the charge per zone call will be dependent on the ratio between the number of zone calls and the number of local calls for each individual subscriber. These inconveniences disappear in automatic zone traffic with debiting from call meters, which we will call *unit debiting.*

Unit debiting means that for each call there is recorded a number of charge units in the form of steps on the calling subscriber's meter. The number of units recorded is dependent on the duration of call and the distance between the talking subscribers. By means of unit debiting, all expenses for noting and handling call tickets are eliminated, so that charges for zone calls can be fixed which fairly well correspond to the cost to the telephone administration, without being unreasonably high.

In place of unit debiting, automatic printing of tickets was introduced some years ago. For calls liable to charge, a printing recorder that automatically makes out a call ticket is connected. The called subscriber's telephone number is recorded by the printing recorder at the same time as the impulses actuate the connecting devices. The called subscriber's number is indicated to the printing recorder through a special identification device set up at the automatic exchanges, which sends impulses to the printing recorder. In addition, devices are connected that cause to be printed the cost of call, time of origin and the printing recorder's number.

If automatic printing of tickets is employed, the administration is not freed from the sorting and other handling of the call tickets. As the expenses for these are appreciable, they constitute an essential part of the charges to be debited when it is a question of zone calls and cheaper trunk calls. As long as low charges are involved it need hardly be feared that the subscribers will insist on specification of the cost of each call separately, but will be content with receiving the charges incorporated in a single sum along with charges for local calls, which would be the case with unit debiting. For economic reasons, the printing recorders must be centralised to the more important places, so that zone calls which do not go through and do not reach any such place cannot be debited by means of call tickets. Thus, by the introduction of printing recorders and identification devices, unit debiting is not entirely avoided.

As it is possible with automatic debiting of trunk calls to use short charging periods instead of the 3-minute periods employed for manual operation, a large number of inexpensive trunk calls will arise, for which automatic ticketing would not pay. The advantages of automatic ticketing will therefore only be felt for a relatively small number of calls, *viz:* calls that are really dear per unit. If the outlays for printing recorders and identification devices along with staff to handle the call tickets are only to fall on these relatively few calls, it would be more advantageous to retain manual operation for those trunk calls for which the subscribers really require a voucher. It can then be so arranged that the subscriber wanting a trunk call may himself decide if he will obtain the connection automatically himself for unit debiting or order the call through an operator and receive a call ticket.

Subscribers who consider they have not sufficient supervision over their instruments to be able to accept unit debiting for trunk calls might be offered special subscriptions, which like coin-box instruments are barred for automatic trunk traffic.

In view of the large possibilities of reduction in line expenses for trunk calls that modern high frequency telephony offers, one is entitled to expect that charges for trunk calls will in future fall appreciably, so that it should be possible to apply unit debiting to all telephone calls that are connected by the subscribers themselves.

With unit debiting, each unit, *i. e.*, each step on the calling subscriber's call meter, will for zone and trunk calls only entitle to conversation for a certain length of time, which is determined by the rate for the call in question. In manual traffic, there is usually employed a fixed time unit of 3 min, and the cost for a 3 minute period varies with the distance between the subscribers. This is due to the fact that the operator who deals with the call should not be required or allowed more often than every 3 minutes to check that the call is proceeding and is to continue. With automatic debiting, this point of view does not arise and the interval of time can be allowed to vary, there being fixed for the charge instead a unit which can simply be recorded as a step on the calling subscriber's call meter. This method of debiting must be considered more correct and just, and it provides moreover the advantage that the technical devices will be simpler, while the subscribers will have access to a new kind of telephony, trunk calls of short duration at a low charge. Theoretically, it should be possible to vary the time unit continuously according to the geographical distances between the exchanges, but the time zone meters would then be extremely complicated and one should therefore confine oneself to a few rates only, which obviously is also desirable if the debiting is to be comprehensible for the subscribers.

If it is taken that local calls are debited with one unit fee per call irrespective of the duration of call, one may, for example, select the following rates for the automatised zone traffic:

rate	1:	one	unit	fee	per	3	min
»	2:	»	»	»	»	1,5	»
»	3:	»	»	»	»	1	»
»	4:	»	»	»	»	0,5	»

As it may be assumed that the savings involved in unit debiting will be, at least partially, to the benefit of the subscriber in the form of cheap call charges, the above four rates should suffice even for fairly long distances.

The special equipment required by automatic unit debiting are *time zone meters*, which are automatically set for the rate that is to apply to the call in progress and send impulses to the call meters. For setting for rates they must contain devices which record the number of the exchange or group of exchanges to which the call is routed. To avoid the recording devices being unnecessarily comprehensive, it is important that the number of figure combinations be limited and that the figure combinations should not contain any large number of figures.

The time zone meters will be particularly simple if calls to exchanges within the same network group are always debited alike. Such a radical simplification, however, can hardly be accepted. This is best illustrated by an example, see Fig. 1. Call from exchange *92* to *93* over a stretch of 4 km would then be debited at the same rate as call from exchange *92* to *64* over a stretch of 35 km. In such a system it would, moreover, be assumed that a higher rate is applied for calls between different network groups. Call from exchange *92* to the 7 km distant exchange *22* would then be more expensive than to the 35 km distant exchange *64*. To remedy such anomalies, without affecting too much the time zone meters, one can arrange matters as shown below, it being assumed that the two lowest distance rates in principle apply to exchanges within distances from the calling exchange of 10 and 20 km respectively.

It will be seen that for exchange *92* there are within 10 km eight exchanges, of which four belong to other network groups, and in an area between 10 and 20 km a number of exchanges in the same network group as exchange *92*, with in addition ten exchanges belonging to other network groups. If the approximation is now made that calls to exchanges more than 20 km distant are debited at the 20 km rate when the called exchange belongs to the same network group as the calling one and according to the distance to the network group centre when the called exchange belongs to another network group, the possibility is created of arriving at fairly simple time zone meters, without departing too much from the principle of distance debiting. Moreover a certain account will have been taken of the interest factor of the traffic and of the administration costs for the calls, seeing that connections inside a network group usually occupy a smaller amount of line material and a smaller number of connecting devices than connections between two adjoining network groups. The conditions to be fulfilled by the time zone meters at exchange *92* will then be that, besides giving definite rate markings for the various network groups, they should also give special rate marking for the eight exchanges within a 10 km radius and for the ten exchanges within a 20 km radius, which belong to other network groups.

It is customary to want to apply cheaper charges for certain routings with large traffic, *e. g.*, for traffic to network group centres. The above described principle for time zone meter construction affords the possibility of taking account of these. In the example selected, for instance, the time zone meters can be so constructed that, with calls from exchange *92* to its group centre *10—30*, marking is made for 10 km rate.

By careful planning of the number system, allowing for the possibilities of the time zone meters and by limiting their rate fixing to a few rates only, the requisite material for the time zone meter can be so restricted that the expenditure only slightly exceeds the cost of a discriminating selector. One might even, with a view to simplification in special cases, make exceptions from the rate limits given. As an example of such an exception it may be assumed that exchange *42* with call from exchange *92* is debited at the 20 km rate. In view of the small amount of traffic which may be anticipated from exchange *92* to exchange *42* such an exception is obviously of no significance.

Time zone meters of this kind should be located at each exchange, since, if they are centralised to junction exchanges or main exchanges, extra expenses arise to decide whence the call comes and to transmit impulses over junction lines to the call meters of the subscribers. Moreover, when located at every exchange they can be used for other purposes, for which as a rule similar equipment would be required for each exchange even if the time zone meters were centralised. Thus the time zone meters can serve as discriminating selectors at sub-exchanges with blind occupation and can also furnish facilities for blocking coin box and similar lines for certain kinds of charged traffic. It may, however, be advisable that impulse clocks and re-switching devices for night rates should be centralised, as time impulses can without difficulty be sent out continuously from the net work group's main exchange to its sub-exchanges.

If it should be found advisable to introduce unit debiting, even for such long distances that a larger number of rates must be employed, the time zone meters can easily be supplemented by devices for connecting in special rates for trunk calls. The determination of these long distance rates would then be made, however, by units centralised at trunk exchanges, which before the beginning of the call indicate to the time zone meters, by means of signals over the junction circuits, the trunk rates to be applied.

As stated above, the number of figures in the call number required for determination of rate is important to enable simple debiting devices to be arrived at.

The choice of the numbering system is also in itself of fundamental importance for the whole problem of nationwide automatisation. All numbering in automatised telephone networks is done by coordinating number series for network groups, exchanges in each network group and the subscribers connected to each exchange. To provide for future needs of new subscribers one can either arrange for ample reserve at the beginning or provide a facility for the addition of a further figure for all or part of the subscribers. The numbering of exchanges and network groups demands careful planning, being determined chiefly to suit line routing, but the question of fixing rates should also be kept in mind.

The question of reserve numbers for the numbering of exchanges is generally settled by the fact that the number series is poorly utilised, so that sufficient reserve numbers arise. Should that not be the case, there can if needed be added a figure in the exchange number, though it should then agree with an exchange number already existing. To avoid complication in the determination of rates, the aim should be that the several exchange numbers arising in this way out of one exchange number should be equal in respect of rates, so that alterations in the time zone meters for the exchanges not concerned need not be made. Any trouble arising from this would be slight, as the need for new exchanges only arises infrequently and the distances to them are always limited by the network group boundaries. Numbering of exchanges in a network group should as a rule be possible of accomplishment in such a way that the call rate can be determined by two figures if other network groups are left out of account.

As it is usual for most calls to go to subscribers who belong to the local network it is an advantage if a division of the subscriber's number is made so that not all figures in the whole number need to be taken for a connection between subscribers in the same local network. It is not however possible without further consideration to make the division in such a way that for traffic in a limited area only the latter part of the number is dialled, while the whole number is dialled for traffic outside the area. The condition for this to be possible is that the first and second parts of the number never contain the same first figure. To avoid the limitation of the number series which this condition imposes there is introduced an extra routing figure, usually *0,* before the first part of the number. Two natural alternatives for division of the complete numbers are available, *viz:* division between the network group number and the exchange number and between the exchange number and the subscriber number. If the network group number is taken away, each network group forms a closed number series and the routing figure *0* is required for all calls to other network groups. If the division is made between the exchange number and the subscriber number then the figure *0* and the complete number must be dialled for all connections that are not local connections. If the area that is to be automatised mainly comprises places which have a comparatively small traffic between them it may be considered natural to make the division between the exchange number and the subscriber number. Usually however there is to be found around the main centres a number of places which have heavy traffic with the main centre and between themselves. If each such group of places constitutes a network group that can be regarded as an area separated from the other network groups in respect of traffic, the division between the network group number and the exchange number will be the most favourable.

It is however in practice often impossible to arrive at such a division that the network groups constitute areas distinct from each other in respect of traffic. Particularly in farming countries, with a fairly even settlement over large parts of the country and along the coast and highways, there will often be large traffic between the rural exchanges which lie on either side of a boundary. On the one side of the boundary a call to a certain subscriber will require, for example, only four figures, while a call to the same subscriber from an instrument on the other side of the boundary will require eight

figures. This inconvenience will always arise as a consequence of dividing the number series but will vary in magnitude according to how large a part of the total number of calls require the longer call numbers, and to what extent this, owing to geographical conditions, is unnatural for the subscribers in the boundary areas.

The distance to subscribers belonging to adjoining network groups will often be shorter than to subscribers in the same network group, while this is not as a rule the case for subscribers belonging to network groups that do not adjoin. This is the reason for a proposal having been made to arrange call numbers differently according to whether they apply to »adjoining» or to »not adjoining» network groups.

In Sweden a number has been proposed requiring that for traffic inside the network group closed numbering is used, for traffic to adjoining network groups there is dialled a network group number before the subscriber number and for traffic to network groups not adjoining *o* is dialled in addition before the network group number. This gives the advantage that for the fairly heavy traffic to adjoining network groups the call number is shortened seeing that *o* need not to be dialled. Moreover it is considered to give the advantage that subscribers by dialling *o* only for actual trunk traffic have their attention especially directed to the fact that the call is debited as a trunk call, unlike calls to an adjoining network group which as regards rate are more in agreement with rural calls within the subscriber's own network group. Employment of this number system, however, causes a certain limitation of the number capacity as there cannot be used as the first figure in the subscribers number the first figure in the network group number of an adjoining network group. It is chiefly the local conditions for network group division and the arrangement of the telephone directory, together with the facilities in respect of traffic, which decide the advisability of arranging three different methods of call for one and the same subscriber in this way.

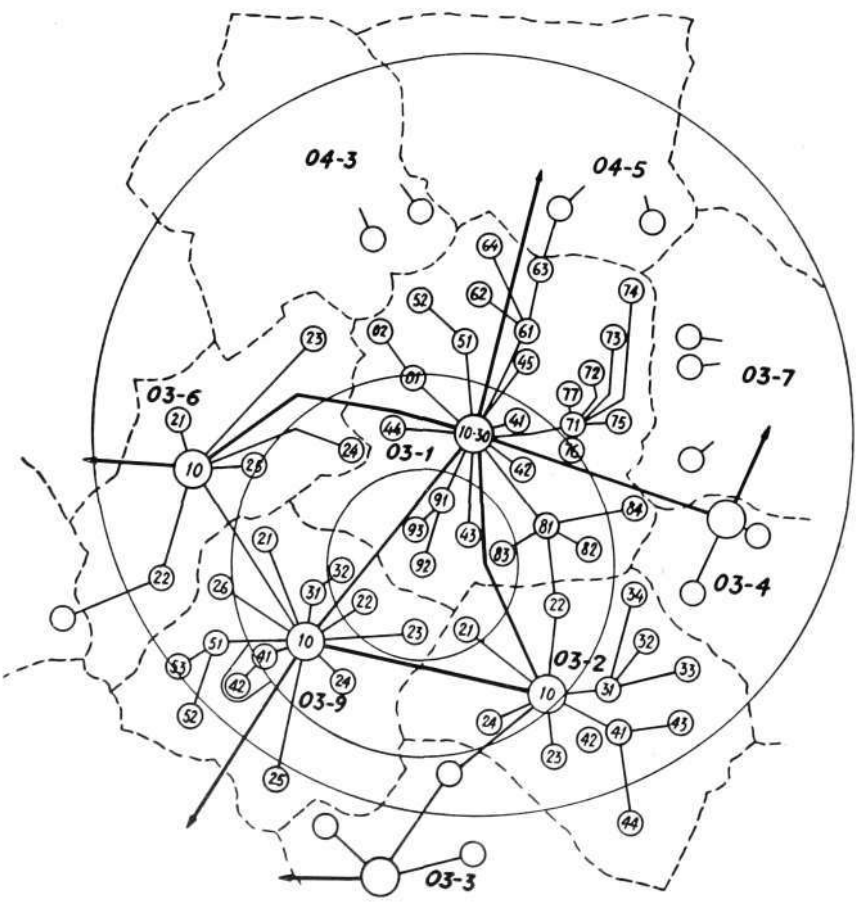


Fig. 1 X 5862
Network group numbered in common number series with adjoining network groups

Another manner of distinguishing the real trunk traffic from the traffic to adjoining network groups is that the number is divided immediately before the last figure in the network number. The first figure in the local number will then mark the subscriber's own or adjoining network group and only the local number is dialled for traffic to both his own and adjoining network groups. For traffic to network groups not adjoining there is dialled, however, the routing number before the local number. The routing number then consists of the routing figure *o* and the network group number without its last figure. A condition for this division will be that the last figure in the network group's number is not the same in adjoining network groups. Little difficulty is encountered in fulfilling this condition as the number of adjoining network groups rarely needs to go beyond six and may be as many as eight, see Fig. 1. Since the figure *o* will be a routing figure it cannot be used as the final figure in the network group numbers but instead the figure *o* may be used as the initial figure in the exchange numbering, whereby 10 % increase of the number capacity in the network group is obtained. In the example selected, Fig. 1, the exchange numbering is two-figure and the network group numbering three-figure (*o* plus two figures). In the subscriber number there will then be a number of figures dependent on the size of the exchange.

By thus combining several network groups to a common number series there will be only a small number of calls, namely those that go right across a whole network group and pass over that network group's further boundary, for which it is necessary to use a routing number before the local number. On the other hand, this combining means that all connections within the network group require an extra figure that is unnecessary for them, that is the last figure in the network group number. The advantage has, however, been obtained that the routing number does not require to be dialled for short distance calls over the network group's boundaries and is only applied for the actual trunk traffic. The subscribers will thereby have particularly pointed out to them that the call will be debited at a trunk rate. The system provides also a simplification of the debiting devices, as the rate determination in the time zone meters for traffic between adjoining network groups can be done from three figures, *i. e.*, the last figure of the network group number and the exchange number. If call to adjoining network groups is done with the complete number, then the rate determination must be made from the whole network group's number and the exchange figure, *i. e.*, in the example selected, from five figures.

Once the number series has been divided up and routing numbers introduced the question arises how the subscribers will be able to remember when the routing number is to be dialled and when it is not needed, and also what number is to be dialled. Suitable arrangement of the directory is of great importance.

If each network group or district forms a number series of its own there is sometimes given in the directory the whole subscriber number for each subscriber, the numbers being divided by a dash between the routing number and the local number, *e. g.*, *031—92789*. There can then be printed at the top of each page for the district *031* in the directory, for example: »For call from subscribers with routing number *031* only the figures after the dash are to be dialled.»

If a network group forms a common number series with adjoining network groups the corresponding instruction would need to cover a number of combinations of routing figures and initial figures after the dash in the subscriber number, *e. g.*, *03—1, 03—2, 03—4, 03—6, 03—7, 03—9, 04—3, 04—5*. It is therefore advisable in this case to retain the usual arrangement of the telephone directory and only give the local number for each subscriber, having separate sections of the directory for network groups. There will then be needed for each network group, on the first page of its directory section, directions regarding »rural traffic area» in the form of a map of the network

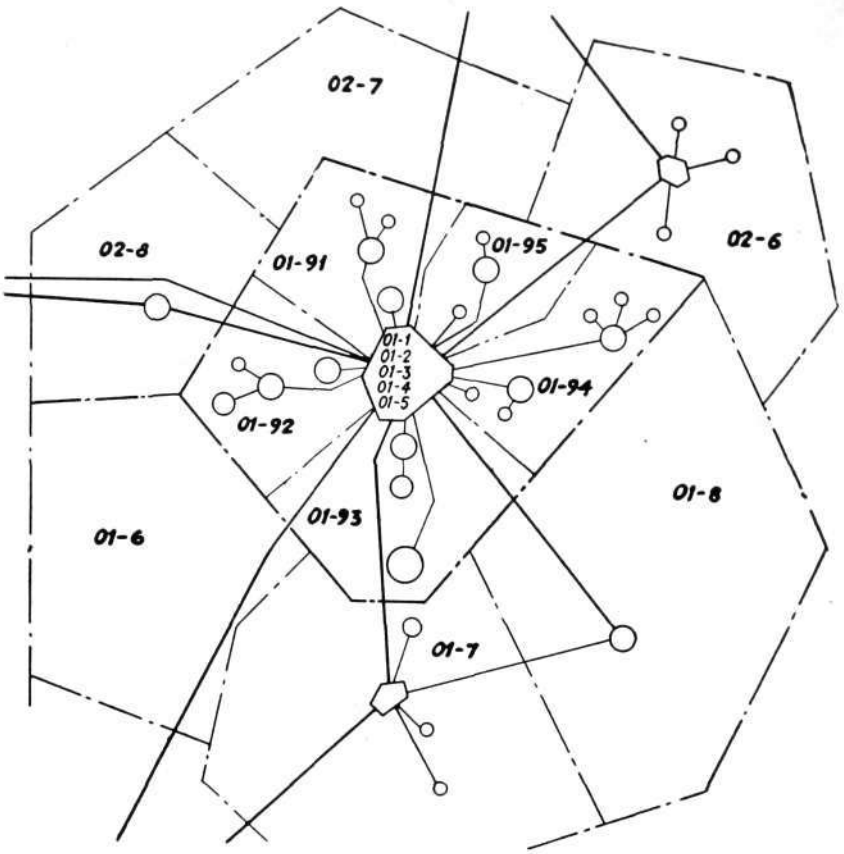


Fig. 2 X 5863
Network group divided in the outer areas, which are numbered in common number series with the network groups main place and adjoining network groups

group itself and adjoining network groups or an alphabetical list of the postal districts from which the network group subscribers can be reached without using routing numbers. The routing number for the network group can be given at the top of each page of the directory.

This may possibly appear more complicated, but it should in practice involve no difficulties. It is of course only calls which go beyond adjoining network groups that are dialled with routing numbers so that the number of such calls will be small and the distance over which the call will be carried is so long that the subscriber will have reason to expect that the call is a trunk call. Moreover it can be stated as a simple rule that in those cases where the subscriber is doubtful whether the connection is trunk or not the complete number should be dialled. Should the connection turn out not to be trunk, it can be routed to a speaking machine, or an operator, or a special tone can be connected which announces that only the local part of the number is required for the establishment of the connection.

If a numbering system which joins each network group with its adjoining network groups to a common number series shows simplification in automatic debiting, that does not mean that it carries with it the simplest and most economical connecting process. The extra figure which is dialled in local connections must be received in some apparatus which decides whether the figure marks the subscriber's own or an adjoining network group. Taking into consideration the connecting process only, it would be preferable to divide up the subscriber's number in such a way that the routing figure *0* is dialled for all connections that are not purely local connections and which therefore remain within the subscriber's own exchange. This system however causes considerable inconveniences to subscribers in all the exchanges which have a considerable number of outgoing calls. As this is the case for nearly all exchanges except the large main exchanges, it has been considered justifiable to increase the plant cost by introducing blind occupations and discriminating selectors or registers both in suburban exchanges and in other ex-

changes on the outskirts of the network groups. If several network groups form a closed number series then all calls going out from the main centres of the network groups and all calls from sub-exchanges, which blindly occupy circuits and devices at the main exchange, will require registers or blind occupation of an extra group selector at the beginning of the connecting process. In those automatic systems where registers take part in all local connections one figure more or less will not involve any appreciable change in cost, so that network group combining would mean increased cost only in those automatic systems that use blind occupation with direct routed selectors.

The cost for blind occupation of an extra group selector is not appreciable unless the network group's main place is so large compared with neighbouring places that traffic to adjoining network groups will be very small compared with traffic inside the network group. Nor in such a case would the local traffic be burdened with an extra figure and even the register system would then require such a technical solution that an extra figure for the local traffic of the main place is avoided.

To sum up, it may be said that the addition of an extra figure for the local traffic may be justified if the main place in the network group is small or dependent on one or more equally large or larger places in adjoining network groups. If on the other hand the main place is predominant both for its own and for adjoining network groups, it may generally be assumed that its superficial area is large enough for the main place and its nearest suburbs to form a network group of their own, while the more distant suburbs can be combined to make outer areas which form network groups of their own, but are included in the main place's number series. With such a division of network groups, see Fig. 2, the main place and its nearest suburbs have at disposal, *c. g.*, the five network groups figures *01—1* to *01—5*, while the outer suburban areas will receive *01—91* to *01—95*. The numbers for the network groups lying outside the outer areas are so chosen that these can receive common number series with the neighbouring outer areas.

The most suitable number system is dependent on local conditions and it can therefore not always be expected that any of the above given solutions can be applied throughout for a whole country. Still, it will often be found that the best result is attained by a combination or by modifications of the possibilities here given. The problem should be given thorough study along with the question of the method of debiting, before countrywide automatisation plans are definitely settled.

Telephone Plant in Medellín

B LINDÉN AND E LINDSTRÖM, TELEFONAKTIEBOLAGET L M ERICSSON, STOCKHOLM

U.D.C. 621.395.343(861)

On 13th July 1937 there was concluded a contract between the city of Medellín in Colombia and Telefonaktiebolaget L M Ericsson for the supply and fitting of an automatic telephone exchange for 10000 lines, reconstruction of the old telephone network for 7300 lines and the building of a new network for 5000 lines, together with the supply of 8000 telephone instruments.

The time of delivery stipulated in the contract was three years. On the Colombia national fête day, 20th July 1940, the plant was inaugurated and handed over to the municipality of Medellín city. All the material was delivered by Telefonaktiebologet L M Ericsson. The automatic exchange was installed by L M Ericsson and the work on the network was carried out by the city employees under the direction of L M Ericsson engineers and foremen. In the ceremony of taking over special stress was laid on the good collaboration between the city and L M Ericsson during the period of construction.

Exchange Equipment

At the time the city of Medellín decided to automatise the local exchange this comprised 5200 subscribers, served by a manual exchange of Stromberg—Carlson's construction. In addition to the local subscribers in Medellín directly comprised in the city's concession area and some small outside exchanges on the C. B.'system there were also connected a number of rural and trunk lines. The automatisation of the local traffic in the city of Medellín itself required that these different categories of traffic must in future be handled in different ways.

For the rural lines there had to be built a new manual plant, particularly in consideration of joint traffic with the new local exchange. The small extent of the rural traffic in relation to the local traffic made automatic establishment of traffic on the local exchange the most economical. Joint traffic with the outside exchanges is handled automatically in the local exchange by having junction lines to these connected in the automatic exchange as P.B.X.-subscribers. They are thus allotted call numbers in the automatic exchange number series for the incoming traffic from the local exchange. The positions in the outer exchanges are equipped with dial etc. for automatic connection to the local exchange.

In the newly erected administration building of the city, in which all the exchange equipments are housed, there is installed an automatic P.B.X. for the internal traffic.

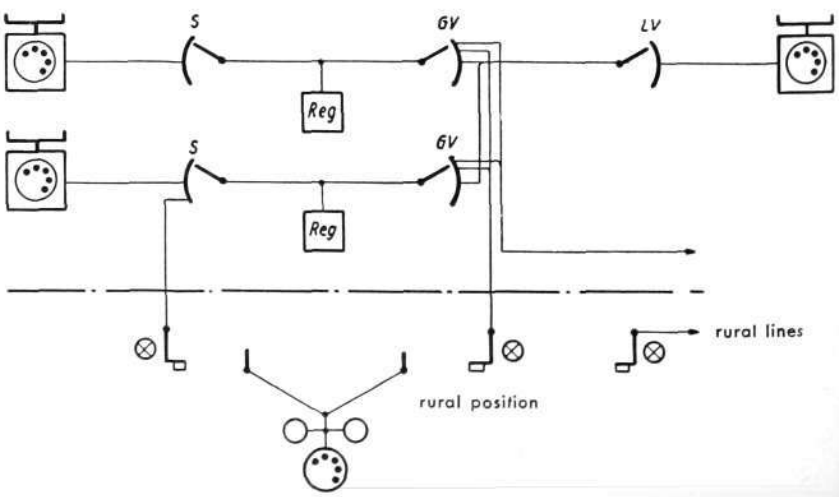


Fig. 1 X 5774
Distribution diagram of the telephone exchange in Medellín

GV group selector
LV final selector
Reg register
S line finder

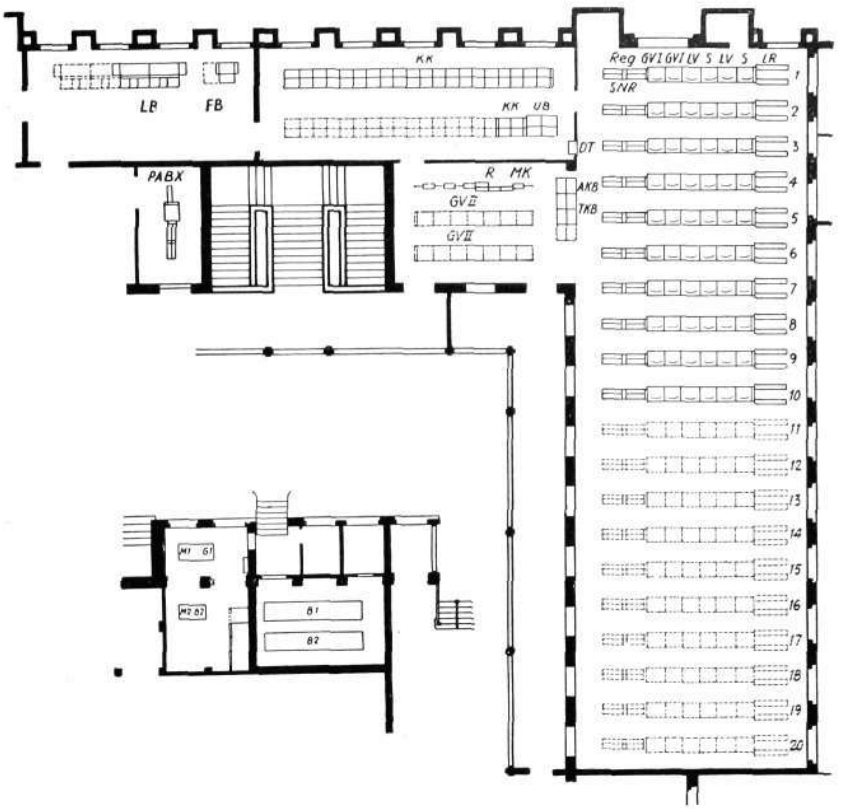


Fig. 2 X 5768

Layout plan of operators' and apparatus hall, machine and battery rooms

AKB	subscriber supervisor desk
B1, B2	batteries
DT	distribution panel
FB	tandem position
G1, G2	generators
GVI, GVII	group selectors
KK	main distribution frames
LB	rural position
LV	final selectors
LR	line relays
M1, M2	motors
MK	intermediate distribution frames
PABX	private branch exchange
R	relay rack
Reg	register
S	line finder
SNR	connecting circuit relays
TKB	traffic supervisor's position
UB	testing position

Local Exchange

To ensure satisfactory reserve for the large subscriber increase that was to be expected in conjunction with automatisation, the local exchange was from the beginning built for 10000 numbers. The local exchange is built according to the LM Ericsson automatic system with 500-line selectors.

The system applied is five figure with the subscriber number series 10000—69999 and has thus a final capacity of 60000 numbers. In addition there are available five special routings with the numbers *01* to *05* for call to rural ordering, fire brigade etc. Of these, three routings are installed at present.

One of the twenty 500-line groups now fitted is so arranged that P.B.X. subscribers can be connected. The difference from the normal groups consists chiefly in the final selectors being made for P.B.X. hunting over an almost arbitrary number of lines and for night connection.

The remaining 500-line groups are intended for ordinary subscribers. Two of these 500-line groups, however, are in addition intended for connection of junction lines from the rural exchange. In view of the present smallness of the rural traffic it was considered when planning the exchange not necessary to build a special group of connecting circuits and registers for the junction group traffic. This traffic is routed instead over special repeaters to the finder multiples in these two groups. The connecting circuit relay sets are in this case arranged for through connecting of the line wires to the above mentioned repeaters, so that complete signalling to the positions and also break facility are obtained. The registers are so arranged that on special signal coming from the repeaters they take care of the through connecting in the connecting circuit relay sets.

A number of final selectors in each group is constructed for mixed local and trunk traffic. Other final selectors are intended for local traffic only. From the two groups to which junction group lines are connected only final selectors for mixed traffic can be reached.

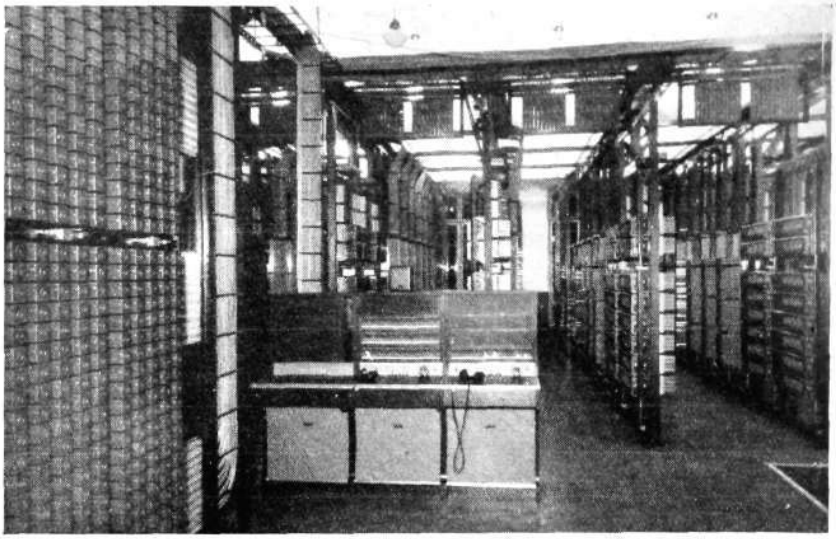


Fig. 3 X 5777
Automatic hall
In the middle, position for traffic supervision and individual supervision

The connecting circuit relay sets in all groups are equipped for the connection of LM Ericsson standard coin box instruments. Pole changing in the calling subscriber's speaking loop is then obtained when the wanted subscriber answers.

The automatic exchange is equipped with a complete range of supervisory devices. In addition to the usual traffic supervision position customary in the 500-line system, which is connected in conjunction with the registers, there is also installed a position for individual supervision of subscriber lines. To this position a number of relay sets belong, which can be connected over the test jacks in the main distribution frame to subscriber lines the traffic of which requires to be supervised for one reason or another. By means of auxiliary relay sets and their lamps in the position both outgoing and incoming calls are marked. For outgoing traffic there is the facility of connecting in a supervisory register which shows on a lamp panel in the position the number dialled. The supervisory device directly connected to the subscriber line consists of a connection by electron tube through which impulsing and signalling to the exchange equipments is not in any way disturbed. A number of subscriber lines can be connected at one time to the position for supervision.

For metering the traffic in the various 500-line groups a traffic meter cabinet has been supplied. This comprises three permanently connected meters per 500-line group for recording the number of connections together with two common call minute meters which can conveniently be switched to the different 500-line groups and to different groups of devices in them by means of buttons. A recording amperemeter for more detailed tests is also included in the equipment

The racks for the different connecting devices are calculated for approximately 25 % increase in traffic. In the ordinary 500-line groups there is room for 40 connecting circuits with their 10 registers and in the P.B.X. group the corresponding numbers are 50 and 12 respectively. At present 32 connecting circuits and 8 registers and 45 connecting circuits and 11 registers respectively are installed, corresponding to the traffic for which the exchange is estimated. The final selector racks for the ordinary 500-line groups comprise 40 units of which up to now 20 final selectors for mixed local and trunk traffic and 12 for local traffic only have been delivered. The corresponding figures for the P.B.X. group are 50, 20 and 25 respectively.

The racks are built together into unit rows each comprising 1000 subscriber lines or two 500-line groups. Ten such unit rows are mounted in the hall of the city council administration building that has been set aside for the automatic exchange itself. Space has, however, been reserved for a further ten such unit rows and for the requisite number of second group selectors which will be added in conjunction with the next enlargment. In the automatic hall the traffic supervision position and the individual subscriber supervision position are set up.

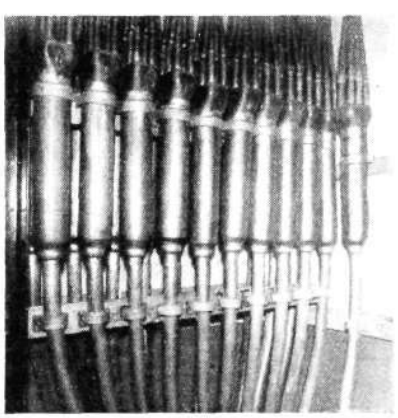


Fig. 4 X 4122
Final splices
on the 21 primary cables each of 600 pairs entering the automatic exchange

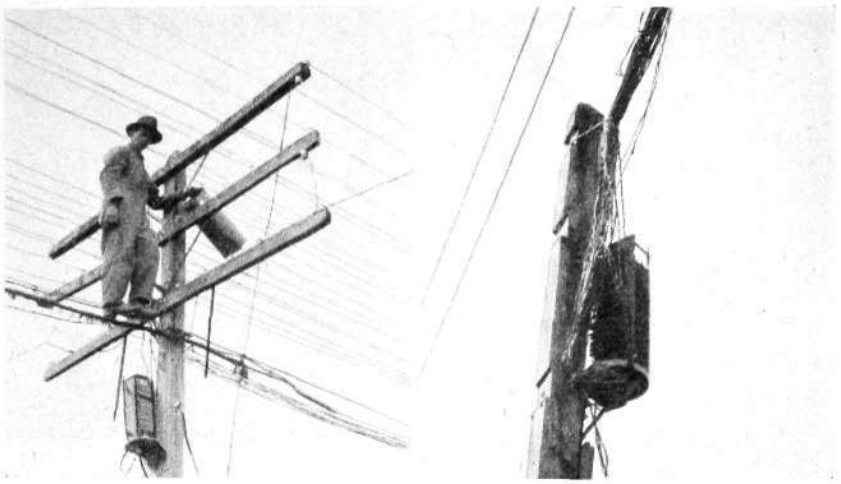


Fig. 5 X 5778
Subscriber lines on poles prior to reconstruction

The main distribution frame is mounted in immediate connection with the automatic hall but separated from it by glass partitions to prevent dust and thread fibre which is invariably cast up during jumpering from spreading to the automatic equipment. Space is reserved for extending the main distribution to correspond with the capacity of the automatic exchange. The two-position test desk is installed in conjunction with the main distribution for testing subscriber lines and telephone instruments. Each position is equipped with a voltmeter for testing the lines and a frequency meter for checking the telephone instrument dials.

The Rural Exchange

The rural exchange is at present built for 400 rural lines of standard construction that are served from four operator's positions. Each operator's position is equipped with 10 cord circuits and impulsing devices for connecting to the local exchange. Two of these positions, however, are mainly intended for ordering and information service. In view of the cooperation with the local exchange, the cord circuits have been specially adapted in certain respects. Thus the character of the ringing signal which is sent out from an operator's position is governed by the line to which the circuit at the moment is connected.

The plant is constructed for 20 junction lines to the automatic exchange.

The rural positions are located in a separate room adjoining the main distribution hall. There is reserve space for extensions in this case also. The relay equipments for the rural lines are mounted in the automatic hall along with the repeaters of the junction lines.

Internal Switchboard

The internal switchboard installed for the internal traffic of the administration building is of the LM Ericsson OS-P.A.B.X. type with automatic outgoing traffic to the city exchange and manually operated incoming traffic. The switchboard is built for 100 extensions and can be enlarged to 280.

The racks have space for 24 connecting circuits but only 12 are required for the present traffic. For the city traffic 10 two-way exchange lines are fitted. The incoming city traffic is handled by a single-position operator's desk which is located in the same room as the rural line desk. The switchboard is equipped with devices for inquiry and transfer on the LM Ericsson modern P.A.B.X. system as described in Ericsson Review No 3, 1937.



Fig. 6 X 4126
Subscriber lines on a wall previous to reconstruction

Power Plant

The power plant is common both to the automatic exchange and the rural exchange and to the P.A.B.X. as well as to other devices belonging to the low tension installation in the city council administration building.

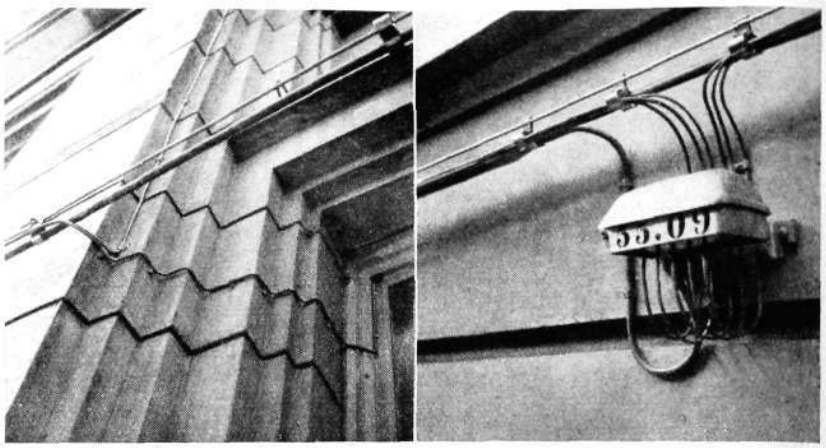


Fig. 7 X 5779
Subscriber lines on a wall after reconstruction

The power plant comprises two 24 V lead accumulators each of 2016/3600 Ah, which are charged by two units each of 300 A, 24/36 V. One of these is electrically driven from the city lighting mains. The other, driven by a petrol engine, is also intended to serve as reserve in case of prolonged interruption in current supply from the mains.

For supervision and operation of the charging and distribution there is an instrument board with the necessary instruments and switches. An electrically driven water distilling apparatus is included in the power plant equipment to facilitate the supply of distilled water to the accumulators. The batteries and the charging devices are mounted in separate rooms in the basement.

Network Plant

The 16 outgoing cables from the old exchange had together 7300 pairs. These cables where of varying size from 250 to 600 pairs with 0.61 mm diameter of wire. All of them consisted of bare cables laid in conduits of 100 mm earthenware piping, with the exception of the two oldest which were armoured.

These cables were branched to protector boxes of 15 or 25 pairs, set up on walls or poles. Multipling of cable pairs between two boxes occurred frequently. The subscriber lines consisted of twisted tar-covered wires mounted in bunches along the house walls and across the streets, see Fig. 5 and 6. In bad weather the boxes and also the tarred wires had poor insulation and produced a number of faults so that the boxes were replaced by LM Ericsson 10-pair boxes NCD 3012. The tarred wire was exchanged for single pair lead-sheathed cable.

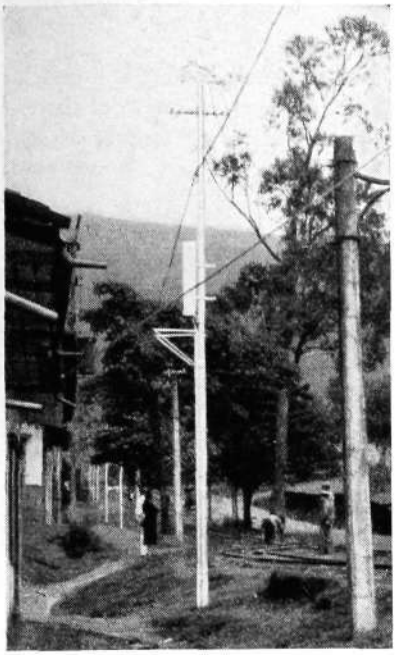


Fig. 8 X 4124
Cable distribution cabinet for 300 pairs primary cable and 400 pairs secondary cable

Side by side with the reconstruction of the old network a new cable network was built on the LM Ericsson distribution system. The new network comprises 5000 pairs in primary cable and 6500 pairs in secondary cable.

In settling the details of the project, for which a careful inventory of existing and prospective subscribers for the next five years in the whole city constituted the bases, the rule applied was first to utilise the old cable to the greatest extent possible and in the most suitable manner and then to fill up the gaps with the new cable network.

The old 15-pair distribution boxes were replaced by two 10-pair boxes, the one with 5 and the other with 10 cable pairs, conveniently located. All the 25-pair distribution boxes were replaced by three 10-pair boxes, one serving five subscribers and the other two 10 each. In those cables where two 25-pair distribution boxes from the same cable could be combined and more than five 10-pair boxes were needed a cable cabinet has been put in, this having 50 incoming primary pairs and as many secondary pairs as corresponded to the number of 10-pair boxes that had to be served. The cabinets thus put up have



X 4127

Fig. 9
Distribution pole
of Mannesmann tube with cable distribution cabinet, working bridge and distribution crossarm

altogether 1650 pairs primary lines. A total of 5120 pairs have been distributed direct to 10-pair boxes while 530 pairs have up to now found no employment and lie in reserve at various points in the city.

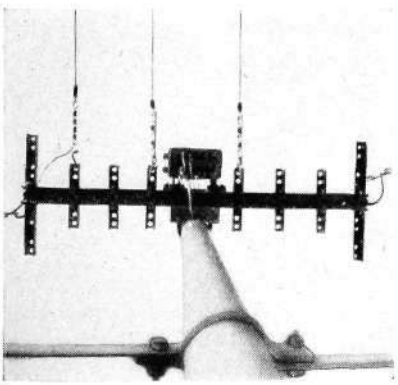
The new network starts from the telephone exchange in the form of 600-pair bare primary cables of 0.6 mm wire diameter in concrete canalisation built for the purpose to LM Ericsson's design, comprising 42 conduits with an extent of altogether 15060 conduit metres distributed in the central parts of the city. In the outer areas the primary cables are armoured and laid direct in the ground. The primary cables terminate in 700-pair cable distribution cabinets placed by the house walls or standing in open spaces, Fig. 8.

The secondary cables from the cable distribution cabinets to the 10-pair boxes have 0.6 mm wire diameter and as a rule consist of bare cables mounted along the house walls. In the residential quarters they are mostly mounted as aerial cables on Mannesmann tube poles. To a large extent also armoured cables laid in the ground have been used on the outskirts of the city. The subscriber lines throughout the city are made of single pair lead-sheathed cable. The lines that branch out from the poles or across streets are made of selfsupporting single pair cable of LM Ericsson design. All the 10-pair boxes and cabinets are of new design with hermetically soldered blocks of bakelite which provide very high insulation.

The wall mounting is of new design specially adapted to conditions in South American and Central American cities. It is based partly on the fact that most of the buildings are single family houses so that subscriber density is sparse and the subscriber lines relatively long and partly on the construction of the houses, most of which are made of dried clay offering poor hold for the direct mounting of the cables on the wall. The design consists of a bearing steel wire stretched along the house wall about 75 mm from the wall, on which hang open supports of stainless steel at 4 dm intervals. In these supports are laid both the secondary cables and the subscriber cables, the supports being double when both kind of cables occur and single when only subscriber cables are carried. The design has proved easy to put up and take down, has good appearance and is particularly convenient for new installations and removals of subscriber lines.

The regrouping on the LM Ericsson system of the existing subscriber lines was, in view of the distribution of the old network, in which tarred-wire lines of up to 1000 m length occurred, a difficult and tedious work that had to be carried out with the least possible disturbance of the telephone traffic.

All the instruments were replaced by LM Ericsson's new bakelite instruments. In view of the great difference in the current feed system at the old C.B.-exchange and in the new automatic exchange, the new instruments could not be taken into service before the old exchange was disconnected and the new automatic exchange put into operation. The new instruments were therefore connected up in readiness in front of the old and sealed by an insulated conductor wire which shortcircuited the new instrument in the manner described in Ericsson Review No 1—3, 1932. A notice on the instrument instructed the subscriber that when the automatic exchange was put into operation the wire was to be clipped off, after which the new and not the old instrument was to be used.



X 4128

Fig. 10
Distribution pole
seen from below

Despite considerable transport difficulties in the last year of the work, this extensive telephone plant was completed within the time fixed by the contract. The extremely good collaboration during the period of construction with the authorities and officials of the city of Medellín contributed very largely to this. It was therefore possible to open the new telephone exchange on the national fête day, 20th July, 1920, to the great satisfaction of the inhabitants of Medellín, not least those whose telephone subscription had been long delayed owing to the old exchange being fully loaded.

Extensions in Medellín

The modernisation and improvement of the telephone service in Meddelín owing to the reconstruction of the network and the automatisation of the exchange in 1940 brought about a very rapid increase in the number of subscribers and traffic density.

For the head exchange, which on opening had a final capacity of 10000 numbers, an extension for 5000 numbers has been ordered. This order comprises a further 5000 numbers to be installed in the suburbs America, Poblado and Aranjuez.

A corresponding enlargment of the network is projected and will be carried out under the direction of LM Ericsson.

The Automatisation of the Telephone Traffic on the Swedish State Railways

O SIEWERT, TELEFONAKTIEBOLAGET LM ERICSSON, STOCKHOLM

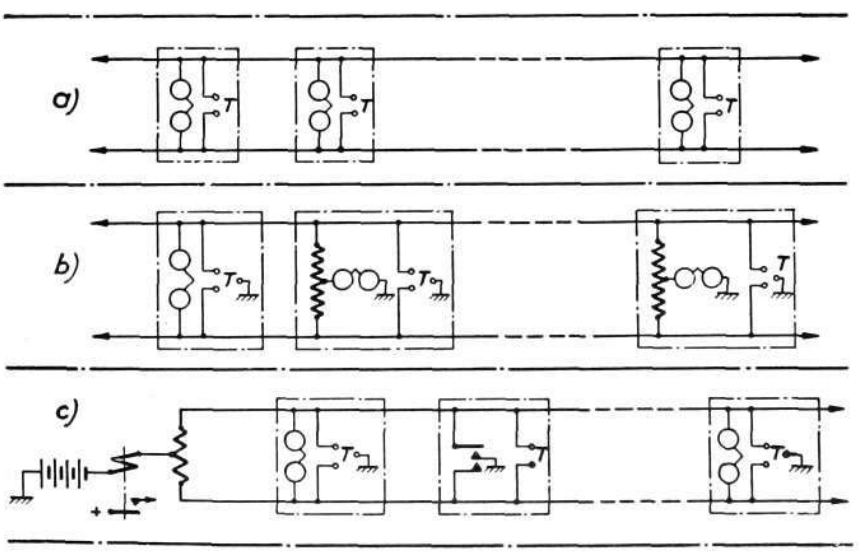
U.D.C. 621.395.34: 656.254.15

The Swedish Royal Board of Railways appointed in 1940 a special committee charged with recommending guiding lines and drawing up a programme for the expansion and rationalisation of the State Railways telephone service. The committee presented its report on 30th March, 1943.

Among the more important of the tasks entrusted to the committee was to study the conditions and indicate the broad lines for the automatisation of the sectional telephone traffic and the long distance telephone traffic. As the results of the committee's labours on these questions should be of interest for a larger circle of readers than can be reached by the above-mentioned report, the following brief account is given here with the kind permission of the Royal Board of Railways. The account has already been published in Teknisk Tidskrift, No 32, 1943, from which it is reproduced with the necessary authority.

The telephone installations of the State Railways may be divided into three categories, *viz: local telephone plants, long distance telephone plants* and what are known as *sectional telephone plants*. The purposes of the two first-named plants are apparent from their names, while the function of the last-named is to provide for communication possibilities between different posts connected to common circuits, *i. e.*, between different telephone posts along the permanent way.

A short description is first given of how the above telephone plants are arranged at present and then an account of the proposals for reconstruction and automatisation of these plants which the State Railways telephone committee put forward in its report. The sectional telephone plants will be dealt with first and after them the local and long distance telephone plants.



X 5940

Fig. 1
Magneto telephone system
a magneto ringing call between the branches
b *magneto ringing* call between the branches and earth
c magneto ringing call between the branches and galvanic call between the branches and earth
T magneto generator telephone instrument

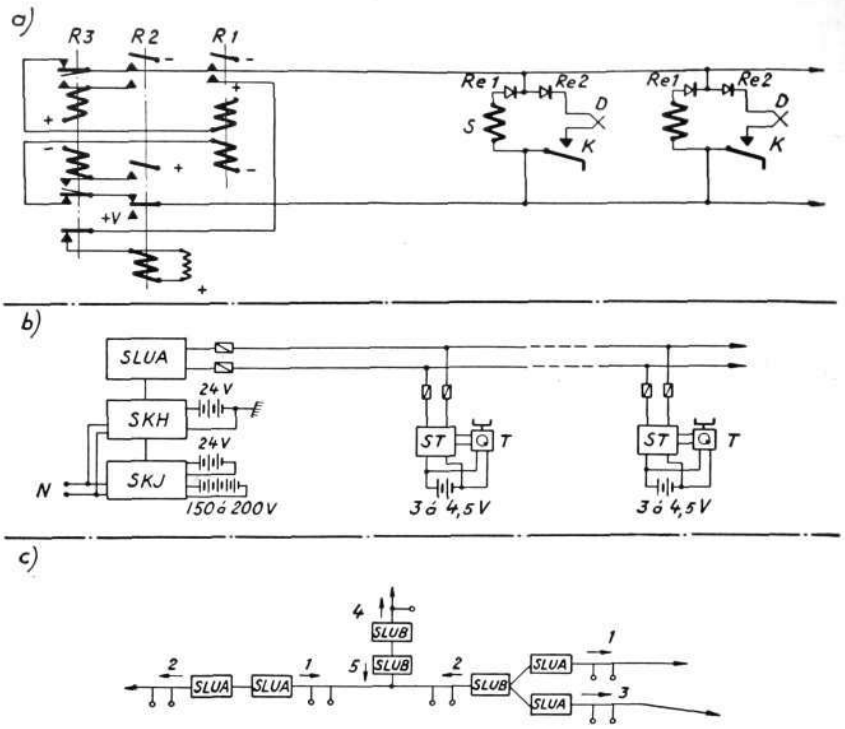


Fig. 2 X 5941

L M Ericsson selective calling system with D. C. impulsing

a diagram of culling and impulsing circuits
D dial contact
H hook contact
R1 impulse relay
R2 impulse relay
R3 impulse relay
Re1 rectifier
S selector magnet
b diagram of selective calling telephone plant in one section
c diagram of selective calling telephone network covering several sections
SKH charging unit
SKJ charging unit
SLUA line equipment
SLUB line equipment
ST selector set
T telephone instrument

Technical Execution of the Sectional Telephone Plants

Sectional telephone circuits are at present arranged along practically all sections of permanent way in Sweden. Only in a few exceptional cases are telegraph circuits still used instead of telephone circuits for corresponding purposes.

To begin with *magneto telephone systems* only were used for sectional telephone communications. In its simplest form a magneto telephone plant consists of a two-wire circuit, to which magneto telephone instruments with high ohmic bells are connected, see Fig. 1 a. A call is obtained by sending various combinations of short and long signals, known as code signalling, by means of the magneto generator of the instrument. All the telephone posts connected will then be rung. This method of calling therefore involves great disadvantages for those telephoning.

To remedy this defect to some extent it is possible to arrange the giving of signals in two groups, *viz:* in addition to ringing between the branches to have ringing between the branches and earth, see Fig. 1 b. The calling devices of certain of the telephone posts are then with this arrangement connected into the one and others into the other calling group. The disadvantage of instruments not concerned being disturbed when calling remains.

By the insertion of what are called selective delayed action relays at a few of the more important telephone posts it is possible to obtain selective ringing of those posts.

If it is required only to arrange selective call for one of the telephone posts the call method shown in Fig. 1 c may be used. The special telephone post is called by momentary shortcircuiting with simultaneous earthing of the line branches. The other telephone posts connected in the circuit are called in the usual way by magneto call with code signalling.

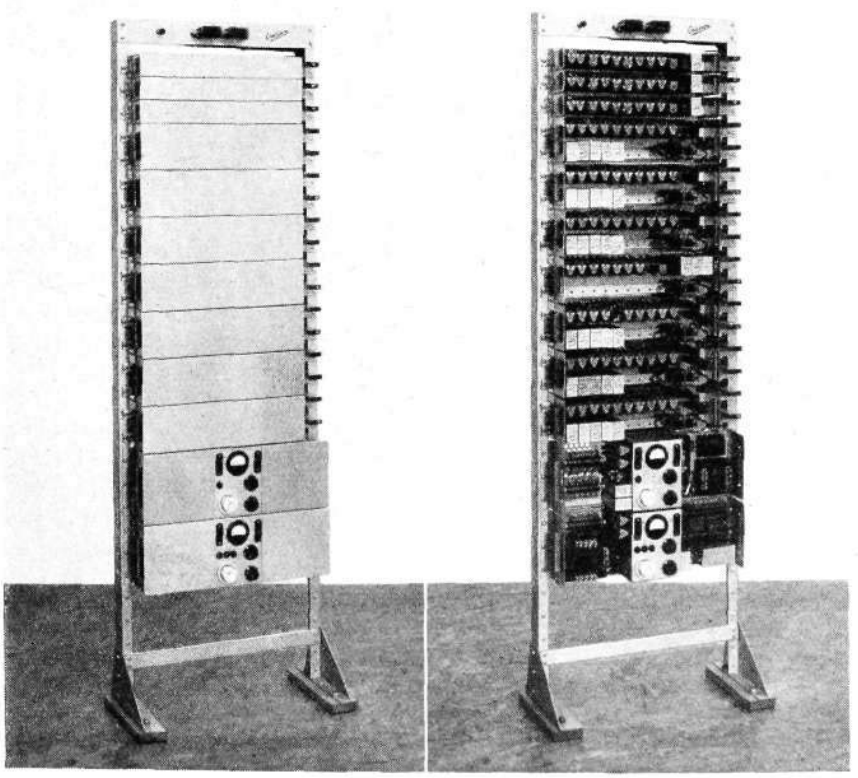
As a result of the disadvantages associated with magneto systems with code signalling, the State Railways have for many years been equipping the sectional telephone circuits to an ever greater extent with *selective calling systems, i. e.,* telephone systems with selective calling of the telephone posts connected.

The individual call facilities in selector systems are obtained by means of small selectors at each telephone post, which can be remotely controlled by impulses from other posts, so that on call only the signal device of the required telephone post comes into operation. In the LM Ericsson system the operating device consists of an ordinary dial, while in the Western Electric system it is done by special keys, rotated a half turn when calling, whereupon impulses are transmitted and the key is restored by spring action.

The selective calling system mostly employed in recent times on the State Railways has been *the LM Ericsson system with D.C. impulsing and with decentralised selection.* Fig. 2 a shows in diagram the impulse circuit in this system. In each way-station the selector magnet *S* and the dial *D* are connected in parallel and in addition each is coupled in series with its rectifier *Re 1*. These rectifiers are coupled in such a manner in relation to the line branches that opposite blocking direction in the two bridges is obtained. The rectifier in series with the selector magnet blocks current in the direction of the normal line tension. When hook contact *K* is made on call a circuit through the instrument is closed and the relay *R1* in the central relay equipment is energised. The relay *R1* closes current to the relay *R2*, which transmits an impulse in opposite direction of current on the line. This impulse actuates all selector magnets connected to the circuit. At the same time the relay *R3* is connected in, and this breaks relays *R1* and *R2* while itself held over the circuit loop. The relay *R3* only falls when the loop is broken by the dial contact. The process is then repeated.

Fig. 2 b shows the principle of a selective calling telephone plant on the system described above. The central equipment consists of a line equipment *SLUA* and a current supply plant comprising two charging units, *SKH* and *SKI*, for main and impulse tensions, together with batteries. Each way-station comprises a telephone instrument *T*, a selector set *ST* and a dry battery.

The selective calling system is so designed that it allows of the dividing up of a sectional telephone circuit into several sections independent of each other,



X 5944

Fig. 3
Relay rack for the L M Ericsson selective calling system, fitted with line equipment and charging unit
left with, and right without covers

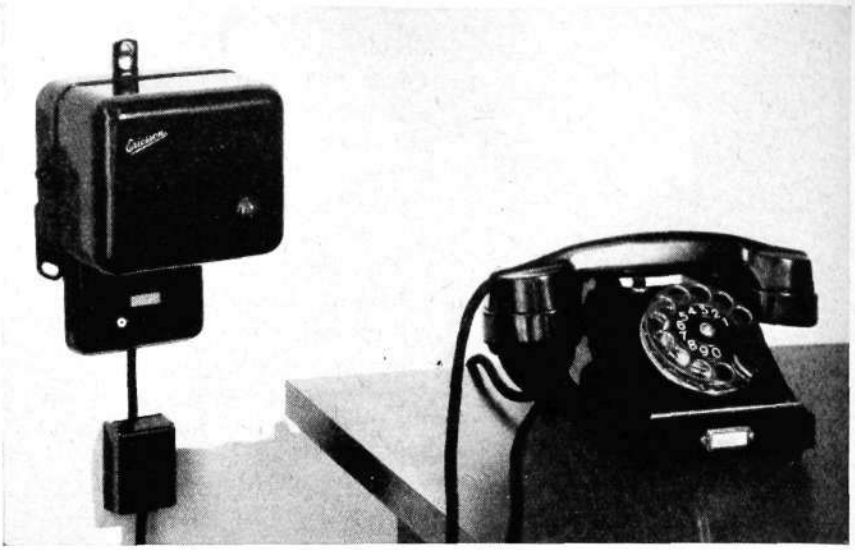


Fig. 4 X 5945
Selector set with telephone instrument for the L M Ericsson selective calling system

between which automatic joint traffic is obtained by means of routing figures, dialled in front of the instrument number. Fig. 2 c shows a selective calling telephone network consisting of several sections.

Fig. 3 shows a relay rack for the LM Ericsson selective calling system fitted with 7 line equipments and two charging units. Fig. 4 gives a telephone equipment for a way-station, consisting of a telephone instrument and selector set.

As it was found that the selective calling system described complied well with the traffic and technical demands that might be imposed on a modern selective calling system, namely, *that* the calls both in the section itself and those adjoining could be made automatically, *that* for making calls standard dials could be employed and *that* automatic joint traffic with automatic exchanges at the stations is possible, the committee proposed that it should be adopted gradually for all sectional communications on the State Railways, with the exception of train dispatching telephones, where for certain reasons magneto call should be retained.

Employment of Sectional Telephone Communications

The sectional telephone communications of the State Railways are at present divided generally into several telephone circuits independent of each other. *Each* circuit is intended for certain telephone purposes or sometimes for certain telephone posts. The most important of these circuits are designated train reporting telephone, permanent way telephone, power telephone, train dispatching telephone and section telephone. In addition there are special telephone circuits arranged on many sections of line. Along the more important sections of line there may be up to 10 sectional telephone circuits, each one intended for a separate purpose.

As for telephoning on sectional telephone circuits direct establishment of the connections is mainly applied (i. e. no recording of calls can be made), it must be obvious to any telephone technician that such distribution of the circuits must involve poor utilisation of the circuits and consequently poor accessibility for those telephoning despite the multitude of circuits. To remedy this the aim should instead be to assemble as many circuits as possible in common bunches with similar circuits.

The committee therefore devoted considerable study to devising such technical measures for the arrangement of the sectional telephone circuits that the number of different kinds of circuits along the track sections might be the smallest possible. The ideal would naturally have been to ensure that a *single bunch*

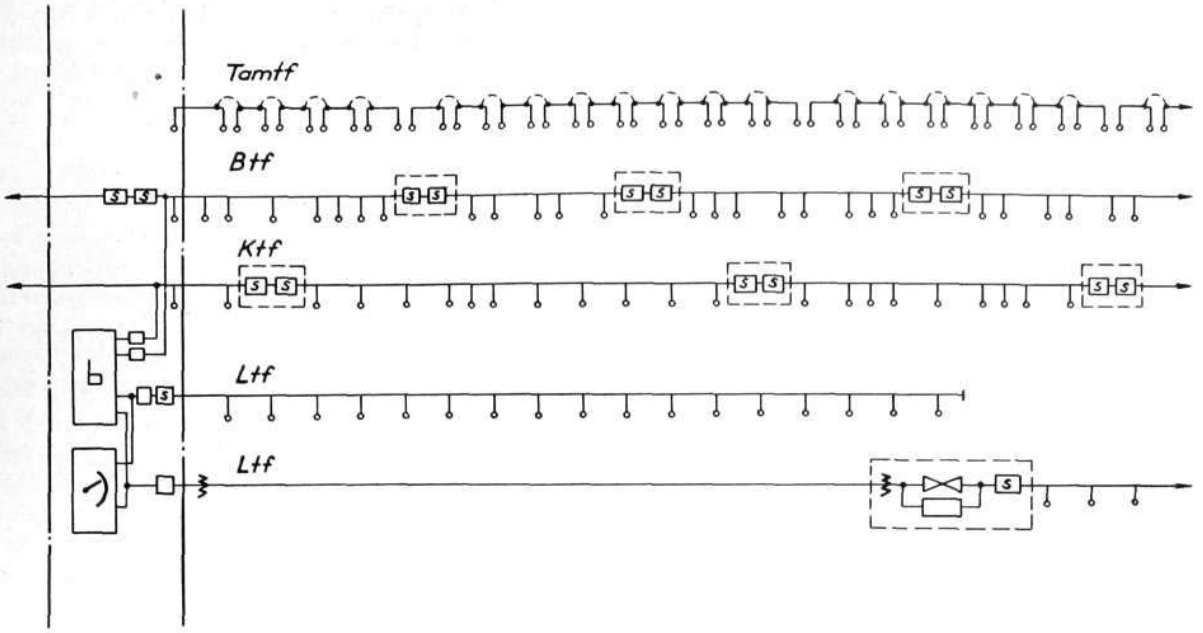


Fig. 5 X 7311
Principle of building up train reporting circuits, Tamtf, permanent way telephone circuits, Btf, power line telephone circuits, Ktf, and line telephone circuits, Ltf, according to the proposals of the committee
S selective calling line equipment

of similar circuits could be arranged. The committee soon found however, that many reasons associated with railway technical practice were against this. After considerable experiment and consideration the committee found it advisable to recommend that henceforth there should not normally be more than four different kinds of telephone circuits along the track sections, *viz:*
train reporting telephone circuits
permanent way telephone circuits
power telephone circuits
line telephone circuits.

Fig. 5 shows these circuits in principle.

The train reporting telephone which, according to the committee's proposals, should be arranged as a separate circuit on all track sections having heavy and medium-heavy traffic, has the object of preventing more than one train being on the same main line track and train reporting section. In order to have a large number of simultaneous call facilities, and also from the standpoint of safety, the train reporting circuit should be sectionised at every station. A call is made by means of magneto generator. As the circuit is sectionised at each station only *one* bell will be actuated on call. Consequently the disadvantages of the magneto system are avoided. The committee has therefore recommended the retention of the present telephone system. When a station is to be left unattended the telephone circuit is to be connected through to an adjoining station, as is indicated on the diagram.

The main purpose of the *permant way telephone* is to carry communications and enquiries between the stations and the permanent way staff. Telephone posts are therefore connected to the permant way telephone circuit at the stations, permanent way men's huts, watcher's sheds, permanent way inspector's offices etc. As in the case of the train reporting telephone circuits, separate circuits must be arranged for the permanent way telephone as it concerns other and also more numerous telephone posts than other sectional circuits.

According to the committee's proposals, as already stated, selective calling systems with decentralised selection should be used for the permanent way telephone circuits. In this way there is obtained automatic connection both within each section and between the sections by using routing figures to be dialled before the instrument number wanted.

On the permanent way telephone circuits there are despatched regularly from certain stations information to the permanent way staff regarding interruptions



Fig. 6 X 4229

Power telephone circuits planned and equipped with selective calling systems along the electrified sections of railway line

○ power station with line equipment *SLUA*
◦ boundary station with line equipment *SLUB*

in the operation of trains and similar events. This is done by means of *general call*. In the selective calling system recommended, general call is obtained by dialling a certain number. All telephone posts whose selectors are set for that number will then be called simultaneously.

A third sectional telephone circuit that must generally be arranged as a separate circuit is constituted by the telephone for maintenance of electrical distribution, in the following called *power telephone*. This telephone has come into use with electrification of railway lines and is employed principally for telephone calls relating to the electric train operation. The power telephone circuit is also used, however, for calls from the track to the power stations, *i. e.*, the converter or transformer stations for electric power, *e. g.*, when work is proceeding or when trains are stopped out on the line. The power telephone circuit, therefore, has posts connected at 2 to 3 km distance from each other. From these telephone posts the power stations mentioned can be called at present by means of magneto instruments carried by the outside staff. The committee has considered it necessary to retain this simple call facility, even after arrangement of the power line telephone circuit on the selective calling system as proposed. The committee has, therefore, in collaboration with Telefonaktiebolaget LM Ericsson, worked out a method of calling which makes it possible to call from telephone posts to the power station concerned by means of magneto call, even though the circuit is equipped on the selective calling system.

This call facility requires, however, that the sectionising of the power telephone circuit is so arranged that direct circuit connection, *i. e.*, circuit without sectionising, is always available between the telephone posts and the power station concerned. This call requisite and other circumstances mean that the power telephone circuit, as was the case with the train reporting and the permanent way telephone circuits, must be given a different technical construction than other sectional telephone circuits. The power telephone communications must therefore in general be arranged as *separate* circuits. In some isolated instances, however, the circuits for the permanent way telephone and the power telephone can be made to coincide. In such cases, according to the committee's proposals, a common permanent way and power line telephone circuit should be arranged. Fig. 6 shows the State Railways power telephone network, covering all sections of permanent way electrified so far. It thus forms a cohesive selective calling telephone network sectionised at the power stations and the power feed line boundaries. Circuit sections that are adjoining may be connected automatically at each sectionising point by means of open routing figures.

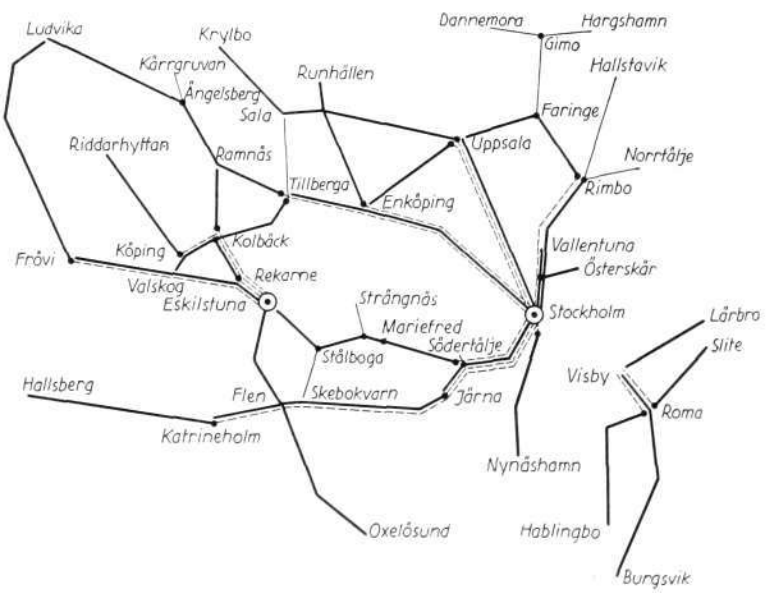


Fig. 7 X 5942

Line telephone circuits planned in district I after taking over by the State of all railway lines

⊙ main centre of traffic section
—— line telephone circuit bunch with instruments on the stretch in question
—— line telephone circuits connected
----- through telephone circuit bunch

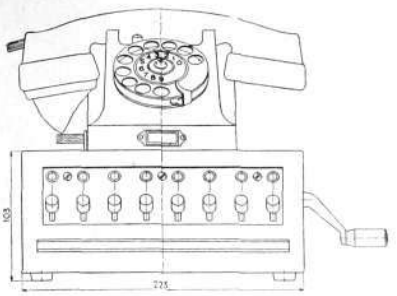


Fig. 8 X 4225
Manual answering and calling device for stations with telephone instrument

In addition to the sectional telephone circuits dealt with for *special* purposes and each consisting of *one* circuit, there are required along all tracks telephone communications mainly intended for calls between the sections officials in the permanent way, machine and traffic departments and the more important service points out on the line. Among these service points may be mentioned goods and passenger stations, locomotive depots, permanent way inspectors' offices, power stations etc. Internal communications between these service points are also carried on these circuits.

As in general *one* circuit is not sufficient for handling all the calls here concerned, the committee has proposed that the circuits for these telephone communications should be arranged as a *bunch of equivalent circuits*. The number of circuits should then be chosen so that a grade of service of at most 5 % during busy hours arises. This arrangement ensures the best possible utilisation of the circuits. Accessibility also will in this way be the best possible with a certain number of circuits. The committee has recommended that the telephone communications obtained in this manner shall be designated *line telephone communications* and be equipped with decentralised selective calling systems.

As the accessibility on the line telephone circuits executed in conformity with the committee proposals will be extremely good, the committee has considered that calls to and from the train dispatchers should be carried on these circuits. The accessibility for all calls in conjunction with train dispatching is estimated to be as a rule better than it is at present. Nevertheless, the committee is aware that on certain stretches already cabled it will — at least for the present — be difficult to allocate for the line telephone bunches the number of circuits corresponding to a grade of service of 5 %. For such cases the committee has made the exception that, if on such stretches separate train dispatching telephone circuits already exist, they should be retained.

As the line telephone circuits are also intended to be coupled up with long distance circuits, the transmission demands on these circuits must be more stringent, than for the sectional telephone circuits described earlier, which would chiefly be carrying short distance calls. The committee has carefully studied these questions and has found that attenuation of the line telephone circuits should not exceed 1.2 neper, representing approximately a 100 km long cable circuit with 1.4 mm conductor area and 160 mH loading. Immediately this value is reached telephone repeaters must be inserted in the circuit. In view of trouble with balancing it is not, however, possible to couple in a repeater in the middle of a selective calling circuit. Instead the circuit must be

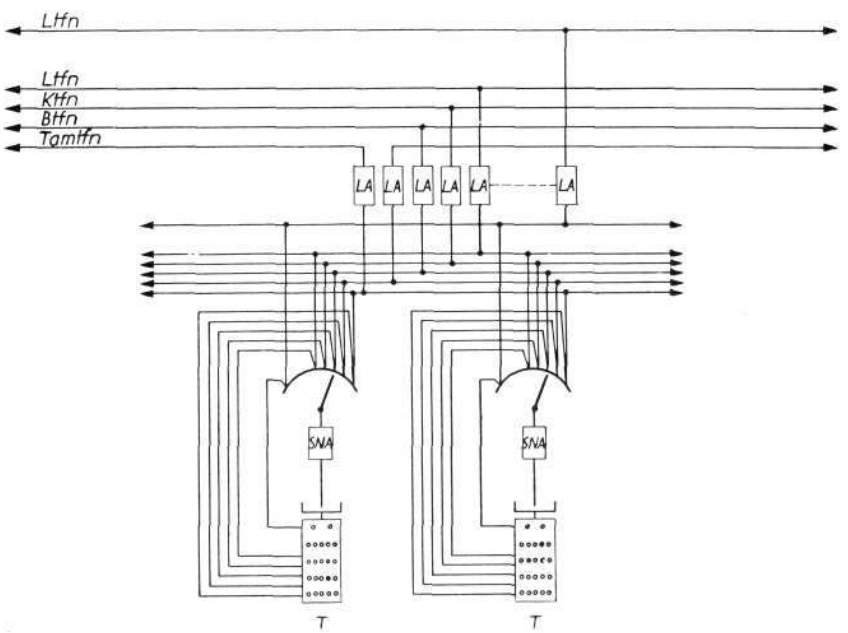


Fig. 9 X 5943
Build up in principle of semi-automatic answering and calling device for stations

LA line equipment
SNA cord circuit equipment
T telephone instrument

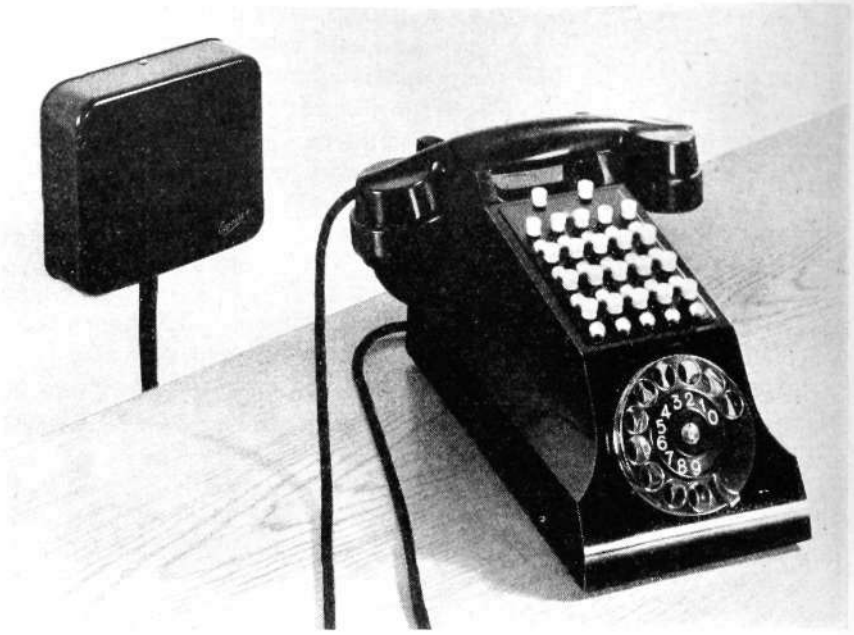


Fig. 10 X 5946
Telephone instrument for semi-automatic answering and calling device for stations

arranged as shown on Fig. 5 at the bottom, where the circuit on one side of the repeater is a through circuit, *i. e.*, without instruments. In this way good balancing of this section is obtained. The *overall* attenuation on the line telephone circuit thus obtained must naturally not exceed 1.2 neper either. From trials made it would appear advisable to distribute the attenuation so that 0.4 neper falls on the through circuit and the repeater and 0.8 neper on the remaining circuit with way stations.

The line telephone circuits, therefore, according to the committee's proposals should be furnished with decentralised selective calling systems arranged as shown on Fig. 5. To obtain the simplest distribution of call numbers, but also on account of the technical difficulties with the present construction of the selective calling system in obtaining answering and clearing signals in connecting over several circuit sections, the committee has proposed that line telephone circuits be always made without sectionising. It should be observed in this connection that the impulse repeater in the line telephone circuit shown at the bottom of Fig. 5 should be so constructed that this circuit from the traffic and technical point of view works as an unsectionised circuit.

Fig. 7 shows the line telephone circuits in district I of the State Railways, account being taken of the extent this district will have when State acquisitions of all railway lines are completed. As only Stockholm and Eskilstuna constitute traffic section main centres in the district the line telephone circuits start out from these places.

Sectional Telephone Circuit Answering and Calling Devices at the Stations

An important question in conjunction with sectional telephone circuits is the execution of the answering and calling devices at the stations. There will of course be at each station a large number of sectional circuits coming in of differing types. The answering and calling devices must therefore be so constructed that one and the same telephone instrument can in simple manner be connected to the desired circuit. A large number of solutions of this problem has been devised in the course of years.

The telephone committee has sought to standardise suitable telephone equipment for this purpose and has worked out proposals for two different answering and calling devices. The one is designed for up to seven circuits and the other for up to 20 circuits. These proposals were later through the State Railways submitted to Telefonaktiebolaget LM Ericsson for further development, with the result that the designs described below were worked out.

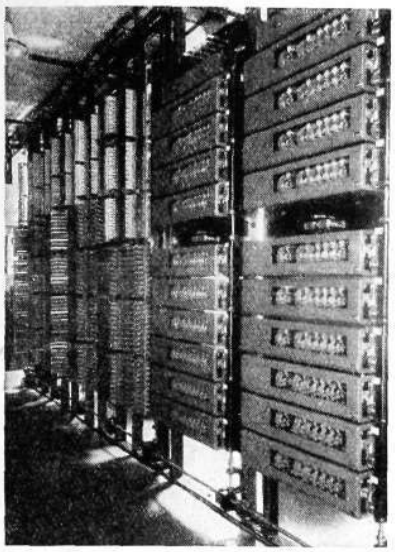


Fig. 11 X 4230
Automatic telephone switchboard on the State Railways

Fig. 8 shows the smaller answering and calling device, designated the *answering and calling device*. As may be seen from the illustration the circuit receiver is made as underpart to a bakelite telephone instrument. The lamps located above the switches constitute call indicators for incoming calls. The circuit receivers are also fitted with creak buzzers, magneto generators, night switch etc.

Fig. 9 shows in principle the build up of the large answering and calling device, designated *semi-automatic answering and calling device*. The figure shows a plant with two simultaneous call facilities. Each circuit included is equipped with a small relay set which receives the call. In addition, for each call facility there is a cord circuit equipment with a 25-line selector. On an incoming call, the lamp belonging to the circuit lights up and a bell rings. The call is answered by lifting the handset. An outgoing call is obtained by lifting the handset and pressing the button for the desired circuit. Even while a call is proceeding, a new call can be answered, the previous call being then placed in a waiting position.

Fig. 10 shows a telephone instrument as used for the plant just described. The two buttons on the top are used for partial disconnection and for visual testing on busy selective calling circuits. The other buttons and the lamps constitute the calling devices of the circuits connected.

Local Telephone Plants and Their Automatisation

Local telephone plants are required in all the administrative main centres and the largest stations. The number of telephone posts connected at the different places varies between 10 or so and almost 900. At the larger places there are already automatic switchboards, while at the smaller ones manual operation is still practised. At present there are in the State Railways telephone network about 30 automatic switchboards. Four of these switchboards, those at Stockholm, Gothenburg, Malmö and Östersund are made as private automatic branch exchanges (P.A.B.X.) with public exchange traffic.

Fig. 11 shows the automatic switchboard at Stockholm which deals with local traffic and the outgoing exchange line traffic. The incoming exchange line traffic, as also all traffic on the railways' long distance and sectional telephone networks, is handled manually on a six-position operating desk.

The committee has found that, with automatic switching of *local traffic*, expenses are normally lower and telephone service better than when manual switching is employed. Another advantage with automatic switchboards is that joint traffic with sectional circuits can be arranged automatically, the expense of manual operation being saved for this traffic also. The comittee has therefore considered that the introduction of automatic switching for the local traffic and for joint traffic with sectional circuits is well justified and has proposed that such switching should be progressively introduced at all main centres and the larger junction stations.

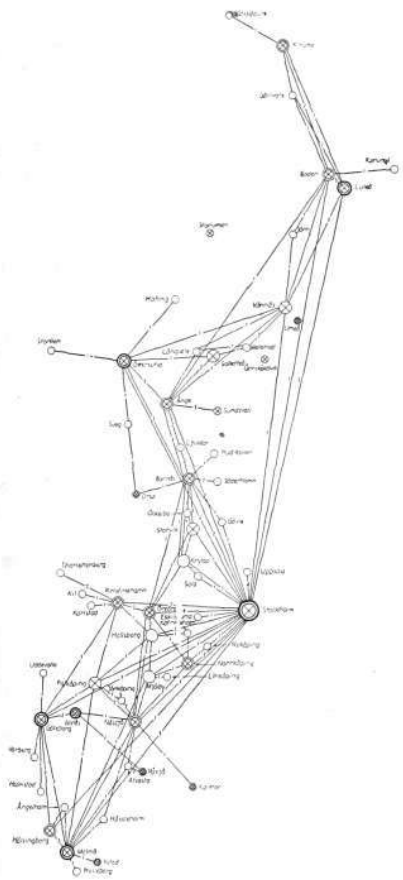


Fig. 12 X 4226
Plan of the State Railways long *distance telephone circuits as on* 1st January 1942

- ○ district main centre
- ◎ district and traffic section main centre
- ◎ traffic section main centre
- × permanent way or machine section main centre
- o other stations

Long Distance Telephone Plants for Manual Handling of Traffic

The main purpose of the long distance telephone plants is to provide telephone communications between the main administrative centres of the railway and between these and certain of the larger stations.

A very widespread telephone network has been built up on the State Railways for this purpose. As may be seen from Fig. 12 the network in general is so built up that Stockholm has direct communication with practically all the other large centres, while other district main centres have direct communications to their subordinate section main centres and larger junction stations and to other neigbouring district main centres. In addition there are direct communications between certain neighbouring places which have heavy tele-

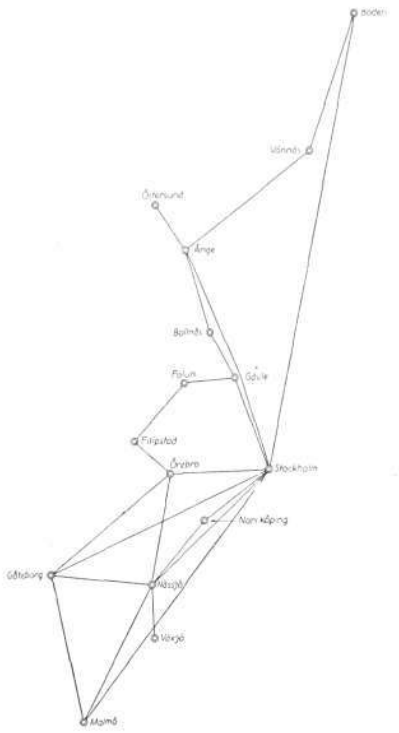


Fig. 13 X 4228
Plan of the State Railways junction exchange network after automatisation

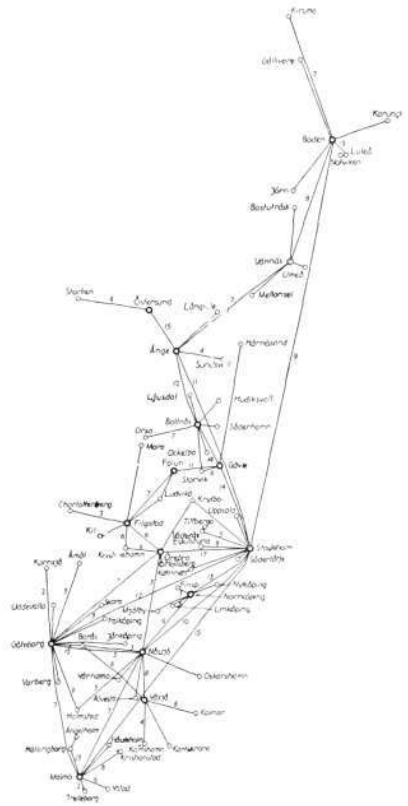


Fig. 14 X 4227
Plan of the State Railways long distance telephone network after automatisation

o junction station
○ terminal station

phone traffic together. In building up this telephone network therefore the usual practice in planning manual telephone networks has been followed and the aim has been to arrange direct communications in all those cases where the magnitude of the telephone traffic has justified the arranging of at least *one* circuit. In this way the State Railways long distance telephone network has obtained the mesh-like structure characteristic of manual networks with a large number of circuit routes and a small number of transit exchanges.

The establishment of long distance calls, with the exception of some places within district IV, is done manually at present by recording the *destination place* at the departing exchange and therefore *not the destination instrument* as when recording trunk calls on the public telephone network. The call is routed on immediately if there is a free circuit to the place concerned, or recorded if all circuits to the place of destination are busy. When this occurs the ordering instrument is rung again immediately the connection can be made. The method of operation may thus constitute a combination of direct operation and recording operation with waiting time.

The committee has studied the advantages and disadvantages of this method of operation with destination *place* recording and a method of operation with destination *instrument* recording and has found that the latter method of operation would be the most advantageous, both for those telephoning and in consideration of the best utilisation of the expensive long distance circuits. The committee has therefore proposed a change over to the method of operation with destination *instrument* recording. This stipulation naturally does not prevent calls in future being established by direct operation with the calling person waiting at the instrument in case free circuit to the place desired is to be had.

Long Distance Telephone Plants for Automatic Operation of Traffic

The committee has also gone closely into the question of automatisation of the long distance telephone traffic and studied what advantages and disadvantages this might involve for the State Railways. Perhaps the most important factor to be considered in this connection is that, while with manual operation recording with waiting time can be applied, direct operation must be applied with automatic operation. This carries with it appreciably improved accessibility for those telephoning but at the same time requires more circuits, for as is well known the circuit utilisation with small amounts of traffic and reasonable grade of service is lower with direct operation than with recording operation.

In this connection it should be observed that with automatic telephone networks it is possible by different lay-out than with manual traffic to bring together the traffic from a number of exchanges on common routes. In this way there are obtained larger amounts of traffic and fewer traffic routes, so that the additional requirement of circuits with automatic switching is in reality not so outstanding.

The committee has found on the basis of traffic measurements that the amount of traffic on the State Railways long distance traffic routes does not in general reach such magnitude that the introduction of automatic long distance traffic could take place *without* increase of circuits. Nevertheless the telephone traffic is rapidly growing and the committee has therefore considered that an automatisation of, for instance, the greatest traffic routes, such as Stockholm—Gothenburg, Stockholm—Malmö, Stockholm—Örebro and others, may be financially justified in the not too distant future. The committee has therefore recommended that automatic switching on these routes should be the final aim.

For a number of other traffic routes also the introduction of automatic switching should under certain conditions be justified financially, according to investigations made by the committee. For this reason and seeing that the quality of the telephone service, thanks to immediate accessibility and rapid clearing, will be considerably higher with automatic than with manual switching, the committee has proposed that all *new* automatic switchboards and cables shall from the start be so made that a future introduction of automatic long distance traffic is made possible. *When* the automatic long distance traffic is to be introduced should however be a matter for decision in each individual case.

The committee has also drawn up the broad lines for such automatisation and drafted a proposal for modified and supplemented network lay out, taking into account the demands of automatisation. Fig. 13 shows the junction exchange network after final automatisation. The number of junction exchanges amounts to 15. A number of terminal exchanges is connected to each junction exchange. To avoid long detours for certain important communications and to ensure alternative routes between the largest main centres, the network has been given the mesh form shown. As the automatic system is intended to be worked with registers the shape of the network involves no difficulties. Fig. 14 shows the complete long distance telephone network after completion of automatisation. The total number of stations which according to the committee's estimate would come into question for automatisation would be about 65 to begin with. As may be seen from the figure, some terminal exchanges are connected to two or three junction exchanges, as Borås, Krylbo and others. But in such cases the switchboards are only intended for traffic to and from their own local extensions and not for transit traffic.

As a clear *numbering system* logically built up is of the greatest importance to ensure good operating results on automatisation, the committee has worked out a proposal for unified numbering system covering the whole country. For a railway telephone network where the switchboards are generally located far apart and the number of internal calls is usually great in relation to long distance calls, there is no doubt that a numbering system with what are known as *open* routing numbers for traffic between the switchboards is the most convenient. The committee has also proposed this numbering system for the State Railways long distance traffic.

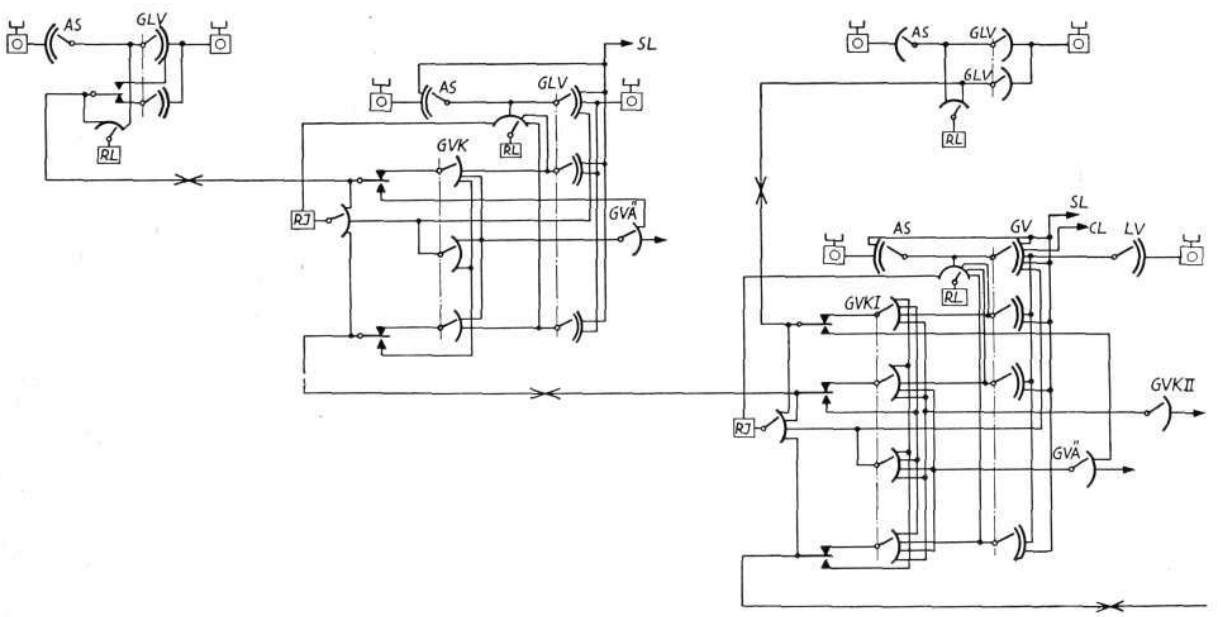
As the number of automatic switchboards in the network is not expected to exceed 100, the routing numbers will be three-figure. The first figure has of course only the object of determining that the switching refers to a long

Fig, 15 X 7312

Distribution diagram of the automatic traffic routes in the telephone system planned for the State Railways long distance telephone traffic

Selector symbols with double sectors designate 500-selectors and those with single sector show crossbar switches

AS	line finder
CL	exchange line
GLV	combined group and final selector
GV	group selector
GVK	junction exchange group selector
GVK I	junction exchange group selector
GVK II	junction exchange group selector
GVÄ	terminal exchange group selector
LV	final selector
RI	trunk register
RL	local register
SL	selective calling line



distance communication and not a local one, while the remaining two indicate the exchange. For first figure in the routing number the committee has selected »9». The figure »0» should continue to be reserved for calls to the public telephone network. The routing numbers for long distance traffic will then lie in the number series *900—999*, thus Stockholm *910*, Gothenburg *920* etc.

For telephoning between two places with automatic long distance traffic arranged in conformity with the committee's proposals, first the routing number for the place is dialled and then the subscriber number of the telephone post required. As the numbering is *uniform* for the whole country, an instrument is always called in long distance traffic with the same number, no matter what switchboard within the State Railways telephone network the call comes from or the number switching stages through which it has to pass.

As regards the design of the automatic switchboards, the committee has considered it of the greatest importance that the number of switchboard types in the State Railways should be as small as possible, even as regards the future. With this condition fulfilled it will be most simple to arrange joint traffic between the different switchboards. At the same time the planning, designing and maintaining of the plants will be facilitated. In the present international situation the Committee has not thought it advisable to consider the introduction of foreign switchboards in the State Railways telephone network and has therefore found it necessary to deal only with switchboards made in Sweden.

After careful consideration the committee decided it should propose that automatic switchboards of over 100 number capacity should be made with 500-line selectors, while smaller switchboards should be made with crossbar selectors.

As regards the principle of construction for the automatic switchboards the committee has only wished to prescribe some fundamental conditions, otherwise leaving the designers free to adopt such solutions as may prove most favourable in view of developments. These fundamental conditions have been that registers should be used in building up long distance communications and that the system shall be so designed that an intermediate tone between routing number and subscriber need not be awaited. Moreover the registers shall allow of three alternative routes for the more important traffic routes.

As soon as the committee, about six months ago, decided in regard to the above questions the principles for the building up of the long distance telephone system, particulars were supplied by the State Railways to Telefonaktiebolaget L M Ericsson who shortly afterwards set to work with the development of this system.

Fig. 15 shows a preliminary distribution diagram for the automatic traffic routes in the system planned. Two junction exchanges and two terminal exchanges are drawn in on the figure. For the establishment of local communications both at junction exchanges and at the larger terminal exchanges with over 100 number capacity there are used 500-line selectors, while the same communications at the smaller terminal exchanges are built up with crossbar selectors. For through traffic at the junction exchanges 8-pole crossbar selectors *GVK* and *GVÄ* only are used. Registers built up with crossbar selectors are to be found at every exchange. For reasons of design and economy the registers at the junction exchanges have been divided into two kinds, *viz:* local register *RL* and trunk register *RI*. At the terminal exchanges there are only local registers. The main purpose of the trunk registers is to route the connection forward to the desired station and to couple in alternative circuits, when the ordinary circuit route to the desired exchange is inaccessible for one reason or another.

Telephone Plant on Curaçao

C BERGLUND, TELEFONAKTIEBOLAGET LM ERICSSON, STOCKHOLM

U.D.C. 621.395.343(729.88)

A new telephone exchange on the L M Ericsson machine-driven system with 500 line selectors has been opened at Willemstad, the capital of Curaçao. At the same time new up-to-date telephone instruments and P. A. B. X. of L M Ericsson manufacture have been connected in the network. The material supplied was largely manufactured in the Netherlands by Ericsson Telefoon-Maatschappij, Rijen. The telephone exchange is the first large public telephone exchange on an automatic system in the Dutch colonies.

The island of Curaçao, Fig. 1, which belongs to the Dutch West Indies, is situated off the coast of Venezuela. Because of its position in proximity to large oilfields the capital of the island, Willemstad, with about 50000 inhabitants, has become the largest oil exporting port of the world. The maritime traffic is so lively that the harbour as regards amount of traffic may be said to be fourth in order in the world. It is obvious that first-class telephone facilities are particularly important in such a city. The telephone administration decided therefore to have the telephone plant in the city modernised. Tenders for the necessary material were submitted through the Netherlands Ministry of Colonies from a number of firms. After both the Telephone Administration at Curaçao and the Colonial Ministry had thoroughly examined the tenders received, the Dutch company Ericsson Telefoon-Maatschappij was commissioned to execute the deliveries in conjunction with Telefonaktiebolaget LM Ericsson. The contract comprised an automatic telephone exchange for 1500 subscribers, 1250 ordinary telephone instruments, 150 intermediate and extension instruments, a number of coin-box instruments, taxicab rank instruments etc. In addition 29 P.A.B.X. were ordered.

A large part of the deliveries consist of Dutch manufacture, this having been a desire expressed when ordering. Thus the telephone instruments, the woodwork, a large portion of the racks and the cabling work for them have been made at Ericsson Telefoon-Maatschappij's factory at Rijen. All necessary cable, the power plant machinery and instrument board have been made by other Dutch makers. The automatic switches and a quantity of other material were supplied by LM Ericsson's Swedish factory.

Telephone Exchange

The automatic telephone exchange, which replaces the manual telephone plant previously installed by LM Ericsson, is on LM Ericsson's OS system with 500-line selectors and built for 1500 subscribers. As, however, the number of sub-

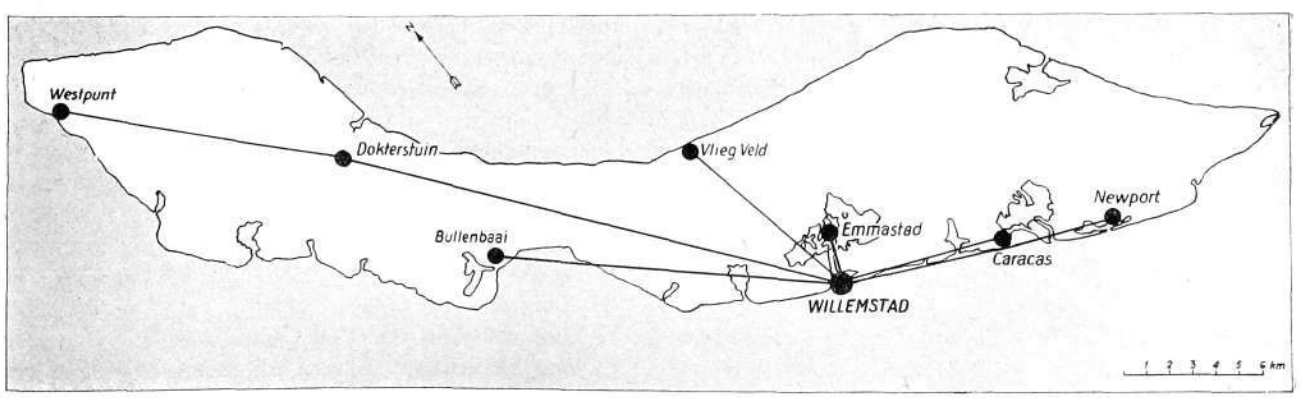


Fig. 1 — Map of the automatic telephone network on Curaçao

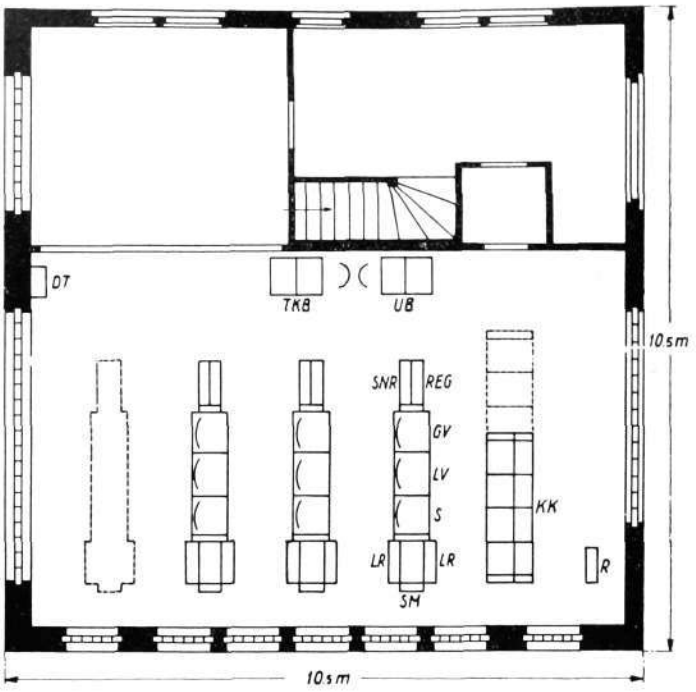


Fig. 2
Lay-out of apparatus room

DT distribution board
GV group selectors
KK main distribution frame
LR line relays
LV final selectors
R relays
REG register
S line selectors
SM call meter
SNR connecting circuit relays
TKB traffic supervision position
UB test position

scribers at present is considerably lower, the exchange is only equipped with the number of switches calculated to deal with traffic for 1200 subscribers. In this way a saving in cost has been achieved and as the switches are connected in with plugs and jacks it will be extremely simple to extend the exchange, merely by putting in more switches as traffic increases.

In Emmastad, situated close to Willemstad, a large community has grown up around the giant oil undertaking Curaçaosche Petroleum Industrie Maatschappij. This undertaking already had, previous to the automatisation of Willemstad telephone exchange, a telephone plant of its own consisting of a P.A.B.X. on the Strowger system. This plant is so large that almost as many extensions are connected to it as to the main exchange at Willemstad. Though it is usually desirable that the incoming traffic to a P.A.B.X. should be received and dealt with by an operator, it was considered advisable for the special conditions prevailing on Curaçao that automatic traffic should be arranged in both directions between the telephone plants. For such connections the subscriber dials a figure before the subscriber's number. For a call from Emmastad to Willemstad there is dialled therefore the figure *0* and in the reverse direction the figure *8*. Nevertheless, it is also possible to have calls to the oil company dealt with by the company's operator. In such case the subscriber dials the figure *9*, whereupon the call is connected to the operator who may then pass it on to the extension desired.

As the automatic system in the Emmastad plant is made in such a way that the connection is released whether the calling or the called subscriber replaces his handset, the automatic system for Willemstad has been made in this way for the sake of uniformity. Otherwise the exchange is made in accordance with LM Ericsson's modern normal practice with such changes as are necessary for an exchange working in a tropical climate.

The system is made for four-digit subscriber numbers from *1000* to *7999*. As stated Emmastad is called by the numbers *8* and *9*, and the numbers *00*, *01*—*05* are reserved for calls to special services; at present the exchange is fitted for traffic to three such services. P.B.X.-lines may be connected to one of the 500-line groups installed.

A number of very long lines to various places on Curaçao, see Fig. 1, are connected direct to the automatic exchange. Lines with resistances below 1500

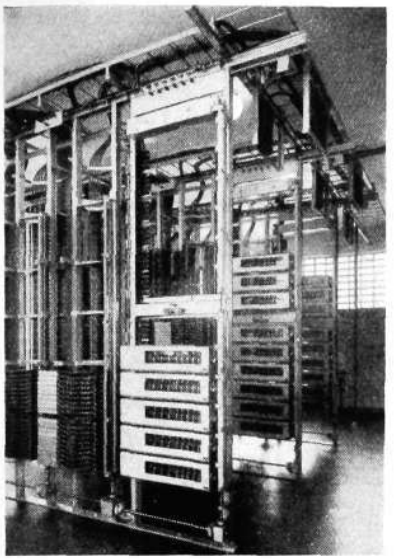


Fig. 3
Interior of apparatus room

ohms are connected in exactly the same way as ordinary subscriber lines, but lines with higher resistance are connected over repeaters of the kind described in Ericsson Review No 4, 1935.

The exchange is housed in a newly erected two-storey building. On the ground floor are the cable intakes and the power plant which consists of two lead batteries for 432 Ah, two charging machines and an instrument board. The cables are led through the floor to the upper storey, Fig. 2, to the main distribution frame which contains the line fuses and test jacks for testing the lines. The automatic system switching equipment is mounted in three unit racks each for 500 subscribers. The exchange is not supplied with call meters for all subscribers but the cabling is executed in such a way that plates with 50 call meters for call count check may be connected over plugs and jacks to any group of 50 subscribers. There is also a rack with relay sets for joint traffic with Emmastad and certain other P.A.B.X., and also repeaters. For line testing there is a test position and for supervision of traffic a traffic supervision position. Extension by 500 subscribers may be made by putting up a further unit rack alongside the others. If still further extension becomes necessary the wall to the room next to the apparatus rooms may be taken out and two unit racks installed in that space.

Telephone Instruments

The ordinary instruments are LM Ericsson's normal table instruments of bakelite with plug and jack for connection. For the Governor-General there has been supplied a white instrument of de luxe pattern, the dial being gilded and having enamel inlay. There were also supplied with the plant 75 intermediate instruments with necessary extension instruments of the type described in Ericsson Review No 2, 1938. In addition there is a number of coin-box instruments (see Ericsson Review No 2, 1937), which along with ordinary wall instruments of bakelite are mounted in cabinets and used for public call boxes. Finally some watertight instruments for outdoor mounting have been delivered.

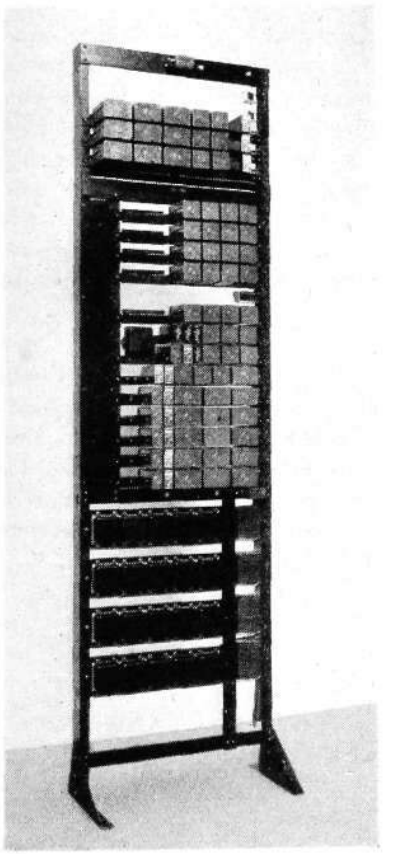


Fig. 4
P.A.B.X., OL 45
for 37 extensions and 3 exchange lines

P. A. B. X.

In order to be able to provide public offices and large undertakings with modern telephone plants for internal and external traffic, when the capital's public telephone system was converted to automatic working, a number of P.A.B.X. were ordered. The orders executed to date comprise 29 P.A.B.X. Ten of these, Fig. 4, are of type OL 45, in sizes varying between 30 and 40 extensions and 2 and 7 exchange lines. Nineteen switchboards are of type OL 35 for wall mounting, Fig. 5, for 10 and 20 extensions and 2 exchange lines.

All the P.A.B.X. have automatic outgoing traffic to the Willemstad exchange and connection is obtained when the figure 0 is dialled. For special reasons three of the larger switchboards have also been made for automatic traffic in the direction from Willemstad exchange. If a subscriber connected to the main exchange wishes to obtain connection with an instrument connected to one of these P.A.B.X. he takes an ordinary subscriber number and then, when fresh dialling tone is received, the number of the instrument. Two of these switchboards have also direct junction lines to the P.A.B.X. in Emmastad, likewise with automatic traffic in both directions. These junction lines are reached for outgoing traffic by the figure 9.

Other switchboards are made for manual handling of the incoming traffic. One of the larger P.A.B.X. has for this purpose a manual wall swichboard but the others are supplied with operator's instruments, set up at the place of the telephone operator. In the ten smallest P.A.B.X. with only 10 extensions

and 2 exchange lines each exchange line comes in to its own telephone instrument which is provided with devices enabling the call if required to be transferred to another extension.

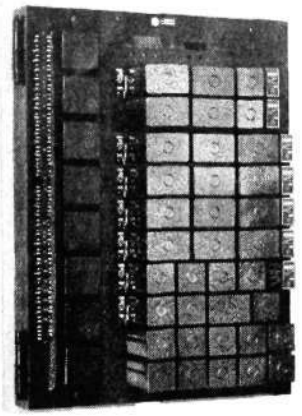


Fig. 5
P.A.B.X., OL 35
for 20 extensions and 2 exchange lines

Each P.A.B.X. has a power plant consisting of a 24 V storage battery with device for automatic charging from the lighting mains. The switchboards with power plant are mounted in specially constructed wooden cabinets made to withstand the effects of the tropical climate.

Installation

The putting up and mounting of the material supplied was carried out by the Adminstration itself with an expert from LM Ericsson as adviser. The work was executed in exceedingly short time. In November 1938 LM Ericsson's expert arrived at Curaçao and the preparations for the assembly of the main exchange could commence. As the exchange was to be assembled in a newly erected building, it was necessary among other things to tap the street cable and lead it in to the new exchange and to lay a new cable between the old and the new exchange to facilitate the change over. The erection was carried out after that with great rapidity and by the following June the work had proceeded so far that the exchange was completed and the necessary telephone instruments and P.A.B.X. in the town had been fitted. The whole plant was then brought into use and, after its operation had been observed for some time, the LM Ericsson expert was able to leave Curaçao in August 1939.

In view of the fact that the plant at Willemstad is the first public telephone exchange on the automatic system in Dutch colonies in the tropics, experience obtained with this plant should be followed with great interest.

It was ascertained during visits by LM Ericsson's engineers to Curaçao towards the close of 1944 that the material, despite the exeptionally unfavourable climate, was in excellent condition thanks to the exemplary maintenance by the Dutch authorities and to the good quality of the equipment itself. Traffic in Willemstad has, however, grown considerably during the war. As Curaçao was for a long period cut off from the Motherland and from Sweden, it has not been possible to undertake any extension of the telephone exchange. The exchange has, therefore, been overloaded for a long time, which has certainly been a great detriment to business life. However, it was found possible about the beginning of 1945 to send from Sweden by air some new connecting devices which should contribute to some diminution of the troubles due to overload.

The intense development of Willemstad during the war is clearly evident from the fact that, in addition to the increase of the present exchange's traffic capacity to provide for 1500 numbers in place of 1200, two new exchanges in other parts of the town, one in Otrabanda for 1000 numbers and one in Mahasi for 500 numbers, have been ordered and are in process of manufacture at L M Ericsson's factories in Sweden. The new extensions represent therefore a doubling of the total exchange capacity at Willemstad.

New Domestic Telephones

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U.D.C. 621.395.721:621.395.2

During the years that L M Ericsson's domestic telephones have been on the market the original lively demand has unceasingly grown, evidence of the public's appreciation of L M Ericsson's efforts to produce an up-to-date, cheap and serviceable domestic telephone. There have recently been put on the market some new types of instruments, the domestic telephones with signal buttons, which further supplement the already abundant series of domestic telephones and considerably extend the spheres of usefulness for these instruments.

The domestic telephone has hitherto been employed mainly for the smallest of local telephone plants, comprising only 2 or 3 instruments, a limitation chiefly due to the lack of suitable calling devices for individual call of a larger number of instruments. To get over this lack it has up to now been a question of placing a loose keyset beside the instrument or fitting extra signal buttons on the instrument case. A more serviceable procedure has now been arrived at by an accessory on the instrument, which while retaining simple call facilities allows of individual call of up to 8 instruments.

In the very small telephone plants with only 2 to 3 instruments the need for table instruments is, contrary to conditions in large plants, fairly limited. Analysis of figures for sales of domestic telephones in the past five years shows that on the average only 20 % of all instruments installed are of table type. With increased number of instruments in the plant, however, the average demand for table instruments rises rapidly. Thus for automatic local switchboards of OL 12 type, with 10 lines maximum capacity, the demand for table and wall types is equally distributed, according to sales statistics. As capacity becomes greater the tendency in favour of table instruments grows more marked.

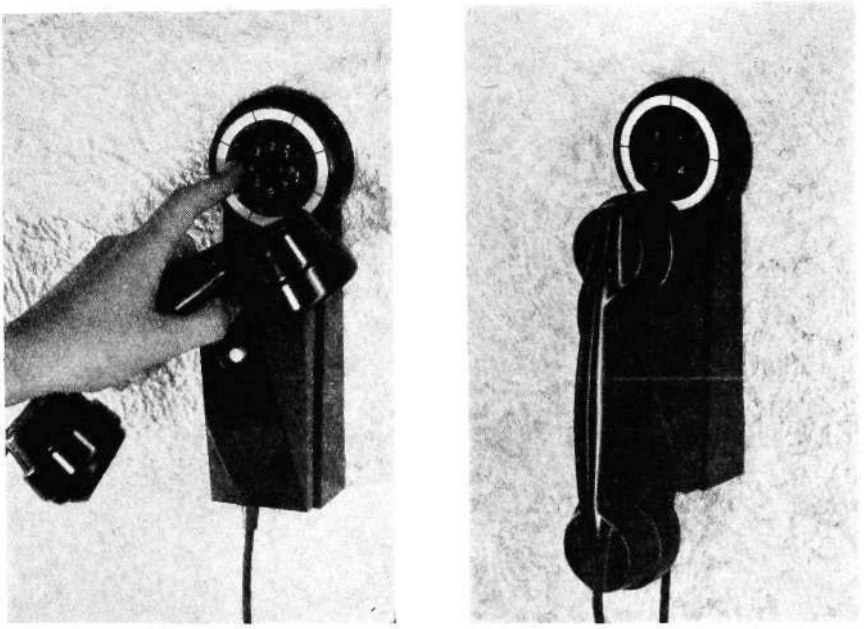


Fig. 1 X 4035 X 4036
Wall telephones with push button sets
left, DEP 3002 with eight signal buttons
right, DEP 3001 with four signal buttons



Fig. 2
Table instruments
left, DEK 9001 with four signal buttons; right, DEK 9002 with eight signal buttons

One of the reasons for this tendency may lie in the fact that the larger domestic telephone plants are as a rule installed in office and similar premises, where it is most convenient to have the telephone on the desk. Another reason may be that increased capacity is generally followed by greater utilisation of the instrument, so that a more convenient placing is also required in other cases as well, especially if the instrument has some selective calling device (dial, signal button etc.) to be manipulated when calling. In making the wall instrument design of the new domestic telephone with signal buttons this demand is taken into account and the keyset is made to suit both types of instrument.

The new wall and table instruments are shown in Fig. 1 and 2. By means of these new instruments the sphere of employment for domestic telephones has been considerably extended. Domestic telephone plants between bedroom and kitchen can now easily be extended also to the study and the garage. In a business the intercom telephone between the shop and the stockroom can easily be taken to the accountants and the office and further instruments can be connected at any time if need should arise. The new domestic telephones should moreover find extensive use in offices, cinemas, hospitals, laboratories, archives and libraries, in department stores, workshops, warehouses and showrooms, briefly everywhere that rapid internal communication can facilitate and rationalise the work. The particularly favourable price, made possible by rational mass production, should moreover permit of the introduction of these instruments in domains where the domestic telephone has previously not been regarded as an indispensable accessory as regards shortening distances , e. g. on farms and in boarding houses, where the distances often are quite considerable between the buildings and places of work and at present involve very much unnecessary running about and wasted time of labour.

In order to adapt the instruments in the best way to actual needs, they are delivered in two different constructions, with 4 and with 8 buttons. The difference, however, applies only to the outer appearance, so that it is a simple matter to supplement the smaller keyset when required. The keysets are also supplied as loose accessories, with 4 or 8 buttons, for completing domestic telephones already installed.



Fig. 3
Push button set RMP 1012
with domestic telephone connected

Wall Instrument

The wall instrument is designed in plastics and made up of three main parts, Fig. 3: *handset*, of LM Ericsson's standard construction with exchangeable receiver and transmitter inset, *instrument case* with inset which, except for some minor alterations in detail, is the same as that used in LM Ericsson's earlier domestic telephones, and *the push button set*.

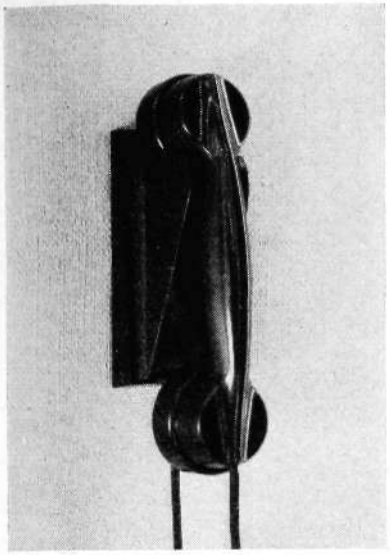


Fig. 4 X 4038
Domestic telephone DEP 1003
with base plate for wall mounting

The push button set, Fig. 3, consists of a baseplate with terminal block and a set of buttons. This last is also made of plastics and has 4 or 8 buttons which act on the contact springs arranged star-shaped below. The label cap on the front with cellon cover has, in addition to the numbering of the buttons, space for the names of the various instrument locations. The design of the keyset is the same for 4 and 8 buttons, the only difference being that for the smaller number every other hole is covered over by the label cap. Nevertheless connection between the keyset and the terminal block is made also in this case for the full number of extensions, so that alteration of an instrument later from 4 to 8 buttons is very easy to carry out: the four empty holes are then provided with buttons, the covering sheet and the label cap are exchanged.

The baseplate has two cable leads, one underneath and one in the bottom, the latter intended for lead in from a wall terminal below the instrument for cable drawn under the plaster. The cable leads are closed when the instrument is delivered by capping which can be removed as required when fitting. To improve the pressure of the handset against the switching button on the instrument and thus obtain more reliability in actuating the spring assembly the base plate has been made with sloping front. A similar base plate is now also available for the wall type of the ordinary domestic telephone, Fig. 4. The base plate considerably facilitates the setting up of the instrument, especially in cases when it is to be mounted on an uneven surface.

Table Instrument for Domestic Telephone

The new table instrument, Fig. 2, is made with the small bakelite case for table instruments and, like the wall instrument, has a keyset fitted in the same place as the dial of an automatic instrument. The keyset is made in plastics and of the same design as in the wall instrument previously described. A D.C. bell located inside the instrument, Fig. 5, is used as signal device.

The instrument also comprises a spring assembly actuated by the hook, which connects the instrument for speaking position when the handset is lifted. The signalling position in the wall instrument's switch has, however, no equivalent in this instrument, as signalling is always done by the buttons.

A 14-wire cable connects the instrument with the wall terminal, which has a terminal block of the same construction as that of the wall instrument. The wall terminal has cable lead both on the lower side and in the bottom, the

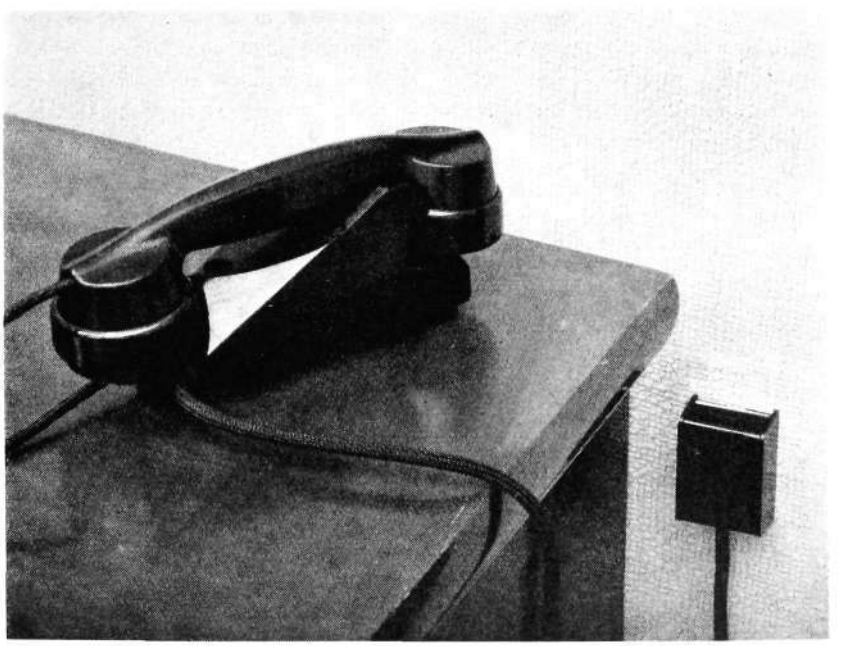


Fig. 5 X 5227
Table telephone DEP 11

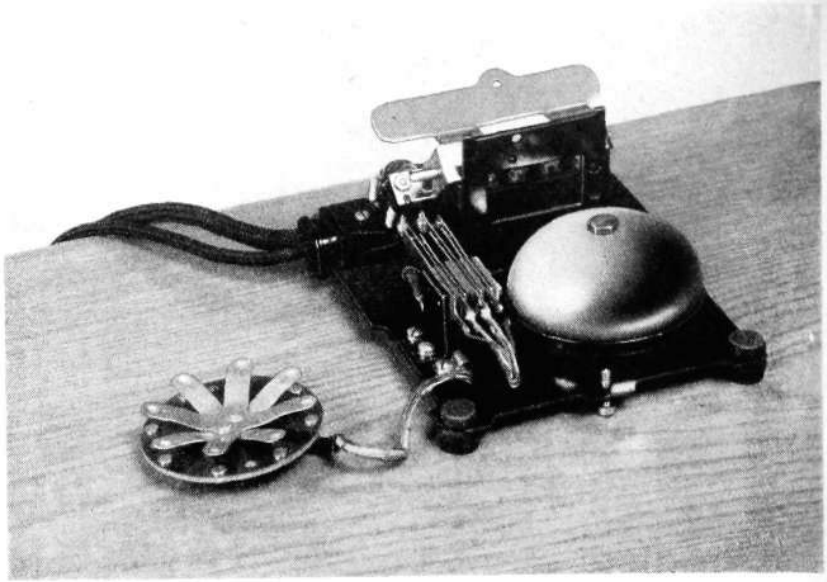


Fig. 6 X 5806
Inset for table instrument
left, button springset, middle, springset and cradle switch, right D.C. bell

latter for leading in the cable from wall connection for cable drawn behind the plaster.

The instrument is supplied in two executions, with 4 and with 8 signal buttons. The instrument with 4 buttons is connected for 8 extensions, so that it can easily be supplemented by a further 4 buttons when enlarging the plant.

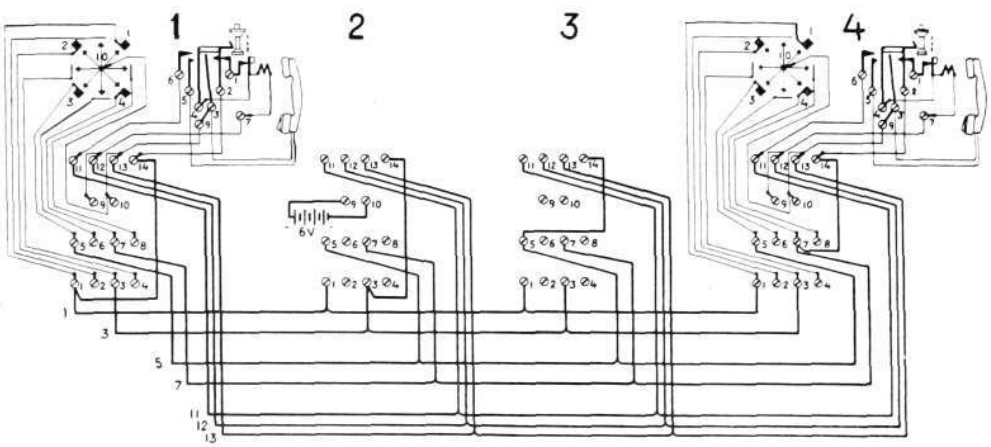
Installation

A domestic telephone plant with these instruments is very simple to install; the work can be carried out by anybody with the help of the directions. The cable is connected in the same way to all instruments, a feature which facilitates the work of connection to a high degree. In each instrument an individual connecting over on the block is done, the terminal clamp *14*, see diagrams, Fig. 6 and *7*, being joined up to the instrument's own signal wire.

Increase of a plant with 4 instruments requires, in addition to the completing of the keyset, change of the instrument's number or the individual connecting over in the original instruments. This is due to the fact that in plants with 4 instruments only every alternate spring in the keyset is utilised.

By utilising the button reserved in each instrument for its own number and therefore not used, it is possible in case of need for a ninth instrument to find a place in the plant. In such case, however, this instrument will have different call numbers in all the other instruments and the buttons concerned

Fig. 7 X 7226
Connecting diagram for intercom telephone plant
with four instruments DEP 3001



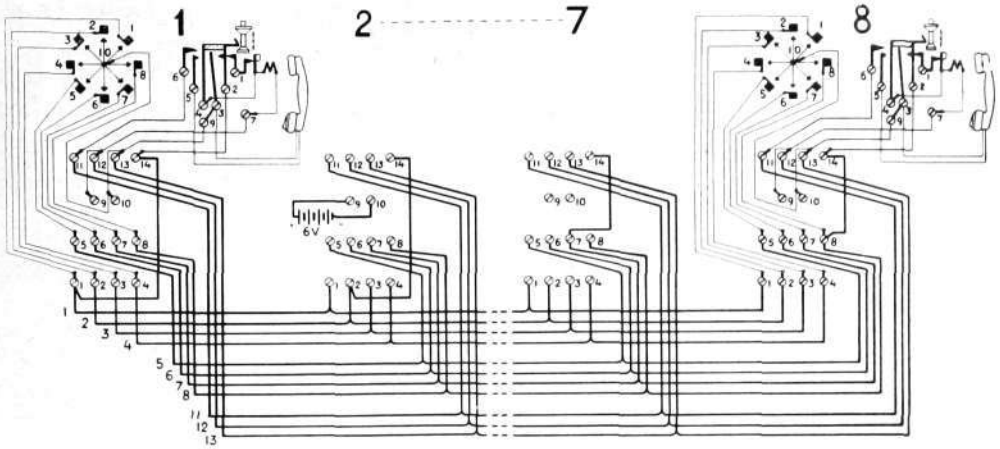


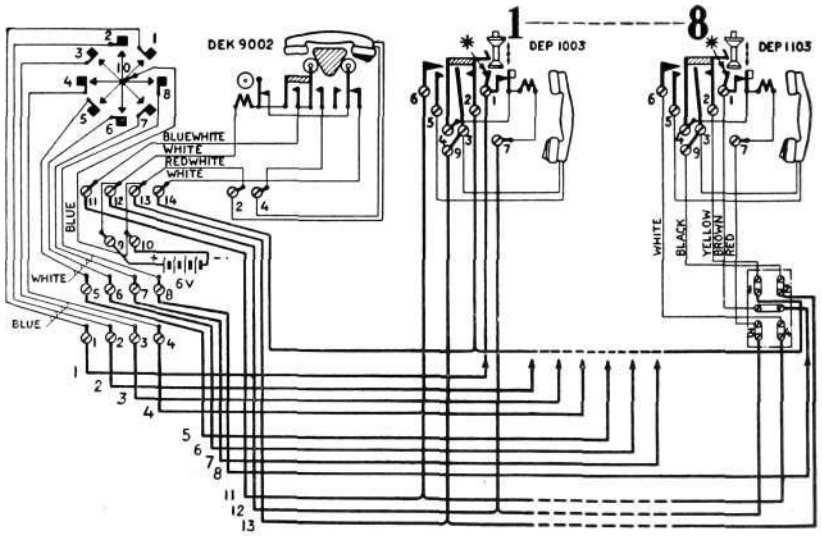
Fig. 8 X 7227
Connecting diagram for intercom telephone plant
with eight instruments DEP 3002

must be designated by the name of the instrument's place. In each instrument its own signal wire will in this case be connected direct to terminal *14*, and the ninth instrument's signal wire will be connected to the terminal clamp which corresponds to each instrument's own number.

Sub-instruments of wall or table type without keyset can be connected in parallel with a main instrument with keyset. Such a sub-instrument is connected in terminals *11*, *12*, *13* and *14* in the same manner as the main instrument. The sub-instrument's buzzer rings on call to the main instrument and the call can be answered from any of the instruments. These can also call each other by means of the signal button on the instrument case.

Another arrangement of a local telephone plant often occurring, with one main station and a number of substations, is shown in Fig. 9. The main station is a domestic telephone with signal buttons, the substations are ordinary domestic telephones. To have call facilities in both directions fivewire connecting cable is required, four wires, however, being common to all instruments in the plant. Table instruments DEP 1103 with fivewire wall bracket cable, Fig. 5, are used for this plant; the wall instruments DEP 1003 are, however, of standard construction. When connecting in substruments the break contact *1—2* in the spring assembly of the instrument is insulated by contact spring *1* being bent out as shown on the diagram. In plants according to Fig. 7 and 8 such connections of instruments with simple call facility can also be done, the connecting being executed in manner shown in Fig. 10.

Fig. 9 X 6388
Connecting diagram for a plant with one main station and a number of substations
* In the substations DEP 1003 and DEP 1103 the break contact 1—2 is set out of action by the contact spring 1 being bent out



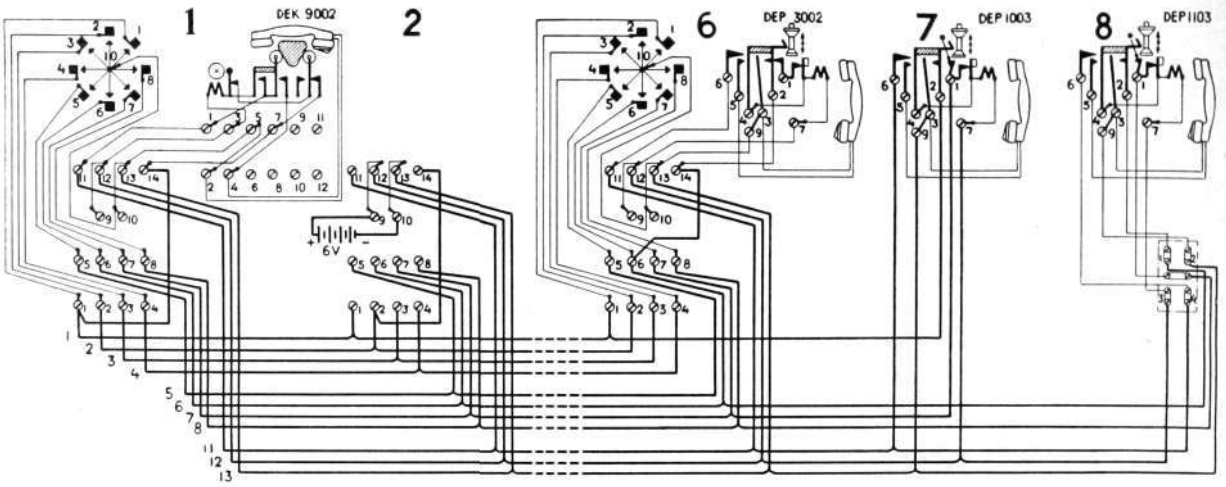


Fig. 10 N 7245
Connecting diagram

for intercom telephone plant with eight instruments

1—6 main instruments DEK 9002 or DEP 3002
7 wall instrument DEP 1003, sub-instrument to 1
8 table instrument DEP 1103, sub-instrument to 6

* In the sub-instruments DEP 1003 and DEP 1103 the break contact 1—2 in the instrument spring assembly is insulated by the contact spring 1 being bent out

A supplementary bell can if required be connected to terminals *9* and *14*. The bell should have the same resistance and voltage sensitivity, 40 ohm and 3 V, as the buzzer of the instrument. A suitable bell is KLD 1002.

The cable network is most suitably executed in lead-covered cable EEB. Plants with 4 and 8 instruments require 7 and 11 conductors respectively, standard cable with the next highest number of conductors, 8 and 12 conductors respectively, being used.

The battery, 6 V, is made up of dry cells, *e. g.*, BKA 1002 or preferably BKA 1004, and is located in the most central position possible in the plant. With a battery tension of 4.5 V the total line resistance between two instruments may amount to 45 ohm, which when using cable with 0.5 mm conductor diameter, corresponds to 250 m distance between the instruments. With 6 V battery tension the corresponding figures are 70 ohm and 400 m respectively. If the capacity of the battery is to be utilised to the full one must reckon on a drop in tension per cell to about 1 V. If four cells are used this limits the maximum distance between instruments to about 170 m with 0.5 mm conductor diameter. This distance can be somewhat augmented if the reserve conductor in the cable is utilised by connecting in parallel to terminal *13* in all instruments.

Telephone Instrument with Call Transfer Relay

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U. D. C. 621.395.63

The unanswered call is the thief of time and thus of money and so is an enemy of good telephone practice. The new telephone instrument here described, which automatically connects the signals of unanswered calls to another instrument, should be for persons often absent from their working place not a luxury but an obvious convenience.

In large concerns and offices the telephone is generally the means of communication most used. When such a telephone plant is being projected, therefore, it is important to bring down loss of time and delays to the lowest figure possible.

There is, however, in such plants a loss of time — the unanswered call — which is often not taken into consideration, despite the fact that in many cases it is of an order of magnitude even greater than other delays. At first sight it may appear that the loss of time is unavoidable — if the person sought is not in, the caller has only to call again. But the caller does not know whether the person wanted is absent for the day or whether he has only left his place for the moment. Perhaps he is just taken up with an important conversation and does not want to be disturbed, perhaps the caller himself has an important communication which cannot be postponed without inconvenience. In any case, repeated ringing will in the long run be time wasting and irritating, both for the person obliged continually to break off his work to repeat his attempt to get through and for persons compelled to hear the repeated signals from the nearby unattended instrument.

How then can one deal with this »enfant terrible» of the telephone? Leaving out of account the most elaborate means, the robot based on the automatic dictaphone instrument, which answers the call, takes the communication and can itself even give a message to the caller, it is still possible in most cases,

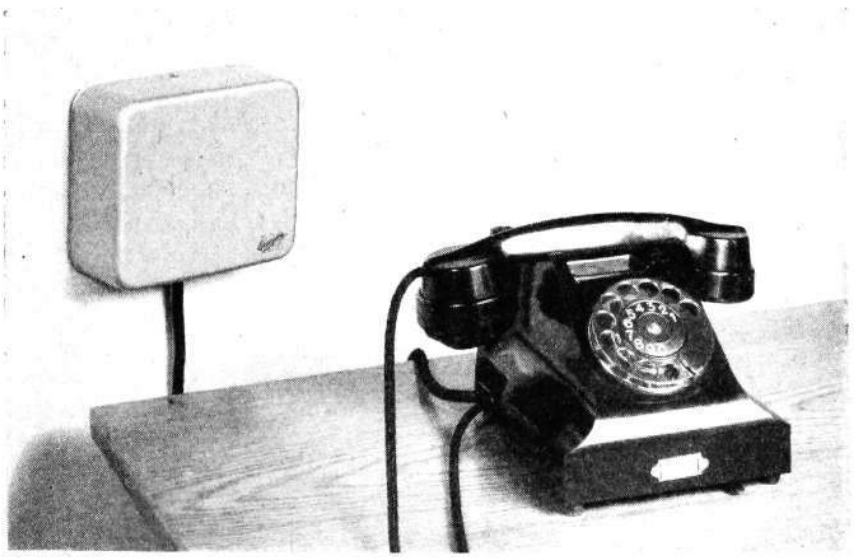


Fig.1 X 3947
Telephone instrument with call transfer DBH 1301

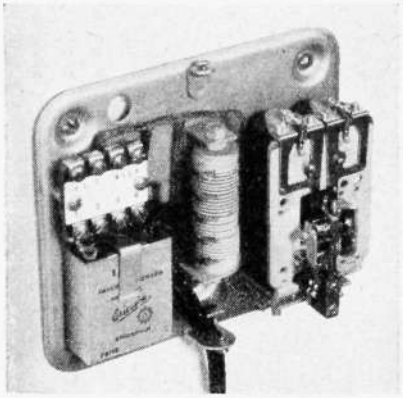


Fig. 2 X 4231
Wall torminal block with relay
left, terminal block with condenser; middle, rectifier; right, step-by-step relay and release relay with step-by-step mechanism

at appreciably lower cost, to ensure reduction, though maybe not complete elimination, of the unanswered calls. The method chiefly used up to now, has been to have a switch for the instrument by means of which the line when the instrument is left unattended can be switched over to another. The weakness of this system, however, is that the switching over may often be neglected.

Employment

The telephone instrument with automatic signal switch removes this disadvantage and very considerably minimises the time lost on account of unanswered calls. A call not answered after two signals is switched over automatically by this instrument to another which can receive a message for the person wanted, and say when he can be found etc. Still further to ensure reduction of time lost the device is so constructed that subsequent calls are immediately signalled at both instruments. Only after the main instrument has been used again are the conditions restored to normal.

It is, indeed, remarkable that the demand for instruments of this kind has not so far been as great as one might expect. One reason maybe that in this case, unlike those needs which immediately create a demand, the necessity is less noticeable to the person needing the instrument than to those about him. Time and trouble is saved by the device, not for himself but for others. How often does one think about whether people have been ringing when one is absent?

But there is saving of time for the owner of the instrument as well. When a visitor comes, when a conference is being held, etc. it is often desirable to be spared the telephone, to be able to devote undivided attention to the matter on hand. This instrument can satisfy this need also. For occasions when one does not want to be disturbed by signals the instrument is equipped with signal reducer, which damps down the noise of the main instrument's bell to a faint buzz.

The device described above can also be employed in other cases. For instance, in workshops when discrimination or delay is desired in the ringing of an extra bell located outdoors or in an adjoining room. If such an extra bell is directly connected, the signals may at times be needlessly disturbing, owing to calls which are immediately answered being unnecessarily repeated by the extra bell. If the instrument here described is employed only those calls are signalled that really require attention.

Construction

In appearance the instrument differs only slightly from a standard instrument, see Fig. 1. For the execution of the switching referred to above, the instrument is equipped with a relay equipment, fitted in a special wall terminal block, belonging to the instrument, Fig. 2. An earlier device of this kind — the call transfer relay — described in Ericsson Review No 1/1935, was made as an independent accessory which could be coupled to a standard instrument. Certain trouble in respect of operation when connected to modern private branch exchanges with single clearing signal, enquiry and transport, combined with limitations of the length of line and transmission properties, have, however, led to this arrangement being discarded.

The arrangement in principle of the new instrument will be seen from Fig. 3. In addition to the components of a normal instrument it comprises a step-by-step relay and a releasing relay. The first relay is actuated in series with the instrument's bell by ringing signal from the exchange causing a wiper to move forward one step for each signal. If the call is not answered by the main instrument, the sub-instrument bell is connected in at the third signal, whereupon the call can be answered from this instrument. Subsequent calls are signalled immediately in both instruments. This connection remains

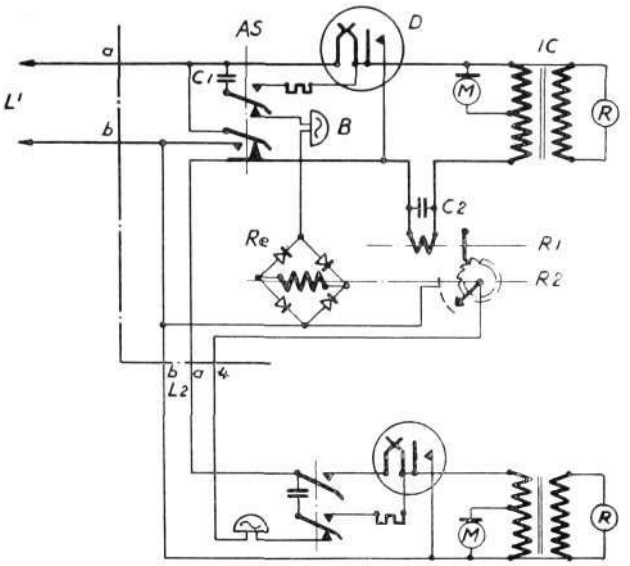


Fig. 3 X 5948

Connecting diagram for telephone instrument with signal switch DBH 1301 and connected sub-instrument DBH 1101

AS hook switch
B bell
C1 condenser
C2 condenser
D dial
IC transformer
L1 main instrument line
L2 sub-instrument line
M transmitter
R receiver
R1 releasing relay
R2 step-by-step relay
Re rectifier bridge

until the main instrument handset is lifted. This operates the releasing relay, the step-by-step mechanism dog is liberated and the wiper returns to home position.

With handset laid down the sub-instrument is connected to the line over the main instrument's switching contact. The speech device of the main instrument is then short-circuited. When the main instrument handset is lifted, it is connected in on the line and at the same time the sub-instrument is short-circuited.

Properties

The switch-over is done by a make-before-break contact, through which the line loop remains closed during the switching period. This prevents the call being disconnected, if during conversation with the sub-instrument the main instrument handset is lifted and replaced. In respect of line resistance and leakance, the instrument works under same conditions as a standard instrument.

The resistance of the releasing relay has no affect on the impulsing properties of the instrument, as during impulsing it lies inside the short-circuited part

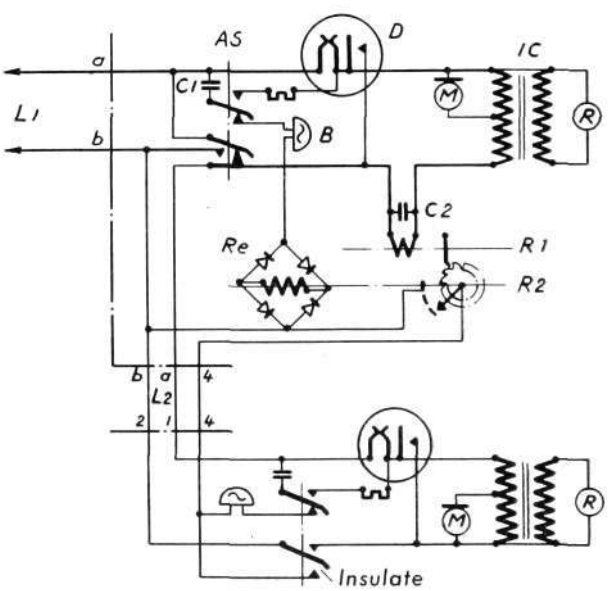


Fig. 4 X 5949

Connecting diagram for telephone instrument with signal switch

with junction connection to sub-instrument with extra bell connected in parallell. One terminal of the bell must in this case be insulated in the instrument, e. g., by insulation of the break contact in the hook switch

AS hook switch
B bell
C1 condenser
C2 condenser
D dial
IC transformer
L1 main instrument line
L2 sub-instrument line
M transmitter
R receiver
R1 releasing relay
R step-by-step relay
Re rectifier bridge

Change-over at Helsingborg. Ericsson Rev. *22* (1945) special number p. 70—75

The change-over of a manual telephone exchange to automatic operation is, of course, a purely technical process. Nevertheless it comprises many features also of purely general human interest. When the automatic exchange in Helsingborg supplied by LM Ericsson was connected up on 29th December, 1940, a journalist was invited by LM Ericsson to describe, chiefly from this latter angle, the change-over from manual to automatic operation.

U.D.C. 621.395.34.003.1

BERGLUND, CORNELIUS: *Economic Viewpoints on Rural Automatisation.* Ericsson Rev. *22* (1945) special number p. 76—86

The normal method of debiting in manual systems is extremely uneconomical, but with rural automatisation automatic debiting can be introduced. It is then possible to apply either unit debiting or automatic ticketing, the former of the two methods being essentially more advantageous economically. With unattended automatic exchanges reliability of operation is of particularly great importance, in view of expence involved in sending out skilled staff for repairs. These questions, so important for rural automatisation, are the subject of observation in this article.

U.D.C. 621.395.361:621.395.34

LUNDKVIST, KARL: *Call Debiting and Numbering for Automatic Telephone Traffic.* Ericsson Rev. *22* (1945) special number p. 87—95

The automatisation of telephone traffic for zone and trunk traffic has increased the demands of unified planning, both because the place names must pe replaced by figures and because it must be possible to record automatically the charges for zone calls.
One of the advantages of automatisation is that it makes possible a debiting of zone calls that is both economical and just. In manual telephone operation the service costs are large, especially if the calls have to be noted. Moreover, the handling of the call tickets involves appreciable cost and this particularly for the short distance calls, will be disproportionally high in relation to the charges that can be made for the calls.

U.D.C. 621.395.343 (861)

LINDÉN, BROR AND LINDSTRÖM, ERIK: *Telephone Plant in Medellín.* Ericsson Rev. *22* (1945) special number p. 96—102

On 13th July 1937 there was concluded a contract between the city of Medellín in Colombia and Telefonaktiebolaget LM Ericsson for the supply and fitting of an automatic telephone exchange for 10000 lines, reconstruction of the old telephone network for 7300 lines and the building of a new network for 5000 lines, together with the supply of 8000 telephone instruments. On the Colombia national fête day, 20th July 1940, the plant was inaugurated and handed over to the municipality of Medellín city. All the material was delivered by Telefonaktiebolaget LM Ericsson.

U.D.C .621.395.34:656.254.15

SIEWERT, OTTO: *The Automatisation of the Telephone Traffic on the Swedish State Railways.* Ericsson Rev. *22* (1945) special number p. 103—114

The Swedish Royal Board of Railways appointed in 1940 a special committee charged with recommending guiding lines and drawing up a programme for the expansion and rationalisation of the State Railways telephone service. The committee presented its report on 30th March, 1943. An account of the results of the committee's labours is given in the article with the kind permission of The Royal Board of Railways. The account has already been published in Teknisk Tidskrift, No. 32/1943, from which it is reproduced with the necessary authority.

U.D.C. 621.395.343 (729.88)

BERGLUND, CORNELIUS: *Telephone Plant on Curaçao.* Ericsson Rev. *22* (1945) special number p. 115—118

A new telephone exchange on the LM Ericsson machine-driven system with 500 line selectors has been opened at Willemstad, the capital of Curaçao. At the same time new up-to-date telephone instruments and P.A.B.X. of LM Ericsson manufacture have been connected in the network. The material supplied was largely manufactured in the Netherlands by Ericsson Telefoon Maatschappij, Rijen. The telephone exchange is the first large public telephone exchange on an automatic system in the Dutch colonies.

U.D.C. 621.395.63

BERGHOLM, ERNST: *Telephone Instrument with Call Transfer Relay.* Ericsson Rev. *22* (1945) special number p. 124—128

The unanswered call is the thief of time and thus of money and so is an enemy of good telephone practice. The new telephone instrument here described, which automatically connects the signals of unanswered calls to another instrument, should be for persons often absent from their workingplace not a luxury but an obvious convenience.

U.D.C. 621.395.721:621.395.2

BERGHOLM, ERNST: *New Domestic Telephones.* Ericsson Rev. *22* (1945) special number p. 119—123

During the years that LM Ericsson's domestic telephones have been on the market the original lively demand has unceasingly grown, evidence of the public's appreciation of LM Ericsson's efforts to produce an up-to-date, cheap and serviceable domestic telephone. There have recently been put on the market some new types of instruments, the domestic telephones with signal buttons, which further supplement the already abundant series of domestic telephones and considerably extend the spheres of usefulness for these instruments.

of the instrument circuit. There is no need therefore to make it delayed acting and, as its load is but slight, it works satisfactorily right down to a line current of 10 mA, which with the L M Ericsson automatic system is equivalent to about 1100 ohm line resistance.

The resistance of the step-by-step relay, to allow for the best adaptation to the circuit's other constants, has been selected as 2000 ohm, which in rectifier bridge with 6 plates per bridge branch gives an impedance of 2700 ohm with the ringing current frequency of 25 c/s. The relay operates on 11 V, the A.C. current being about 4 mA. The condenser C and the instrument bell are connected in series with the relay. The impedance at 25 c/s of the whole device is about 7000 ohm. As ringing signal normally has a tension of 70—100 V the sensitivity of the step-by-step relay is quite sufficient, even for long lines. The transmission properties of the instrument are practically the same as those of a normal instrument. Crosstalk attenuation for all normal combinations is at least 10 neper.

Installation

The instrument can be connected to all telephone systems having periodical ringing. In automatic systems the first signal as a rule is transmitted immediately the connection is complete, after which periodical ringing is switched in. If this switching takes place just before or during a ringing period, two signals will follow each other immediately. In order that it may be possible to answer the call in such a case, even before the signal is disconnected, the third signal has been taken as the switching signal. Another reason is that trunk calls are as a rule signalled by two signals one after the other. If for any reason the switching period proves unsuitable, the step-by-step relay's make contact can easily be set to meet the desired requirements.

Connection of the two instruments will be seen on Fig. 3. A standard instrument can be used as sub-instrument. If it is desired to supplement an instrument already existing with signal switch, this instrument can then be used as sub-instrument. If the sub-instrument is connected for coupling an extra bell in parallel with the instrument bell, the coupling of this to the instrument must be insulated, *e. g.* in spring assembly as shown on Fig. 4.

If the sub-instrument is to have a separate line for its own calls there is used as sub-instrument a two-line instrument DBH 2101. The connection with the main instrument is then coupled in as an enquiry line on the main instrument. In this way the calls to the main instrument can be answered immediately even when a call is proceeding on the instrument's own line.

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New Toll Exchange at Helsingfors

V E HAVERINEN, CHIEF ENGINEER, BOARD OF POSTS AND TELEGRAPHS, HELSINGFORS

U.D C. 621.395.722

Up to 1935 toll traffic was handled in Helsingfors by two toll exchanges, one belonging to a private undertaking and the other state-owned. In 1935 the State bought out the private undertaking, but toll traffic had still to be handled over the two exchanges because of lack of other accommodation.

Owing to the great difficulty in ensuring efficient operation with a toll exchange situated in two localities and as a heavy increase of toll traffic was anticipated in conjunction with the Olympic Games planned for 1940, the Finnish Board of Posts and Telegraphs began in the autumn of 1936 to plan for a new toll exchange. In 1938 L M Ericsson was entrusted with the supply of the necessary exchange material. The new toll exchange is described below.

As rural automatization has only been carried out to a small extent in Finland, the toll line network is typically manual with a multitude of small routes. The new toll exchange had therefore at the beginning to interwork with such a network and later on as rural automatization advanced with automatized network groups.

A cordless system with the toll lines permanently terminating in the connecting circuits of the toll boards was not considered advisable, as the utilization of the operators would be poor in view of the large number of small routes. An ordinary cord-pair system was also found unsuitable owing to the size of the exchange — about 600 toll lines and 140 toll positions.

The Board of Posts and Telegraphs decided upon a system which may be said to take a middle course — a »semi-cordless» system or, as it might also be called, »a cordless system with cords». This means that all the toll lines



Fig. 1 N 6098
Posts and Telegraphs building at Helsingfors

terminate in a toll line multiple covering a certain number of positions. The toll connecting circuits are at the toll side provided with single cords while at the local side the connection is done without cords by means of automatic selection. As the connecting circuits are not tied to the toll lines each of them can be served by a number of operators. In this way the utilization of the operators will be good, even if the toll lines are not heavily loaded, and progressive concentration at decreasing traffic is easy to carry out.

A definite advantage with the system is that the toll operator always knows which line she has occupied. Consideration might of course have been given to a system with automatic distribution of incoming calls and automatic selection of outgoing lines. As an alternative the Board of Posts and Telegraphs did also invite tenders for a toll exchange equipped in this manner, but it was found that the costs of such an arrangement would be considerably higher.

Prior to 1935 there were two toll exchanges in Helsingfors; one of which belonged to a private undertaking »The South Finland Toll Telephone Co. Ltd.», handling toll traffic in South Finland. The other was owned by the State and dealt with toll traffic to the rest of the country. In 1935 the private concern was purchased by the State, which then took charge of the whole toll traffic, but on account of lack of other accommodation the traffic had still to be handled by the two exchanges, situated about 200 metres apart. All toll lines for a certain route were assembled in one or the other of the two exchanges. All records were received centrally in the one exchange and recording tickets concerning the other were dispatched to it by pneumatic tube. There was a sufficient number of junctions between the exchanges for transit traffic and each exchange had its own junctions to the local network, which belongs to a private undertaking, the Helsingfors Telephone Company, and which is mainly automatic on the Siemens & Halske system.

It was of course extremely troublesome to ensure efficient operation with a toll exchange spread over two buildings and, as in addition there was anticipated a great increase of toll traffic during the Olympic Games planned for 1940, the Board of Posts and Telegraphs began in the autumn of 1936 to plan a new toll exchange. In the tender specifications sent out in the autumn of 1937 to a number of telephone manufacturers the principles of operation of the planned toll exchange were very clearly defined. On the other hand the would-be contractor was given fairly free hands in the developing of the separate circuits.

After considering the tenders submitted, the Board of Posts and Telegraphs decided to entrust the supply of material for the exchange to Telefonaktiebolaget LM Ericsson and the contract was signed on 28.9.1938. The material was delivered ready wired as far as possible and the mounting on the spot was carried out by the staff of the Board of Posts and Telegraphs. Towards the completion of the installation the contractor put a testing engineer at the Board's disposal for the final trials. Owing to the 1939—1940 Russo-Finnish war the erection could not be completed in the time contracted and the exchange was not opened for service until 19.10.1941.

General Method of Operation of The Exchange

As stated in the introduction the exchange is built on a semi-cordless system with the toll lines terminating in a multiple field, where they are connected to the circuits of the toll positions over single cords. The whole toll multiple has however not been led through all the toll positions, which would have involved an inconvenient switchboard design with high multiple field, but the exchange has been divided into a number of groups, enabling the multiple capacity to be limited to 200 lines.

Division into groups ensures not only a decrease of the costs but also that extension can easily be made by building up new groups of boards. No disturbance of toll board groups already in service needs to be done.

The semi-cordless system adopted is so constructed that all signals from the toll line are carried to the connecting circuit over the toll cord, as this is connected to the toll line. It is therefore not necessary to take down the cord after each call and the system then functions as if it were cordless.

This procedure is employed as a rule in the positions for outgoing or both-way traffic. In busy periods an average of four toll lines is dealt with per position, though the number of connecting circuits available is six. With decreasing traffic the number of operators is reduced and at the same time the number of lines directly connected to the positions still in service is increased. With further concentration the positions are combined in pairs and each operator has at her disposal 12 connecting circuits. In the last stage of concentration the whole of the night traffic is transferred to special night concentration positions which contain multiple for all the toll lines.

It is obvious that with the system adopted the number of operators can be flexibly adapted to the size of the traffic and that progressive concentration presents no difficulty.

As a matter of fact, the semi-cordless system functions like an easily operated intermediate distribution and corresponds to the special ranging board which is usual at old toll exchanges, though in this case it is spread over the whole exchange.

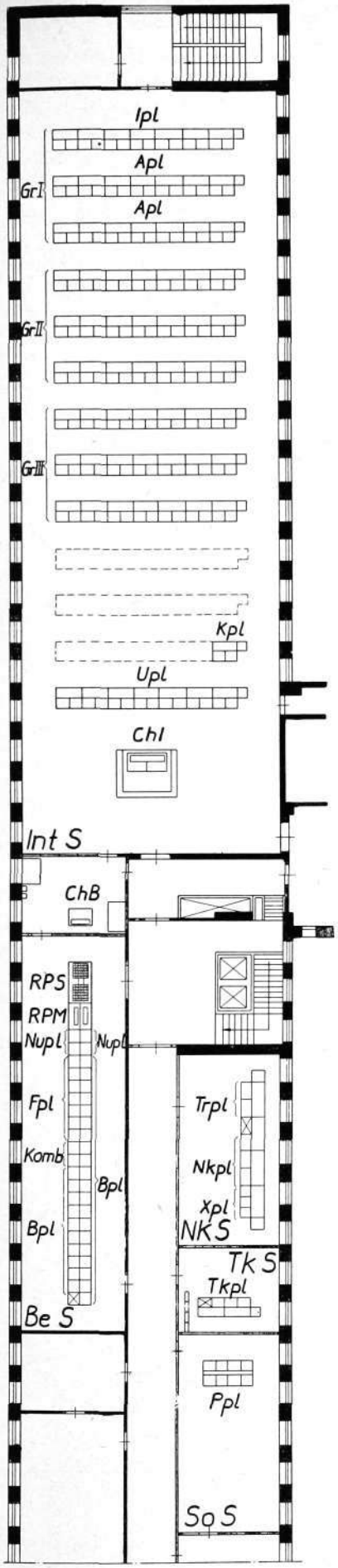
For the incoming traffic it is important that the time of answering is short and it is therefore not advisable that an incoming toll line should be directly tied to an operator, as at the time of the call she may be busy with another call. At the incoming positions therefore the toll cords are taken down after each call and the function is the same as in a multiple lamp system.

The operations over the local side of the connecting circuits are done cordlessly by means of automatic switching apparatus. Subscribers in the Helsingfors local network are reached over this route, as well as the internal routes inside the toll exchange among which may be noted subscribers directly connected to the toll exchange (direct subscribers), PABX switchboard for the Posts and Telegraphs building, and service lines between the positions.

As the connecting circuits are not tied to any particular toll lines it is possible without any great trouble to introduce no delay service over one or several routes, when the number of lines per route has grown so large in relation to the traffic that this form of traffic can be allowed. In such cases separate order numbers must be introduced for that traffic and the exchange equipment be supplemented by devices for distributing the order calls over the no-delay positions. It is advisable at the same time to supplement the internal routes by devices for no-delay traffic, so that transit calls to the no-delay routes need not pass the transit positions.

By completing the line equipments of the incoming toll lines it is possible likewise to arrange incoming no-delay traffic in such a way that a distant toll operator can select a local subscriber in Helsingfors directly without the intervention of a Helsingfors operator.

During the day, transit traffic between two toll routes is handled over special transit positions. After the transit connection has been established by the transit operator the supervision of the call is passed over to the toll operator who deals wih the outgoing toll line. During the night, transit is dealt with directly in the night concentration position.



Recording traffic is centralized to a separate group of positions and recording tickets are sent to the toll positions through pneumatic tubes. In the same group there are a number of enquiry positions which subscribers can call for information required. In these positions also international calls must be recorded as it is only the enquiry operators who have the necessary telephone directories at hand. Incomplete tickets are completed by special number checking operators before being passed on to the toll operators. Recording and enquiry positions have separate call numbers. Should a subscriber call a recording position instead of an enquiry position he needs not call again as the recording operators can transfer calls to the enquiry positions.

During busy traffic the delay is fairly long. The recording and enquiry positions have therefore been provided with automatic devices for delay enquiry. Among the operators serving a certain route *one* receives all the tickets applying to that route. She can then from the number of remaining tickets at any moment decide the approximate time of delay. This is set on potentiometers graduated in minutes. For each route there are two of these and they indicate the delay for ordinary and urgent calls. When an operator wants to know the delay she calls over the automatic devices of the exchange an enquiry number special for the route and is then connected to the potentiometers of the route and connects in to one of these a voltmeter graduated in minutes. The delay is thus obtained without disturbing the toll operator.

This procedure, however, can only be used when a call is being ordered. If the subscriber later asks how long delay there is for the call ordered, the recording operator must get in touch with the toll operator concerned.

If a subscriber finds the delay too long, ha can cancel the call or change the class of the call by calling a recording operator, who enters his request on a special ticket. This is transmitted in the normal way by pneumatic tube to the toll position. After the original ticket has been altered the toll operator sends the new ticket by pneumatic tube to the sorting position, to which all tickets dealt with are sent as the calls are finished.

The assorting positions can give subscribers information about the cost of toll calls. They have, however, up to now no call number of their own, but all calls concerning price enquiries must go through the recording or enquiry positions which transfer the calls to the price enquiry.

For traffic between the different positions inside the exchange, there are special service lines which are connected to the automatic devices of the toll exchange and are reached over service line numbers individual for the operators.

For dealing with traffic for the staff of the Posts and Telegraphs building there is a special PABX switchboard with junction lines to the Helsingfors local network.

To prevent several toll operators trying to connect simultaneously when a subscriber orders several calls at a time, the exchange has been equipped with a special queue position which arranges the calls one after the other.

Fig. 2 X 4349

Lay-out of upper floor, comprising:

toll switchboard room (IntS) with

3 inland groups Gr I—III each with 3×14 toll positions divided into outgoing (Apl) and incoming (Ipl)
1 international group (Upl) with 14 positions
2 queue positions (Kpl)
2 supervisor positions (ChI)

Night concentration room (NkS) with

2 transit positions (Trpl)
3 night concentration positions (Nkpl)
3 manual positions for Posts and Telegraphs building PABX switchboard (Xpl)

Recording room (BeS) with

30 recording positions (Bpl)
2 combined recording and enquiry positions (Komb)
7 enquiry positions (Fpl)
4 number checking positions (Nupl)
1 supervisor positions (ChB)
pneumatic tube dispatcher (RpS)
pneumatic tube receiver (RpM)

Sorting room (SoS) with

4 price enquiry positions (Ppl)

Secret supervision room (Tks) with

3 positions (Tkpl)

Capacity, Erection and Mechanical Lay-out

When planning the exchange in 1936 there were connected to the old exchanges 252 inland toll circuits and 9 international toll circuits, of which 219 were metallic and 42 were carrier circuits on aerial lines. When the new exchange was opened the corresponding figures were 354 inland and 12 international circuits, of which 247 were metallic, 52 carrier circuits on aerial lines and 67 were carrier circuits on cables of the 12 or 16 channel systems. The numbers of circuits on 15/8—45 were 404, 13, 263, 80 and 74 respectively.

To provide sufficient reserve and allow for the increase of traffic that was anticipated in connection with the Olympic Games planned for 1940, the exchange was built for

600 inland toll circuits
40 international toll circuits

supplemented by

200 direct subscriber lines
350 PABX extensions for the Posts and Telegraphs building

together with the requisite junction circuits to and recording circuits from the Helsingfors local network.

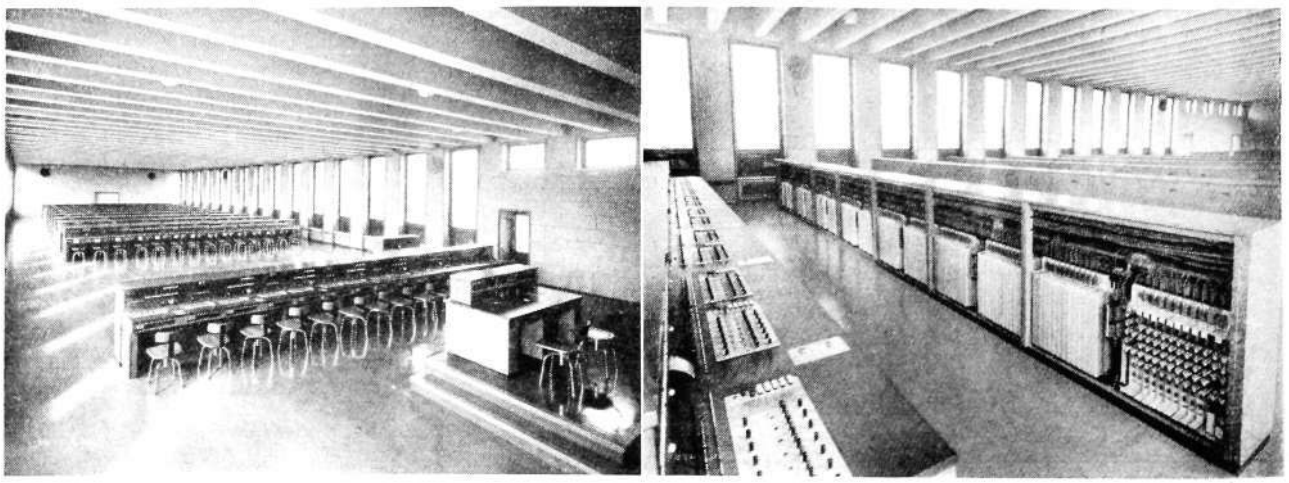
The exchange is housed in the two top floors of the 5 storey block of the new Posts and Telegraphs building in Helsingfors, which was completed in 1936 and which, besides the toll exchange, accommodates the Board of Posts and Telegraphs, the general post office, the head telegraph office, customs service for postal packets, training institutes of the posts and telegraphs etc.

The toll exchange comprizes at present 203 operator positions, housed in the top floor, see Fig. 2, distributed in toll board room, night service room, recording room, sorting room and the secret supervision room. The numbers of positions in the different rooms will be seen from the figure text.

Toll Board Room

Owing to the toll multiple being limited to 200 lines the switchboard frameworks in spite of the multiple could be made so low that they could be set up in parallel rows, see Fig. 3, with the operators looking in the same direction, but the supervisor still has a good view of the whole.

The 600 lines for inland traffic are distributed over three groups of boards — with space for a fourth — each consisting of three rows of switchboards with 3×14 positions in each group. For convenience of service an inland group



X 7381

Fig. 3
Toll switchboard room

left, front view with supervisory positions in foreground; right, rear view, with rear panels removed from one row of boards

Fig. 4 X 6081

Key shelf for an outgoing inland position, comprizing from the left:

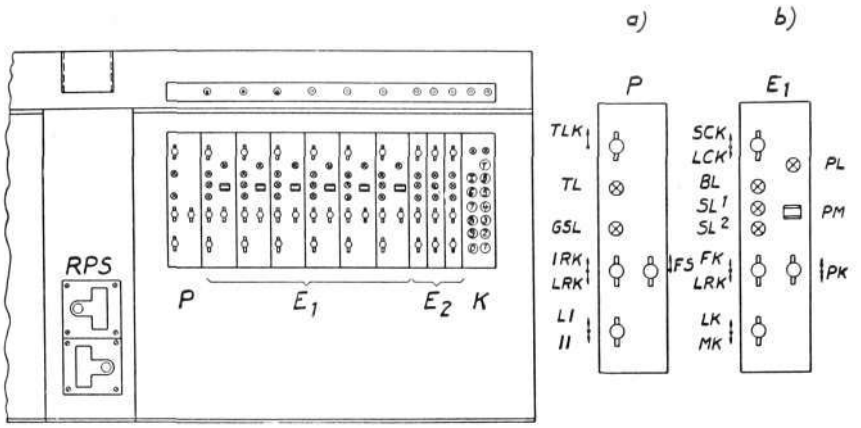
2 pneumatic tube dispatchers (RPS)
1 common key set for the position (P)
6 toll cord switching units for outgoing or both way traffic (E_1)
3 toll cord switching units for incoming traffic (E_2)
1 keysending set (K) (see Fig. 5)

Detail a) for the common positional equipment which comprizes:

TLK	service line key
TL	service line lamp
GSL	clearing lamp
IRK-LRK	toll and local ring key
II-LI	toll and local separation key
FS	key for regulation of amplification of cord repeaters

Detail b) for toll cord switching unit with time check containing:

SCK-LCK	routing key for internal routes or Helsingfors local network
BL	transit waiting lamp
SL1-SL2	toll and local clearing lamps
FK-LRK	key for transit transfer and local ringing
LK-MK	speech and listening-in key
PL	time check lamp
PM	time check
PK	time check connecting key



is divided into 12—14 positions for incoming and 28—30 positions for outgoing traffic. As all positions have the same wiring, it is possible to alter the distribution at any time, and the only difference is that the incoming positions have a larger number of connecting circuits but are without time checks. These positions are more to be regarded as purely B-positions and can therefore connect a larger number of calls than the others.

In the toll multiple, call lamps have been inserted only in the positions where the corresponding lines are to be served. Thus the lamps for incoming lines are placed only in the multiple of the incoming positions. In this way the operator escapes being troubled by calls which are to be served by another.

For international traffic there is a special row of switchboards comprizing 14 positions. The connecting circuits of these positions are provided with double exits on the local side to make it easy for the operator during a call to prepare for the next one. In the inland toll positions such preparation is done, as required, over a disengaged connecting circuit. When the call in progress ends the operator changes the toll cords.

The two-position queue switchboard has also been set up in the toll board room. Of course it takes up some of the space reserved for a fourth inland group to come later, but can when necessary be moved to another place.

All the toll switchboards are of the same construction. They are made of natural light oak and each comprizes two positions with common multiple field.

All switching keys are assembled in removable units in the keyshelf. Fig. 4 shows the appearance of shelf in an inland position for outgoing or both-way traffic. The functions of the keys and lamps can be seen from the figure text.

In Fig. 6 and 7 there are shown two constructions of switching units. The operator's telephone set consists of LM Ericsson's newly designed headset, Fig. 8.

Behind the keysending set there are a couple of cords for connecting in the delay potentiometers to the delay multiple which is inserted in the switchboard groups.

Between the two positions of a switchboard there are the pneumatic-tube devices. The pneumatic-tube receivers which are located in the lower part of the multiple field, are provided for only four switchboards of a row, as it is only the head operator in an operator group for a number of routes who receives and distributes the tickets. These operators also manipulate the delay potentiometers, which are located in the multiple field. All switchboards are



Fig. 5 X 4353

Keysending set

1—9, 0 digit keys

S final key, to be operated when all the digits in a number have been sent

I key by which the keysending set is switched over to the toll side

T test key

Behind the I and T keys two register control lamps which indicate when the number sending from the register on the toll side or the local side is completed

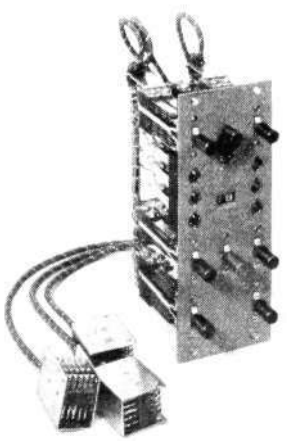


Fig. 6 X 4354

Switching unit with double exits for international positions

The knob above the check switches in the toll cord between the exits

equipped with double pneumatic-tube dispatchers fitted in the key shelf, one for ready tickets dealt with to the sorting positions, the other for wrongly sent or incomplete tickets for return to the recording room.

The relay sets belonging to the connecting circuits are fitted vertically in the toll switchboards and can be taken out from the rear, see Fig. 3 on the right.

Night Concentration Room

This room, Fig. 9, contains all switchboards with high multiple, as these did not fit in with the normal toll switchboards. The room contains, besides the night concentration positions, the transit positions and the manual switchboard for the PABX and is therefore attended throughout the 24 hours.

Recording Room

The recording and enquiry switchboards in the recording room, Fig. 10, which have no multiple fields, are doublesided and set up in one row with operators on either side. Along the middle of the switchboard row two narrow conveyer bands are built in. Above each band there is a track in which the tickets are put in edgeways. One track conveys to the dispatch positions of the pneumatic-tube plant constructed by Mix & Genest AG of Berlin, from which the tickets are distributed over separate tubes to the different toll positions. The incomplete tickets are conveyed via the other track to the number-checking operators for completion.

The pneumatic-tube plant is also equipped with receiving devices for the tickets which have to be returned from the toll board room. It may be a question of completing insufficient particulars and the number checking positions have therefore been placed close to the receiving tube devices.

As with the toll switchboards, the relay sets and switching units of the recording and enquiry positions are fitted so that they can be taken out. Fig. 11 shows such a unit.

Sorting Room

All ready tickets are conveyed by pneumatic-tubes from the toll positions to the sorting room where they are filed in the usual way.

Secret Supervision Room

The switchboards in the supervision room, Fig. 12, are provided with a multiple field to which the toll lines and the operator supervision lines are wired to jacks. The supervisory devices which are provided with listening amplifiers with silent connection-in, are connected over plugs and cords to the lines that are to be supervised. Each supervisory position has two listening amplifiers connected to different cords and coupled in parallel so that the supervising operator can listen in simultaneously on a toll circuit and on the operator who is to be supervised. Among the supervisory devices are call meters, located in the multiple field, by means of which the supervisory operator can keep traffic statistics for the operators during supervision. In the multiple field there is also a number indicator board for each supervisory position, so that the supervisory operator can at any time check the number sending. The print recording machines at the left on the key shelf are connected by plugs and cords to number supervision circuits and are used for running supervision of the number sending of the incoming operators.

Automatic Switch Room

Fig. 13 shows the lay-out and Fig. 14 an inside view of the automatic switch room. This has been housed on the floor below the toll board room so that the cable routes are the shortest possible. All selectors, relay sets, repeaters

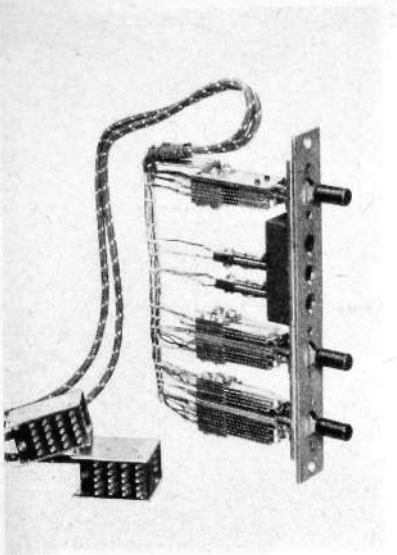


Fig. 7 X 4355
Single row switching unit

etc., which are not fitted in switchboards, are assembled in this room. The constructions are of LM Ericsson's standard design for large exchanges. Practically all selectors are 4-wiper 500-selectors. For testing the lines there is a special testing desk *UB*, installed in a separate room.

Power Plant

The exchange is constructed for — 24 V working voltage, but in addition it requires — 60 V auxiliary voltage for working with the local exchanges, + 12 V auxiliary voltage for signalling over the toll cords and + 130 V anode voltage for repeaters and carrier equipment. The requisite charging units, which are all made with selen rectifiers, have been supplied by ASEA, Västerås. They are regulated on the »avostat» principle and hold the voltage constant with ± 1.2 % accuracy when the load varies between zero and full load, even if the mains supply should vary with ± 10 % of the nominal value.

The batteries for the exchange are set up in a separate room behind the rectifier units and were delivered by Accumulatorenfabrik AG, Berlin.

Lay-out Diagram

The distribution diagram, Fig. 15, shows the schematic lines of the exchange.

Toll Circuit Equipment

Over a main distribution frame which also includes the line transformer and where the test desk multiple is connected, the toll lines are wired to a relay rack which for each line contains a relay set with requisite relays for receiving calls from the line, sending out ringing signal to the line, transferring the signals over the toll cord to the connecting circuits of the toll positions etc. Over an intermediate distribution frame the toll lines are carried on to the multiple field in the group of switchboards where the lines are to be served and to the transit and night concentration positions.

A number of toll lines which go to automatized places, the toll exchanges of which are closed at night, are provided with special relay equipments which can be switched over so that remote selection can be done from Helsingfors when the remote toll exchange is closed. In these cases the remote subscribers order their calls in Helsingfors over the toll lines.

Incoming Traffic to The Toll Positions

If no connecting circuit is connected to the line call lamps light up on call in the group of boards where the line terminates. A disengaged operator inserts the plug of an unoccupied toll cord in the multiple jack, throws the speaking key and is connected to the line — the operator's equipment will be seen on Fig. 4. The call lamps of the multiple go out and instead busy lamps light up everywhere the line occurs. Should more than one operator attempt at the same time to answer the call only one gets connected and the others receive busy tone and must take down the cords.

After the connecting circuit has been joined over the toll cord to the toll line the connection is quite independent of the speaking key and is maintained until the cord is taken down. Signals from the toll line will not then light the call lamps in the multiple field but are transferred direct to the toll clearing lamp of the connecting circuit. The lamp goes out when the operator throws the speaking key.

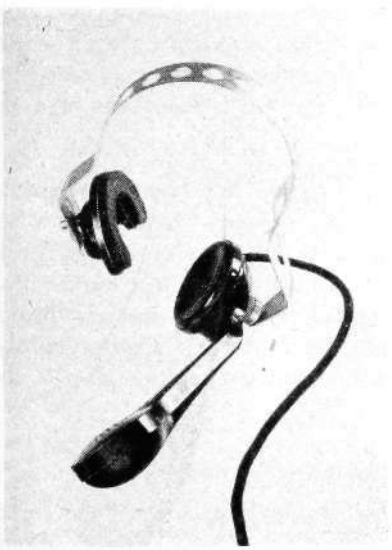


Fig. 8 X 4356
Operator's headset

Outgoing Toll Traffic from The Toll Positions

The connection of the connecting circuit to the toll line takes place in the same way as for incoming traffic, and the cord therefore does not need to be taken down between calls. The toll line is called by throwing the toll ringing

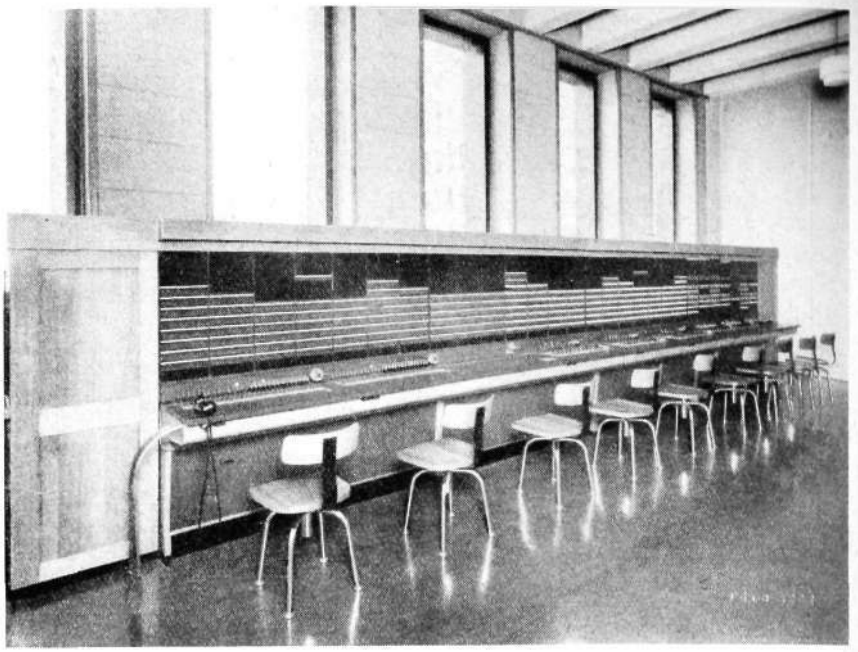


Fig. 9 X 6099
Night concentration room
containing 2 transit positions, 1 emergency position, 3 night positions and 3 positions for PABX switchboard

key of the common position equipment. By this a D.C. signal is transmitted which actuates a relay in the toll line relay set, which in turn transmits over the line A.C. of suitable frequency, *viz:* 25 c/s for ordinary lines and voice frequency 500 c/s for *e. g.*, carrier circuits.

Selection of Routes and Number Sending

The local side of the connecting circuit equipment is connected to two line-finder multiples, one of which leads to the Helsingfors local network and the other to what are called internal routes. 500-line selectors are used as line-finders but the number of connecting circuits is so large that 3 multiple groups each of 500 lines are required. In each multiple group there are required three 60-racks for traffic to the local network and one 60-rack for the internal traffic. The operator makes a call to one or the other multiple by means of a routing key belonging to switching unit. By this there is connected to the connecting circuit equipment an unoccupied line-finder in the desired direction and, to the keysending set, a keyset register over a register finder. Immediately the register is connected a lamp on the keysending set lights up and the operator sends the number desired. This is received in the register which is set over two wires and is constructed as a condensor register, which, if required, can be extended to nine figures. As the number of figures may vary the operator must when the whole number has been given press a special final key. This marks in the register that the number sending is completed and that it is to be disconnected when the number received has been re-forwarded.

Immediately a line-finder for the desired direction has been connected to the connecting circuit this is signalled to the register which starts reforwarding the number received. The impulse wire from the keyset register is conveyed over the relay set of the connecting circuit in such a manner that it is not broken until the register has finished even if the operator disconnects the common position equipment from the connecting circuit. As long as the register is connected to a connecting circuit the register lamp of the keysending set remains lit.

Traffic to Local Subscribers in Helsingfors

As the selectors at the local exchanges are step-by-step operated the keyset register can actuate the selectors at these exchanges directly: On account of the arrangement of the local exchanges it has been necessary to provide the position equipments with a special test introduction key, located in the key-

sending set. This key is thrown by the operator when the register lamp has gone out and the connection is thus completed. Breaking of local call in progress and ringing are done from a local ringing key in the common position keyset or from an individual ringing key in the switching unit belonging to the toll cord.

As long as the called subscriber does not answer the local clearing lamp in the switching unit flashes. It goes out when the subscriber answers and lights up again with a steady light when the subscriber replaces his handset. This principle is applied as far as possible throughout. A flashing local clearing lamp means therefore that the connection is not fully established or that answer is awaited, a steady light in a lamp indicates that the call is terminated.

The time check belonging to the switching unit is connected in at an outgoing position when the call has been established. Nevertheless the connection depends not only on the key of the time check but also on the clearing relay of the local side, and the time check records only effective time of a call. The time check, which is driven by 10 s impulses, is provided with a warning lamp which lights up 10 s before the end of each 3 minute period. During the call the operator can listen in over a transformer with high impedance by throwing the listening-in key of the toll cord.

Traffic for Internal Routes

The internal line-finder with a combined group and final selector *(GLV)* forms a link. As this selector is a 500-line one and the keyset registers have only decimal translation there are required translation registers for the internal links, these registers controlling *GLV* and any succeeding selector steps with 500-line selectors. The registers are connected to the link by a rigid connection and each is capable of serving up to 9 links.

In the internal *GLV*-multiple the disposition of the frames is as follows:

Frame	Numbers of routing digits	Purpose
1	9	Reserve for no delay traffic
2	100—599	Aut. traffic to PABX-LV
3	04	Manual PABX switchboard
4	05	Transit-B-cords
5	06	Cord repeater
6	8300—8599	LV for direct subscribers (reserve)

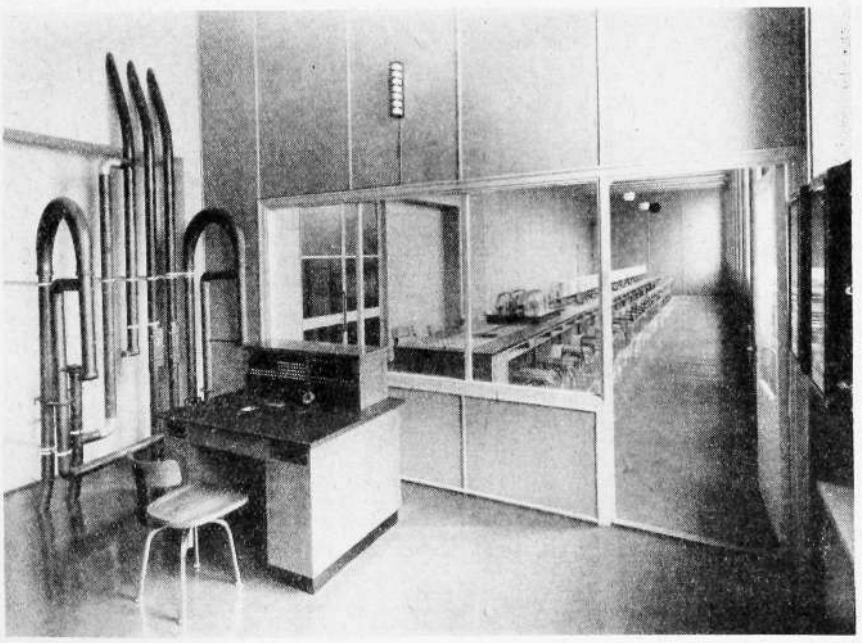


Fig. 10 X 6100

Recording room with supervisor's desk in the front room

In the front end of the row of positions may be seen devices for pneumatic-tube dispatch and reception. On the wall at the right may be seen two 6-colour printers for continuous load control

Frame	Numbers or routing digits	Purpose
7	08	Reserve
8	09	»
9	00	Queue positions
10	0100—0399	LV for service lines and delay enquiry
	0700—0799	
11—20	600—799	Direct subscribers
21—25	8200—8299	Direct subscribers, reserve

At first sight routing digits and numbers may appear rather strangely selected. This, however, is due to the fact that the numbers for the PABX switch board and the direct subscribers are also used by the public and should therefore not begin with »0». The figure »9» is fixed for no delay traffic throughout Finland. Those numbers which begin with »0» are used only by the operators at the toll exchange itself and should all be regarded as service numbers.

Below the different internal routes are dealt with.

Transit Traffic.

If a remote operator requires a transit call the Helsingfors operator as a rule throughconnects the incoming toll line over the internal link and a service line to the operator who handles the outgoing route. This last operator receives the record for the call and announces approximately when it can be established. The service connection inside the Helsingfors exchange is then taken down and the connecting of the desired transit communication is passed over entirely to the outgoing operator. When she gets an unoccupied line she calls over the internal link, with separate routing figures for a cord-pair with repeater or for a single cord without repeater. If the wanted line is unoccupied the transit operator completes the desired connection directly and the whole supervision is then passed over to the outgoing toll operator. The transit operator will then have no need to intervene until the call is finished, when she takes down the connection established.

If the wanted line is already engaged by a transit call a special busy lamp lights up in the transit multiple and the new call must wait. However, if the line is engaged in a toll position, this being indicated by another busy lamp, one cannot be certain that call is proceeding as the line only needs to be joined to a connecting circuit of a toll position. It has therefore been necessary to insert a signal — »transit waiting» — between transit positions and toll positions. Transit waiting is of two kinds: single transit waiting and group waiting.

For the *single transit waiting*, employed with routes having few lines, when the call must be established over the line on which it was recorded, the transit operator inserts the plug in the jack of the busy line. This actuates the toll line relay equipment in such a manner that a transit waiting lamp shows flashing light in the connecting circuit equipment connected to that line. The toll operator should then liberate the line for transit as quickly as possible, which is done by taking down the toll cord or by making transit transfer. For this transfer she throws a key in the switching unit, which produces transit transfer. During the time the transit call is going on the transit waiting lamp shows fixed light and when the transit call is disconnected the toll line is returned automatically to the position which lent it out, after which the transit waiting lamp is extinguished.

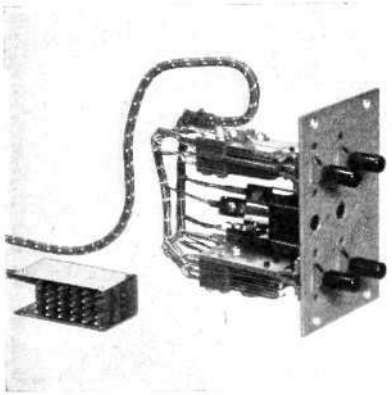


Fig. 11 N 4357
Switching unit for enquiry positions

For *group waiting* which is used on the large routes where the remote operator has access to a group of lines, the transit operator sets up the cord in a group waiting jack located alongside the multiple jacks of the line group. In the multiple of the switchboard group comprising the line group there

is then lit a group waiting lamp and the toll operators should as quickly as possible take down a cord and make a line free in the group, after which the transit operator gets a flashing cord lamp and transfers her cord to this line. In this case therefore the transfer key cannot be employed.

During all waiting the toll position local clearing lamp flashes and only goes out when the transit connection is fully established.

The carrier circuits have as a rule high input level and line pads are therefore inserted in their line equipments for traffic to the Helsingfors subscribers. For transit traffic these are disconnected and there is therefore no need to use repeaters for transit to or from a carrier circuit. Circuits with terminal repeaters can be dealt with in similar manner.

For repeater connections the line pads are not disconnected and the two toll lines are joined up direct over the repeater with its cord pair. After the joining, the circuit over the internal link between the toll position and the transit cord only functions as supervisory line and it is so designed that the operator has the same method of operation as for other traffic. The repeater cord pair is 6-wire, as it connects in the line balance to the repeater at the same time as it connects the line. The amplification is regulated automatically in sex stages for each line. The toll supervisor can by a key in her common equipment decrease the amplification one stage if required. The two transit positions, which are provided with multiple covering the whole exchange, each contain 15 transit cords with and 15 transit cords without repeaters. Each cord has a speaking key, a calling and a clearing lamp.

Traffic to direct subscribers

The greater part of the traffic over the internal links goes to the direct subscribers who are directly connected to the toll exchange. As the traffic on these lines is extremely high it was particularly desirable to save one selector stage and the lines have consequently as far as possible been put in the selector multiple of the internal link where there is space for 300 subscribers. As the first stage of erection only comprises 200 subscribers, there is already a certain amount of reserve, but the internal register is so connected that, should it prove necessary, 200 more subscribers can be connected in over final selectors which then are reached by the internal link.

All lines for direct subscribers are also put in a line finder multiple. These line finders have small registers so that the direct subscribers can, over their lines to the toll exchange, reach the recording and enquiry positions by means of routing digits.



X 6101

Fig. 12
Secret supervision room

Left, on the key shelf may be seen two recording machines for running control of number sending in incoming toll positions. The rack at the right holds call meters and call minute meters for traffic statistics

Traffic to the PABX Switchboard

The PABX switchboard which has a capacity of 400 extensions, is made on LM Ericsson's system with 500-line selectors and is equipped with all up-to-date facilities such as enquiry, transfer and night connection. Internal and outgoing exchange line traffic is dealt with automatically. For the incoming traffic from Helsingfors there is a manual switchboard which also has lines from the toll exchange, over which toll calls coming from outside places are handled. Moreover the automatic switchboard has also been provided with special toll final selectors connected in the internal *GLV* multiple, and the toll operators can thus also reach PABX extensions without the manual switchboard operator, which is chiefly done for calls recorded by PABX extensions themselves.

Enquiry and transfer over the toll and local exchange lines is done over the selector units *IFS, ITS, FAS* and *FMS*. Night connection is carried out over the night connection units *NK*, which contain selector pairs, of which the one sets itself to calling exchange lines and the other to a corresponding ringing cord of the operator's cord pair. These, which are lent for night connection and which are switched over to the *NK* units by means of press buttons, are set up by PABX operators in the multiple jacks of those extensions which are to be night connected.

Service Line Traffic

All operators can communicate with each other by selecting a service number over the internal link. For this the toll operators use a connecting circuit. All other operators, who have no connecting circuits, are connected to the internal line-finder multiple and select the number wanted by dialling. All operators are connected to a service selector multiple, the final selector of which is connected to the GLV-multiple of the internal link.

Traffic via the Queue Positions

As present arrangements are that an outgoing toll operator in general only deals with the traffic for one or some routes, special measures have been taken to deal with the case where a subscriber — as a rule a direct subscriber — orders a number of calls at a time. To avoid several operators trying at the same time to connect for this subscriber, the tickets are marked in a certain manner and the outgoing toll operator should then not connect directly to the subscriber but should pass what is called the queue positions, where she records the call. The queue operator knows how many calls come before and can give the approximate delay. A little while before the call can be connected the toll operator is informed over the service line and she con-

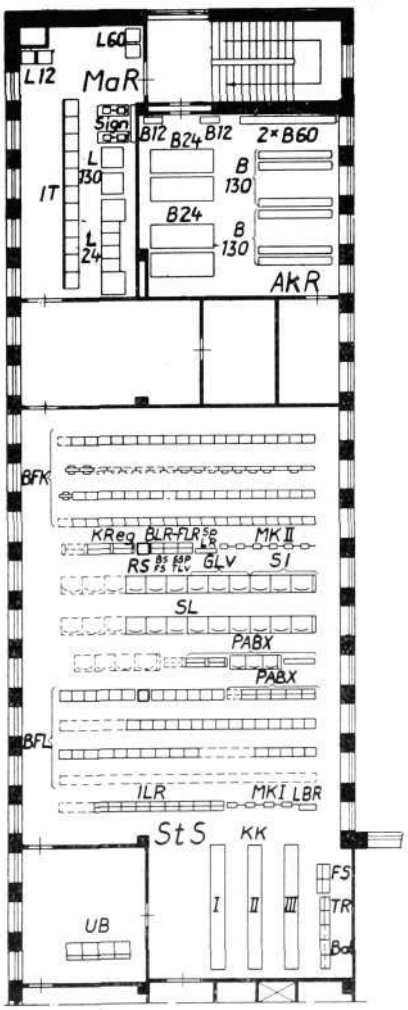


Fig. 13 X 4348

Lay-out of 4th floor comprizing

Automatic switch room StS with

KKI & II	main distribution frames for toll lines with line transformers
KKIII	main distribution frame for local lines
FS	repeaters
TR	relay sets for transit positions
Bal	balance rack for toll lines
ILR	toll line equipments
MKI	intermediate distribution frames
LBR	intermediate relays for blocking lamps
BFL	racks for 1-channel systems
PABX	PABX switchboard
SL	finders for traffic to Helsingfors local network
RS	register finders for keyset registers
BS, FS	finders for recording and enquiry positions
SSP	finders for direct subscribers
TLV	final selectors for service lines
GLV	combined group and final selector for internal links
SI	internal finders
KReg	keyset registers
BLR, FLR	line equipments for recording and enquiry lines
SPLR	line relays for direct subscribers
MKII	intermediate distribution frames for GLV-multiple
BFK	carrier multi-channel systems
UB	test desk

Machine-room MaR with

IT	power board comprizing 11 fields
L24	2 rectifiers — 24 V, 500 A
L12	2 » + 12 V, 27 A
L60	2 » — 60 V, 27 A
L130	2 » + 130 V, 45 A
Sign.	2 signal units for ringing current, buzzer tones etc.

Battery-room AkR with

B24	2 batteries — 24 V, 3 500 Ah
B12	2 » + 12 V, 110 Ah
B60	2 » — 60 V, 110 Ah
B130	2 » + 130 V, 180 Ah

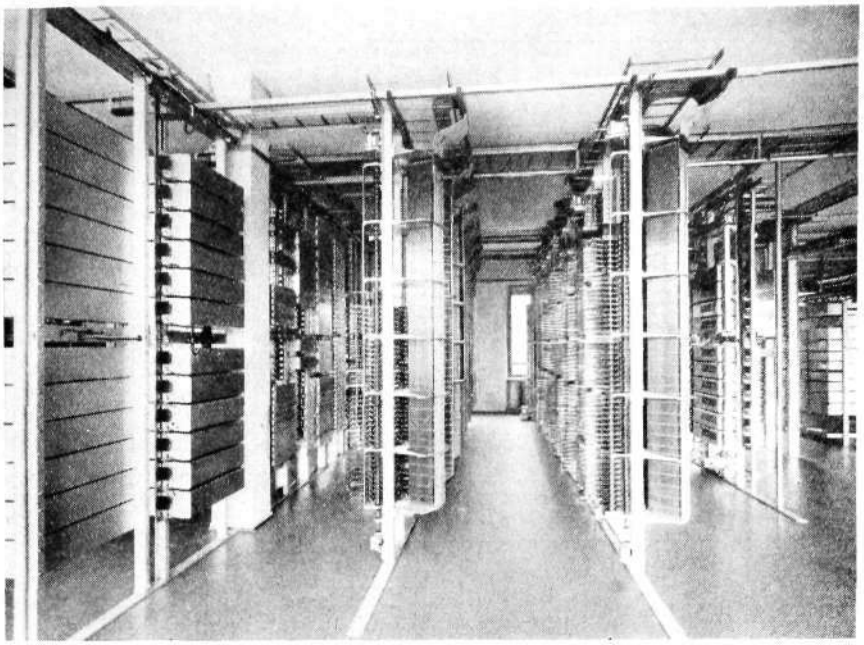


Fig. 14 X 6102
Interior view of automatic switch room

nects herself to a queue line over an internal link. In the queue positions the direct subscribers are connected in a multiple and the queue operator has for traffic to such a subscriber only to join up the queue line to the subscriber by means of a cord pair. For queue traffic to local subscribers in Helsingfors there are equipments similar to the connecting circuits of the toll positions. When the call comes into the queue line the queue operator answers it with an unoccupied cord and gets to know the subscriber wanted. When this subscriber becomes disengaged she inserts in the queue jack the plug of the cord connected to the wanted subscriber without disconnecting him. After the queue operator has established the connection the whole supervision of the call is passed over to the toll operator and the queue operator has only to await clearing signal from the toll operator.

Recording and Enquiry Traffic

All recording from local, direct subscribers and PABX subscribers is conveyed to the recording positions via finders which distribute the traffic. For enquiry there is likewise a line bunch which is connected over finders to the enquiry positions. Two positions are combined recording and enquiry positions and are so connected that they work normally as recording positions but are switched over to enquiry positions if all the others are busy. If there are no other recording and enquiry positions free they can function either as one or the other. In this way there is facility for progressive concentration before the whole recording and enquiry traffic is transferred to the night concentration positions.

To enable transfer of calls to be done from the recording to the enquiry positions, the recording lines are also connected to the enquiry finder multiple. For the transfer the recording positions are equipped with two keys, one for general enquiry and one for price enquiry, while the general enquiry positions have only one key for transfer to price enquiry.

All recording and enquiry operators have devices for outgoing traffic over the internal link to the service lines as well as devices for incoming service traffic. In addition, the enquiry operators can, over the local finder multiple, get into connection with the local network, as these operators must, with a view to obtaining complementary information, be able to call all subscribers. Moreover the recording and enquiry operators have for each two an extra inlet in the internal finder multiple, over which delay enquiry can be made.

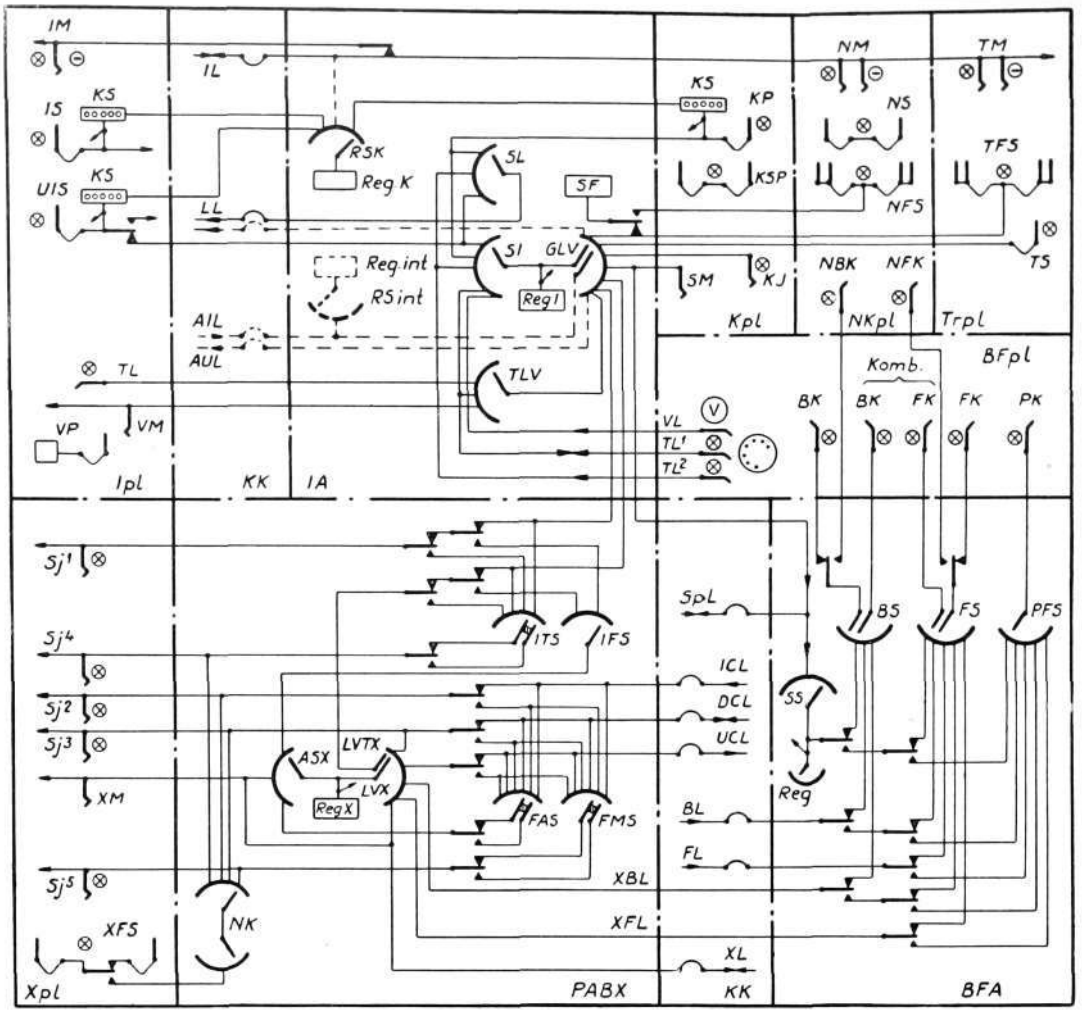


Fig. 15 X 7384
Distribution diagram

KK Main distribution frames

- IL manual toll lines for incoming and outgoing inland traffic and international traffic
- AIL and AUL future incoming and outgoing automatic toll lines
- LL junctions to Helsingfors local network
- SpL direct subscribers lines
- ICL, DCL and UCL incoming, both-way and outgoing exchange lines for PABX switchboard
- XL PABX extensions
- BL recording lines
- FL enquiry lines

Ipl Toll positions

- IM toll multiple
- IS connecting circuits for inland positions
- UIS do with double exits for international positions
- KS keysending sets
- TL service lines for toll and queue positions
- VM delay multiple
- VP delay potentiometers

Kpl Queue positions

- SM multiple for direct subscribers
- KJ queue lines
- KSP cord pairs for queues to direct subscribers
- KP single cords for queues to Helsingfors subscribers
- KS keysending sets

Nkpl Night concentration positions

- NM toll multiple with balance multiple
- NS cord pairs without cord repeaters
- NFS do with cord repeaters
- NBK and NFK answering devices for recording and enquiry traffic

Trpl Transit positions

- TM toll multiple with balance multiple
- TS single cords without cord repeaters
- TFS cord pairs with cord repeaters

BFpl Recording and enquiry positions

- BK, FK and PK answering devices in the positions for recording, general enquiry and price enquiry
- Komb combined recording and enquiry positions
- TL 1 both-way service lines with dial for recording, enquiry, night concentration, transit and PABX positions
- TL 2 outgoing service lines for general enquiry and price enquiry positions
- VL devices with voltmeter V for delay enquiry in recording and general enquiry positions

Xpl Manual PABX switchboard

- SJ 1 answering jacks for manual toll exchange lines
- SJ2 and SJ3 answering jacks for incoming and both-way exchange lines to Helsingfors
- SJ4 and SJ5 answering jacks for manual enquiry lines for toll and local exchange lines
- XM extension multiple
- XFS cord pair, switchable to night concentration

IA Automatic devices for toll exchange

- SL finders for junction lines to Helsingfors local network
- SI finders for internal routes
- GLV combined group and final selectors for internal links and future incoming aut. toll lines
- RegI registers for internal links
- TLV final selectors for service lines
- RegInt and RSint registers with register finders for aut. incoming toll lines
- RegK and RSK keyset registers with register finders. Those toll lines that have aut. night traffic are provided with special equipments connected to the RSK multiple
- SF cord repeaters, of which a number can be switched over to the night concentration positions

BFA Automatic devices for recording and enquiry traffic

- SS finders with registers Reg for direct subscribers
- BS recording finders
- FS general enquiry finders
- PFS price enquiry finders

PABX Postal buildings automatic switchboard

- ASX line finders
- LVX final selectors
- LVTX final selectors for aut. toll exchange lines
- RegX registers
- ITS and IFS manual and aut. enquiry lines for toll exchange lines
- FMS and FAS do for local exchange lines
- NK night concentration units
- XBK and XFL recording and enquiry lines

Night Concentration

Above it has been indicated how the progressive concentration takes place in the toll board and recording rooms. When traffic has decreased sufficiently the traffic is transferred to the night cencentration positions. The calls from the toll lines are then switched over to call lamps in the night concentration positions, while at the same time the relay sets for those toll lines that have remote selection for night traffic are switched over so that remote impulsing can be done from the concentration positions. For this the keysending set is first connected on the local side and after the local number has been sent it is transferred by means of a special key to the toll side. After the keyset register has been connected to the relay set of the night connected toll line, a toll register supervision lamp lights up and the composing of the toll numbers can proceed no matter how far the register which connects on the local side has got.

From the recording positions there are borrowed a number of distribution finders for recording and enquiry and from the transit positions a number of cord repeaters to the night concentration cord-pairs. For handling the traffic the night concentration positions are equipped with

3×8 single cords with routing keys for traffic to the Helsingfors network, direct subscribers and PABX extensions

3×2 cord-pairs with single plugs without cord repeaters

3×2 cord-pairs with double plugs with cord repeaters

At each position in addition there are answering circuits for recording and enquiry calls.

Operator Supervision

Besides the secret supervision — see page 136 — the supervisors of the toll board and recording rooms have been equipped with the customary supervisory devices. Thus the supervisor positions have for each position that is to be supervized a jack connected to the operator's speaking set and lamps that are connected in parallel with the operator's pilot lamps. The lamps in the supervisory position normally are not burning. They are only connected in when a position is to be supervized.

The supervisor's desk in the toll board room contains in addition a number of lamps which indicate if all lines in a line group are busy, e. g., junction lines to the local network, internal links.

In the supervisor desk of the recording room, supervizing lamps light up if all enquiry or recording positions having operators in attendance are busy and calls are waiting. Each recording and enquiry line has a lamp which lights up if it takes too long a time for a call to be answered. In addition there is for each position a press-button and a lamp so connected that the supervisor receives signal if an operator in an attended position disconnects her speaking set in order to block her position for calls.

In the toll board room there are besides the two supervisors a number of sub-supervisors who directly supervize the work in the toll board room and intervene if any trouble arises. To enable toll operators when necessary more easily to get in touch with these subsupervisors there is in each group of toll positions a supervisory device with the necessary service line, which is multipled to answering jacks in the multiple of the group. The sub-supervisor can answer a call after plugging her handset into the nearest answering jack.

Control of Load

The connecting devices of the various groups are equipped with circuits for traffic statistics. The number of calls is recorded on call meters and the total call time on call minute meters located in the same room as the secret supervision. In addition the head of the exchange has at his disposal two recording

6-colour printers with which it is possible to record simultaneously the momentary load in 12 different groups. The statistics cover not only calls connected but also those that are lost because of shortage of operators or connecting devices.

Operator Training School

For training new operators a training room has been fitted at the toll exchange, comprizing three toll positions, one transit position, one recording and one enquiry position, together with six instructor positions. By means of press-buttons and signal lamps the instructors are able to produce the different stages of operation and check that the pupils execute the work of operation in a correct manner.

Operating Qualities of the Exchange

In general it may be said that the exchange fulfils the conditions set up when planning it. Operators for incoming calls can deal with 6—7 connections during the heaviest traffic time. In the outgoing positions an average of 4 connections per operator is handled.

To characterize in some degree the efficiency of the automatic devices it may be stated that the time required to establish a connection to a wanted local subscriber amounts on the average to 11 s. These tests were carried out in busy time and for several different operator positions. This time is obviously dependent on the power of concentration and the speed of the operators.

Although the total call time per circuit and hour is not solely dependent on the construction of the exchange equipment it may be stated that with the above number of operators the utilization time per toll line amounts to a mean of 39 min/h. The average length of call in busy time is 5.5 min. By means of a large number of measurements, attenuation conditions have been ascertained and the following results may be of interest.

Crosstalk attenuation at 1000 c/c between two transit connections is at least 9 N, even if all connection devices are selected with the talking circuits as near as possible to each other in the wiring. For a toll connection to a Helsingfors subscriber the effective attenuation in the exchange is not more than 0.019 N at 1000 c/s and zero-level. In this are not included the attenuations for the toll line transformer and toll line pad. When the operator enters a call with the speaking key the effective attenuation is increased to 0.28 N, but remains at 0.045 N if the listening key is employed.

Summary

By building the new exchange on the semi-cordless system adopted, the following advantages have been attained:

By constructing the exchange as a group exchange where the capacity of the groups is sufficiently large, the exchange has received the many-sided flexibility of the multiple exchange without the construction of the switchboards becoming high and clumsy, which is of benefit for the supervision of the exchange. Enlargement of the exchange is easy to carry out by the addition of new groups, as no changes or work are required in the groups already existing.

All the toll positions in the exchange are alike as regards mechanical construction and circuits, which is an advantage for the operation.

No special partial concentration positions are required, and yet the number of operators can be smoothly adapted to the magnitude of the traffic. The operators are well utilized thanks to the multiple lamp system.

In the exchange there has been no need to arrange any separate ranging boards between the toll line relay sets and the toll positions, which is always an expensive and troublesome matter.

As it is possible for the greater part of the day to leave the toll cords plugged in the toll jacks of the outgoing positions, the method of working is in general as convenient as with an entirely cordless system.

Toll lines can be temporarily handled in any position belonging to the same group and outgoing lines can easily be changed to incoming or vice versa, which may be of great use in case of fault and the like.

Change over to no delay traffic on the routes where the line bundles are sufficiently large is easy to carry out, as each position has the facility of handling any line whatever belonging to the group, if the plugs are taken out after the close of the call.

Loud-speaker Telephone

G THAMES, TELEFONAKTIEBOLAGET L M ERICSSON, STOCKHOLM

U.D.C. 621.395.623.8:621.395.721

As a step in efforts to make work in offices and similar places of employment more efficient, various systems conveying speech by loud-speaker devices of one kind or another have in recent years been introduced for intercom telephone traffic. The loud-speaker device, adding much to the comfort and facility of work, has undoubtedly very largely contributed to the great prevalence of these plants. Nevertheless, no similar device for the telephone instrument connected to the telphone exchange was available until Telefonaktiebolaget L M Ericsson put on the market a new type of telephone instrument, given the name of loud-speaker telephone, which is described in the following article.

In 1885 the first handset was introduced by LM Ericsson: the transmitter and receiver combined together in a single unit. Up to that time the transmitter had been fixed on the telephone instrument and only the receiver was flexibly connected to the instrument by a telephone cord. People using the telephone, who previously had their freedom of movement restricted by the fixed transmitter, were now less restricted by the location of the telephone instrument, their movements being only limited by the length of the handset cord.

Today we have advanced a step further. In LM Ericsson's loud-speaker telephone it has been possible to replace the handset by a loud-speaker and a table microphone transmitter and in this way a person telephoning has full freedom of movement. Nothing now ties him to the telephone instrument; he can move freely about the room and carry on a conversation just as if the other person were present. What that means for the comfort of those telephoning is obvious. Notes can be made, papers can be looked through



Fig. 1 X 6132
Loud-speaker telephone
from left to right loud-speaker RLE 1001, amplifier ZGA 1001, telephone instrument DBH 2511 and microphone RLC 1001

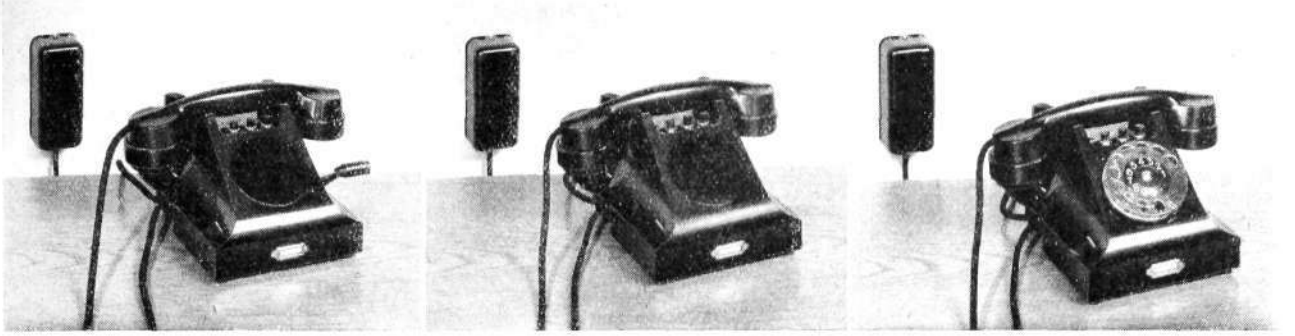


Fig. 2 X 7380
Telephone instruments
left, DAH 9902 for L.B.-system; middle DBH 2411 for manual C.B.-system; right, DBH 2511 for automatic C.B.-system

and so on, without interference from the handset. In addition the advantage is gained that other persons in the room can take part in the conversation, thus troublesome and tedious references and repeating need not be done.

The loud-speaker telephone installation, Fig. 1, which comprizes four parts: microphone, loud-speaker, amplifier and telephone instrument, may be connected to both LB-system and CB-systems, manual and automatic.

The loud-speaker telephone, modified to suit the conditions of the Swedish Telephone Administration, has been approved by the Royal Swedish Board of Telegraphs for connection to the national telephone network.

Employment

Conversation is normally carried on by means of the microphone and the loud-speaker; call is answered by pressing one button and when the conversation is finished another button is pressed.

No further manipulation need be done by the speaker while the conversation is going on, unlike those amplifier installations with talk-listen key in which the speaker must during the conversation switch over each time he wants to hear the other speaker. The loud-speaker telephone amplifier is so balanced that speech is conveyed unhindered in both directions, so that no special care in talking need be observed, as is the case with those systems where the acoustic cross-talk is prevented by automatic echo-supressor. Apart from the fact that syllables and complete words may be lost during conversation on this systems, it is impossible to carry on a conference if those taking part should happen to talk together at the same time, but conversation is not so prevented when the amplifier is balanced as in the LM Ericsson system.

There are some calls, however, such as those of a confidential nature, which cannot conveniently be carried on with the loud-speaker telephone if a visitor is present. The loud-speaker installation has therefore been supplemented by a telephone instrument, the handset of which on being lifted automatically disconnects the microphone and the loud-speaker, after which the *call can be carried on unhindered with the handset.*

Fig. 3 X 6052
Diagram for loud-speaker telephone
with telephone intrument DBH 2511 för automatic C.B.-system
AS switch
BZ buzzer
C condenser
D dial
EB extra bell
IC transformer
L microphone lamp
L_1 line
LK left-hand button
LS loud-speaker
M_1 microphone
M_2 microphone
MK middle button
R receiver
R_1 connecting-in relay
RK right-hand button

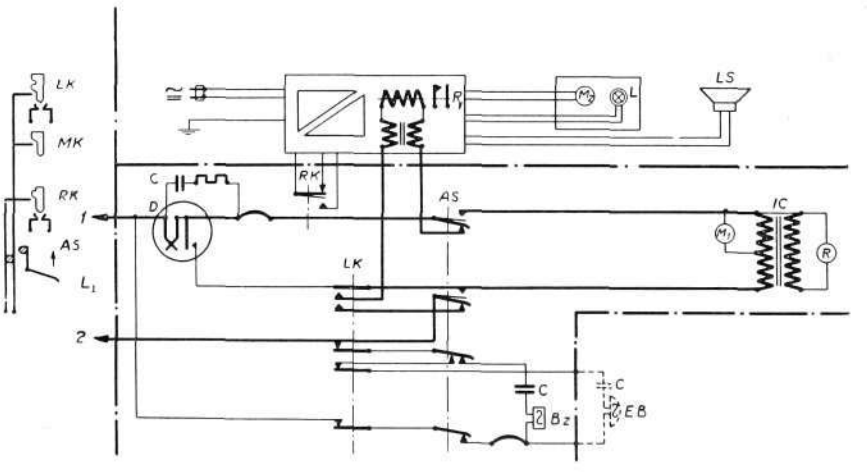
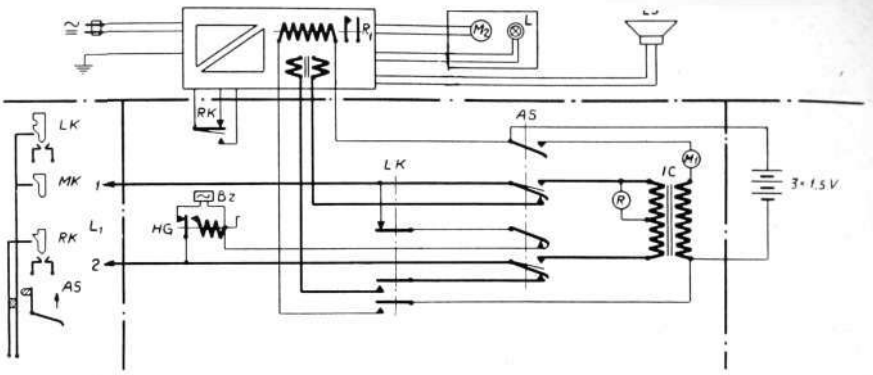


Fig. 4 X 6084

Diagram for loud-speaker telephone with telephone instrument DAH 9902 for L.B.-system

AS switch
BZ buzzer
C condenser
IC transformer
HG magneto generator
L microphone lamp
L_1 line
LK left-hand button
LS loud-speaker
M_1 microphone
M_2 microphone
MK middle button
R receiver
R_1 connecting-in relay
RK right-hand button



Telephone Instruments

The telephone instruments, see Fig. 2, are, in addition to the components distinctive for the LB- and CB-systems, furnished with three press-buttons at the top of the case. The press-buttons have the following functions, Fig. 3—4:

the left-hand button (LK) connects in the speech to the amplifier
the right-hand button (RK) intensifies the amplification of the incoming speech
the middle button (MK) releases the other two.

A call can be answered after pressing the button on the left hand side—but the call can also be answered when the hand-set is lifted at which the set will function as a regular telephone set.

As already stated, a call which is being carried on with the microphone-loudspeaker is automatically connected over to the telephone handset when this is lifted. The handset has, however, still another function, namely to ensure complete operating reliability for the installation. For this reason the telephone instrument has been so designed that it is entirely independent of the amplifier and consequently any failure in the electric mains does not affect the facility of carrying on conversation with the handset. If the handset is used and it is desired to change over to the microphone-loudspeaker the left-hand button is held pressed down while the handset is being replaced.

The sound intensity of the loud-speaker may be increased as required by pressing down the right-hand button. Return to the lower sound intensity is done by pressing the left-hand button right down to the bottom, which releases the right-hand button. At the close of a conversation the handset is replaced in the ordinary way or, if the conversation has taken place over the microphone-loudspeaker, the middle button is pressed.

Microphone

The sound collecting device of the microphone is a dynamic loud-speaker with permanent magnet. This is fitted in a wooden case at the front of which is an indicator lamp which lights up when the microphone is con-

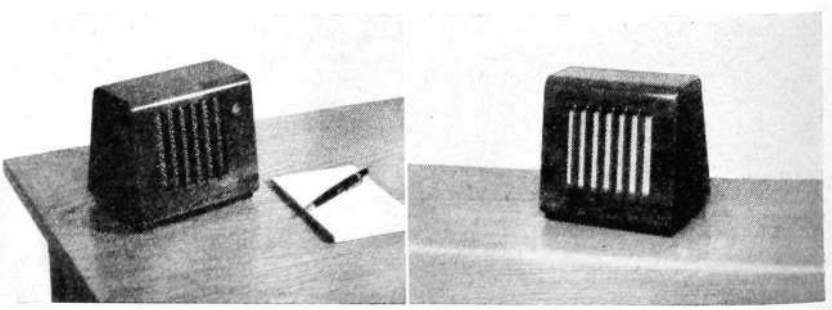


Fig. 5 X 6097

Microphone RLC 1001 (left) and loud-speaker RLE 1001 (right)

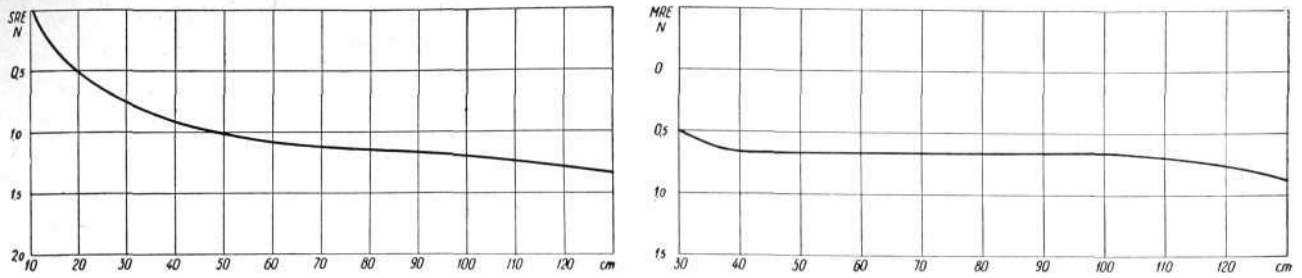


Fig. 6 X 7382

Reference equivalents for transmitter and receiver

left, transmitting reference equivalent against SFERT (SRE) for microphone RLC 1001 as function of the distance between the microphone and the sound source
right, receiving reference equivalent against SFERT (MRE) for loud-speaker RLE 1001 as function of the distance between the loud-speaker and the listener

nected, Fig. 5 at left. Should the speaker omit to press the middle button after a call, the lamp serves as a reminder. Moreover any visitor can see at once from the indicator lamp as he enters a room if a call is proceeding.

As may be seen from Fig. 6 at left, distances greater than 50 cm between the speaker and the microphone do not appreciably affect the sending efficiency. This means that if a number of persons are taking part in a conversation, differences in their distances from the microphone do not affect the sending efficiency. On the other hand the reponse shows that the shorter the distance is than 50 cm the stronger will be the transmitted effect. This means sending efficiency. On the other hand the response shows that the shorter the speaker has a possibility of augmenting the sound intensity without raising his voice by speaking closer to the microphone.

The microphone has practically the same sensitivity in all directions, as may be seen from the circular form of the direction response, Fig. 8, left. It does not matter very much, therefore, if the speaker happens to be a little to the side of the microphone.

In Fig. 7 are shown the frequency response of the electro-dynamic microphone and the corresponding response for a carbon granule transmitter. As may be seen, the response for the former has a more even shape without any marked resonance peaks. The co-efficient of non-linear distorsion for a carbon granule transmitter is moreover many times greater than that of an electro-dynamic microphone. This, together with the absence of noise from the carbon granules, makes the sound quality and therefore the intelligibility good.

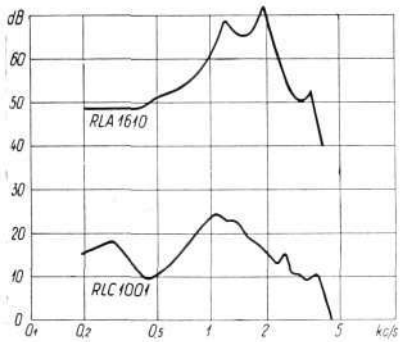


Fig. 7 X 4351

Characteristics of microphone RLC 1001 and carbon granule transmitter RLA 1610

Level above 1 mV E. M. F. at 1 n/m² (10 μb) and the microphone matched with 600 Ω
0 dB = 1 mV.
RLA 1610 is fitted in handset with funnel-mouthpiece

Loud-speaker

The loud-speaker is likewise dynamic with permanent magnet and is fitted in a wooden case similar to that of the microphone, see Fig. 5 at right.

Fig. 6, right, shows the sound intensity delivered as function of the distance from the listener. The response shows that the volume is constant between 40 and 100 cm after which it falls off somewhat.

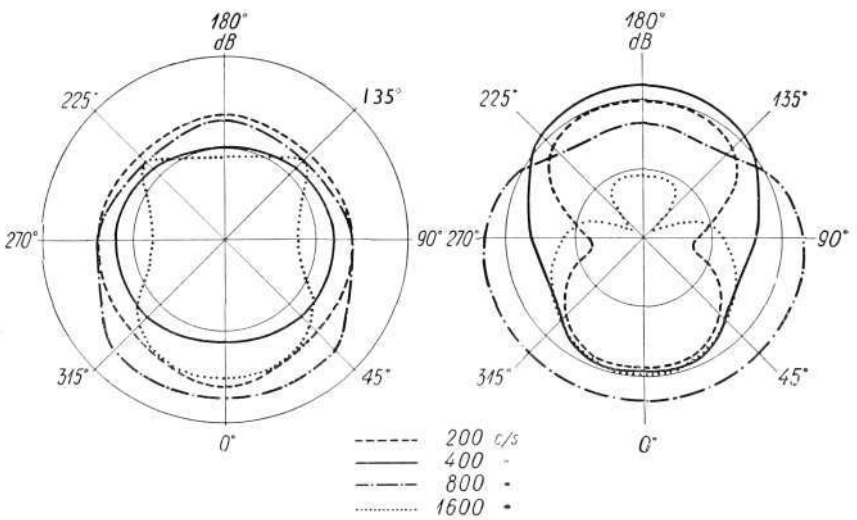


Fig. 8 X 6086

Direction characteristics for, left, microphone RLC 1001 and, right, loud-speaker RLE 1001

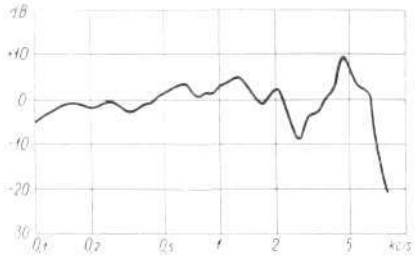


Fig. 9 X 4353

Characteristics for loud-speaker RLE 1001

Level above 0.1 n/m² (1 μb) at 60 cm distance with 1 V impressed voltage
0 dB = 0.1 n/m² (1 μb)

The direction responses for the loud-speaker, Fig. 8 at right, show that the sound intensity in a forward direction is approximately the same wherever one happens to be in relation to the loud-speaker, which is important when a number of people are listening.

The frequency response, Fig. 9, as may be seen, is fairly flat within the voice frequency range, so that sound reproduction will be natural and the sound intensity for all frequencies of approximately the same magnitude.

The loud-speaker reproduces incoming speech clearly and distinctly so that intelligibility will be of the best. Intelligibility and sound intensity are of course dependent on the microphone of the other speaker and line attenuation. If there is great line attenuation this may be compensated by pressing down the right-hand button on the telephone instrument, which augments the loud-speaker sound intensity by 1 neper.

Amplifier

The amplifier, see Fig. 10 and diagram Fig. 11, is a balanced two-way amplifier with an amplifier stage for each of the microphone and loud-speaker circuits and with a hybrid coil to which the line is connected.

For regulation of the amplification levels of the transmitted and received effect there are two screws inside the case.

As the loud-speaker telephone must always be ready for immediate use the valves are kept constantly warmed up. The valves are so connected, however, that the filament current is smaller when the valves are not in function, which appreciably increases their length of life. The filament current is only increased to its full strength by a relay when the microphone-loudspeaker is connected in. Thus current consumption is 0.1 A during conversation and 15 % less in rest periods.

The amplifier is connected direct to the electric lighting mains over a wall tapping and is independent of the nature of current. It is adjustable for tensions 110—130 V, 135—150 V and 220 V. The current can be disconnected by the switch on the front of the amplifier, see Fig. 10. The lamp at the right of the switch lights up when the current is connected.

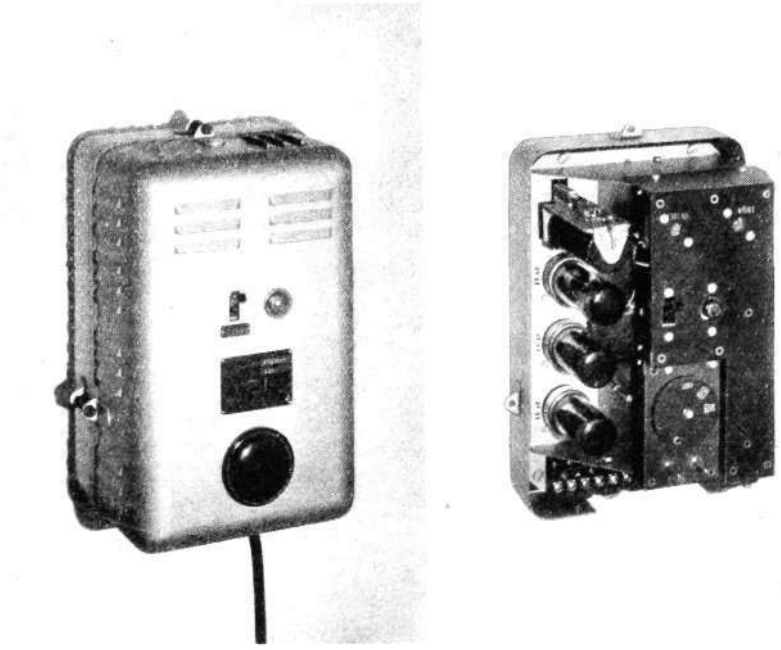
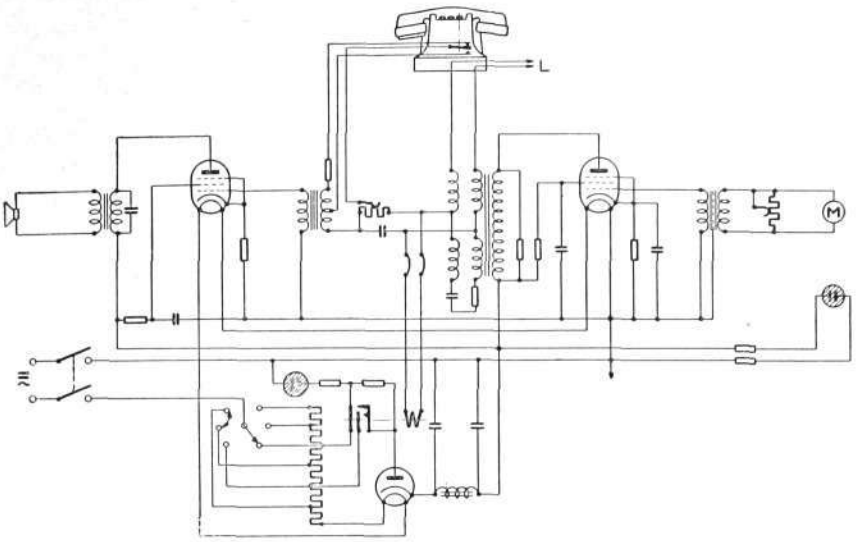


Fig. 10 X 6052

Amplifier ZGA 1001

left with and right, without cover



X 6090

Fig. 11
Diagram of amplifier ZGA 1001
L line
M microphone

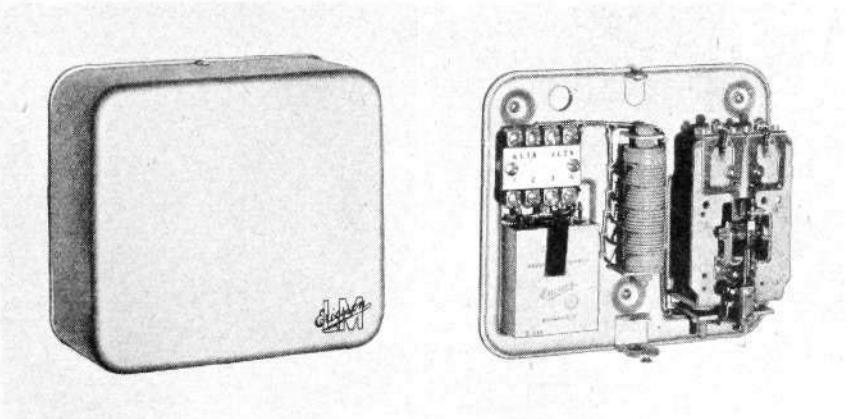
All tension carrying parts are protected against tampering and the cover cannot be removed without disconnecting from the mains. The amplifier is approved for connection to mains by the Swedish Electrical Material Control Institute.

The cable bushing placed in the lower part of the case is divided in two to facilitate fitting the cables. Both halves of the bushing have at one side milled grooves to hold them to the case and when the cover is put on the two halves are pressed together so that the cables are held in place. The cables terminate in blocks in the lower part of the amplifier.

Signal Repeater

The loud-speaker telephone may be equipped with a signal repeater which automatically repeats signals to a sub-instrument if the call is not answered. The sub-instrument is usually put beside a secretary. In this way the caller can have his call answered and give or receive information.

The signal repeater, Fig. 12, is of the same construction mechanically as that described in Ericsson Review, Special Number 1945, but differs from it as regards connecting. The signal repeater KFB 1001 can only be employed in conjunction with the loud-speaker telephone and cannot be connected to LM Ericsson's ordinary telephones.



X 6096

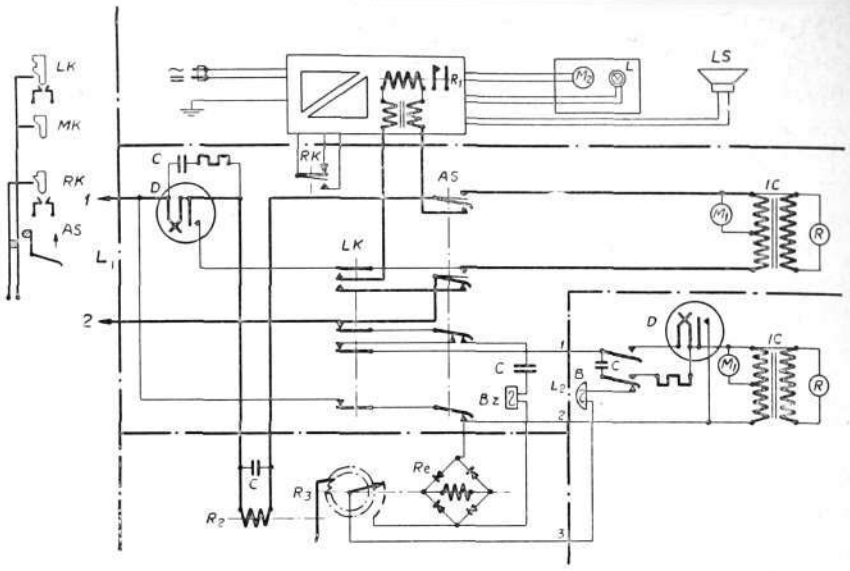
Fig. 12
Signal repeater KFB 1001
left with and right without cover

Fig. 13 X 6091

Connecting diagram for loud-speaker telephone installation

with telephone instrument DBH 2511 and signal repeater KFB 1001 and sub-instrument DBH 1101

AS	switch
B	bell
Bz	buzzer
C	condenser
D	dial
IC	transformer
L	microphone lamp
L_1	loud-speaker instrument's line
L_2	sub-instrument's line
LK	left-hand button
LS	loud-speaker
M_1	microphone
M_2	desk microphone
MK	middle button
R	receiver
R_1	connecting relay
R_2	releasing relay
R_3	step-by-step relay
Re	rectifier
RK	right-hand button



The principle for the signal repeater may be seen from Fig. 13. On call the two first signals sound only in the loud-speaker instrument. The third signal and all succeeding ones are heard in both instruments and the call can now be answered in the sub-instrument as well. When once the signal has been switched over the first signals of any new call will go to both instruments. It is not until the loud-speaker telephone is again used that the sub-instrument is disconnected.

Valby Station, a New Safety Plant in Copenhagen Local Railway Traffic

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U.D.C. 666.257

During the war no electric safety installations were built in Denmark besides those which were already planned and ordered in 1940. The latest and most up-to-date one is Valby station which was put into service in September 1941, at the same time as the electrified local traffic of Copenhagen was extended to the Valby—Vanløse section.

The safety installation took the place of an older electric safety plant which had been in operation since 1911 and therefore was ripe for replacement.

The new electric safety plant was supplied by Signalbolaget, Stockholm, in conjunction with L M Ericsson A/S., Copenhagen, and Dansk Signal Industri A/S., Copenhagen. The installation is built up on the principle of standardization introduced by the Danish State Railways for the construction and diagrams of safety plants and it is the first of the new plants of this kind delivered by L M Ericsson.

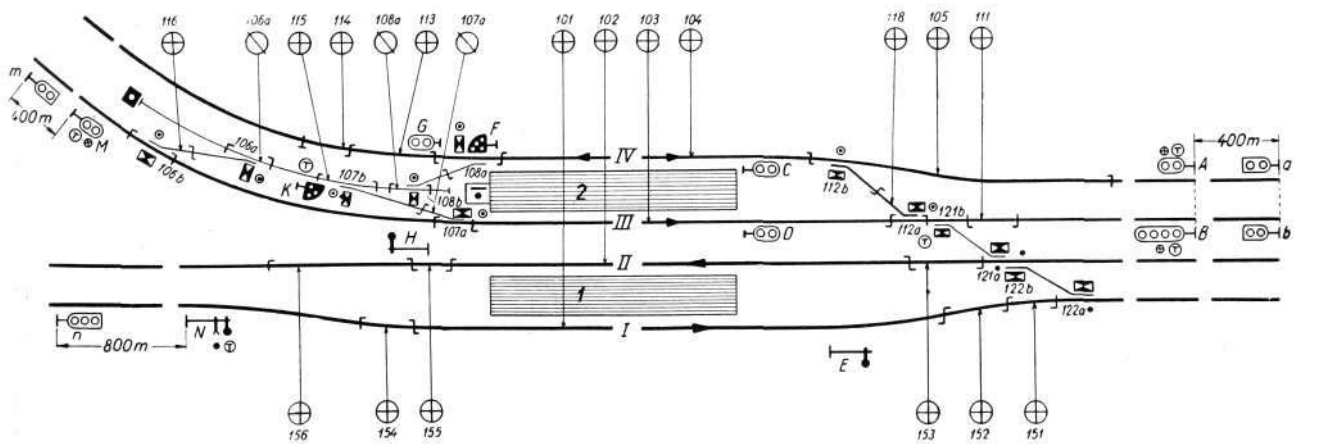
The plant is made with interlocking apparatus for electric operation and with mechanical connections between the levers, with track relays of enclosed design and other relays in the standard unenclosed design of the Danish State Railways. The track insulation is for the most part applied only in the passenger train tracks, which are used by the Danish State Railways at the smaller stations as train succession locking.

Fig. 1 X 7385
Track diagram

- Semaphore, main line entrance with »run-through» arm
- Semaphore, departure signal
- red / green / yellow / green — Daylight signal, main line entrance with »run-through» indication
- red / green — Daylight signal, main line entrance without »run-through» indication or departure
- green / yellow / green — Distant signal (»advanced»), flashing, three readings
- yellow / green — Distant signal, two readings
- Dwarf signal for shunting
- Track insulation with relay
- Track insulation with point locking magnet

Valby station is a busy suburban station in the Copenhagen local traffic, and, besides, there is considerable movement of passengers from the main line to the electric city line.

The station is provided with a turn-table and may thus be utilized also as departure station for the electric trains.



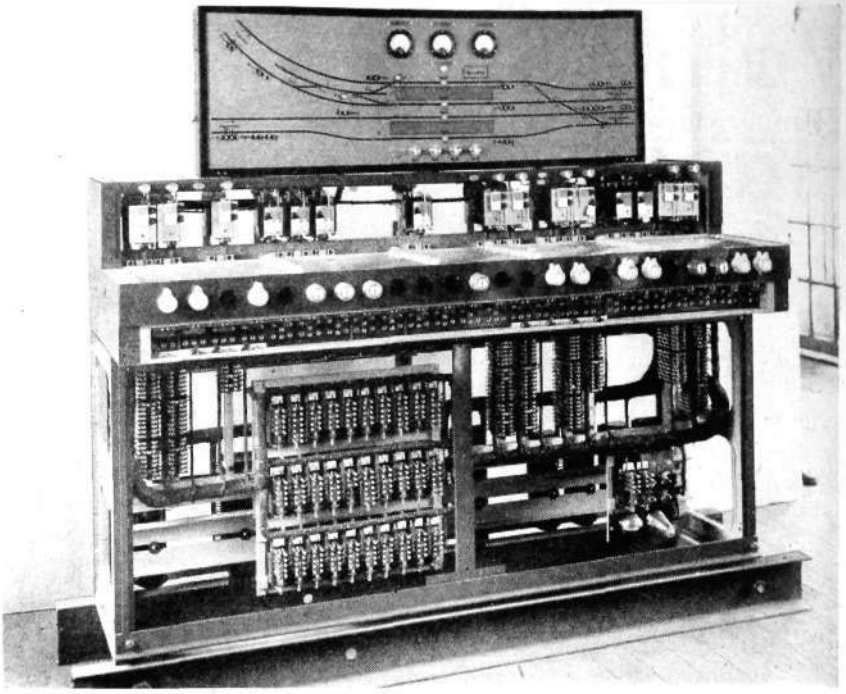


Fig. 2 X 6103
Interlocking apparatus (open) with track diagram above

In the local traffic, tracks III and IV, the station is used solely by electric trains running at intervals of 20 minutes. For main line traffic, tracks I and II, in addition to local trains for Roskilde, the station is used by all main line trains including express trains over the Copenhagen—Roskilde section, the most important line section in Denmark.

It is not the intention here to give any exhaustive description of the safety plant and its importance as this would take up too much space, and, besides, the safety plant is built on principles that are well known. The chief aim of this article is to describe certain special conditions with this safety plant as well as various new devices and constructions employed and certain details which will no doubt be of interest in connection with other plants.

As a general introduction there is shown in Fig. 1 a track diagram which illustrates the extent of the station, its signals etc. In view of the electric traction line network there are employed daylight signals for local traffic, signals for main line traffic being normally semaphores. In this case, however, the entrance signal at the east end of the station is also a daylight signal owing to the lay-out of the traction line which prevents good visibility with a semaphore. All points are electrically operated except in the emergency crossing which connects the local and the main line sections and in the crossing in the main line track where the points are locked by motor locks. To and from the return track at the west end of the station running takes place over special shunting roads, for which reason dwarf signals *F* and *K* are provided.

Construction

A modern safety plant at a station of moderate size is generally built up with through running track insulation so that supervision of the train tracks can be done by switching the lamps on a track diagram in the signal cabin. But owing to the simple traffic conditions, with practically no shunting, Valby station is not completely through-insulated; the train tracks are only provided with track insulation for the length of the platforms which, however, at the east end of the station stretches to the above track crossing, while track IV is through-insulated at the east end of the station owing to poor visibility from the signal cabin which is situated at the western end of platform 2.

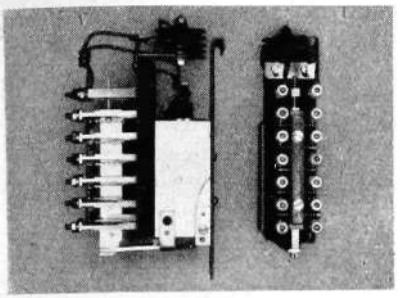


Fig. 3 X 4358
Interlocking apparatus relay with 6 contacts, for suspension on iron brackets in the interlocking apparatus or relay box (with adjoining rectifier)

The track insulation in the platform tracks is utilized as track succession locking, in order to obtain a guarantee that the preceding train has left the platform track when signal is given for the following train. In Fig. 2 may be seen the interlocking apparatus above which the station track diagram is set up. The station being, as stated, not completely through-insulated, there are on the track diagram lamps only for the insulated track sections with track relays (enclosed relays) and lamps for all signals. On the track diagram there are, in addition to instruments, a number of auxiliary press-buttons which are used for manipulating the above mentioned insulated track sections in case these are out of order; it is thus possible in any case to set the signals for the track concerned, naturally observing the special precautions for supervision of the track area in question. The interlocking apparatus is shown open at the factory when it is fully fitted.

In the interlocking apparatus there are fitted a number of interlocking apparatus relays (unenclosed relays according to the Danish State Railways' specifications, made by Dansk Signal Industri A/S), mainly releasing relays, while the majority of the interlocking apparatus relays are fitted in a separate box which will be referred to later. The relays are placed with the view to obtain the shortest possible drawing of lines. In Fig. 3 there may be seen an interlocking apparatus relay with a fitting for suspension on an iron bracket. Fig. 6 shows the interlocking apparatus, which has 24 panels, installed in the signal cabin. Behind it the relay box is shown.

In view of the electric line, which is fed with 1500 V direct current, the safety plant is made without earthing point, for the cable-installation in the lower room, special regulations are consequently applied, which will be referred to later.

The plant utilizes the new State Railway point machine, type DSB 1940, which has 3 fuses: Motor current fuse 10 A and 2 control current fuses of 0.3 and 0.7 A respectively, the last mentioned one being fitted on a special fuse strip in the interlocking apparatus together with the rectifier belonging to the point machine circuit. Point machines are of the type with built-in lock; the deflection of the point of blade is 150 mm (later experiments have led to the State Railways deciding to adapt a deflection of the point of blade of 160 mm).

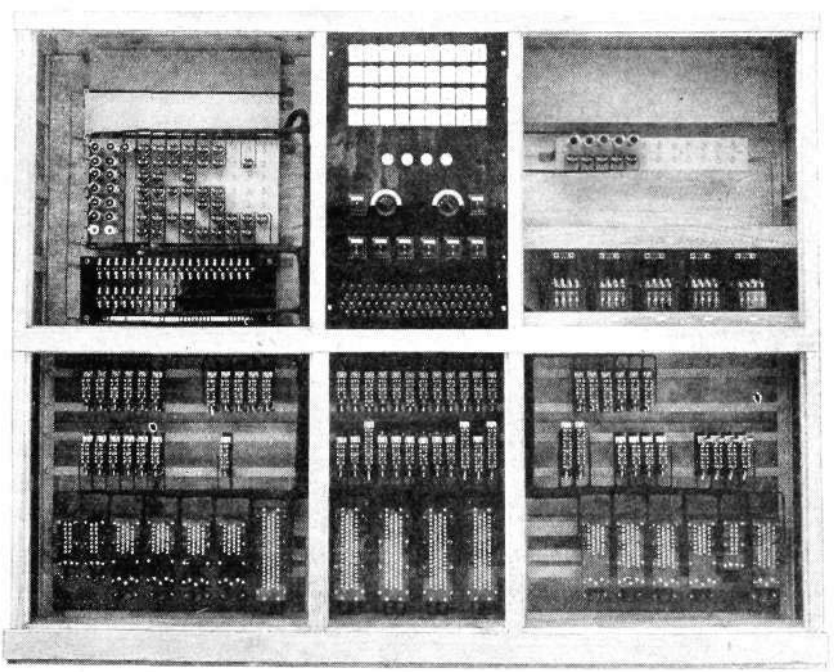


Fig. 4 X 6106
Relay box
(open); top left, resistance panel. In the lower room there are two rows with open relays, and below them terminal sleeves.

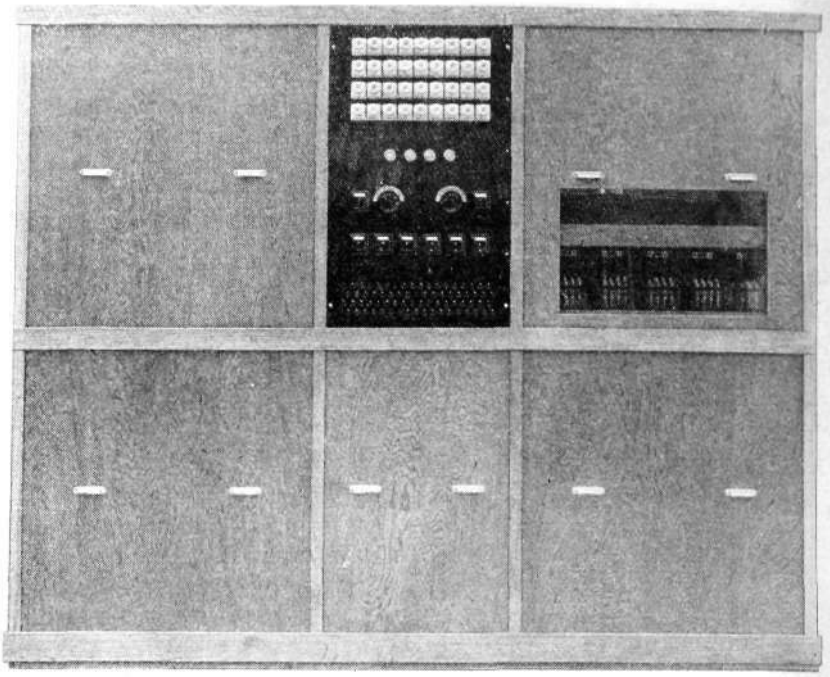


Fig. 5 X 6105
Relay box
closed; in the middle, distribution board, to the right, glass window behind which may be seen the enclosed track relays

Both double tracks are provided with manual line blocks, which, however, for the Valby—Vanløse section are not yet completed. The old block apparatus of the station have been used for this purpose.

Power Supply

The power plant consists of 2 motor batteries, 136 V, which are charged by way of a converter from the city mains (A.C.), whilst the control battery, 34 V, which is charged by way of a action buffer is charged by way of a dry cell rectifier connected to the mains. It should be observed that this power plant from the old safety installation has remained unchanged in essentials and is still housed in the same place in the cellar of the main building, though the machine room and the accumulator room have been brought up-to-date.

The power supply to daylight signals, track insulation and lighting is obtained from transformers fitted in a relay box behind the central apparatus in the signal cabin. In Fig. 4 the relay box may be seen partly opened. This photo was taken while the relay cabinet was in the factory ready assembled. The transformers, to be placed at the left hand side at the top, are not fitted in until the relay box is put up in the signal cabin. Below them resistances and knife fuses are fitted. To the right in the box are the track relays, which are D.C. relays with built-in rectifier. The lighting switchboard is fitted with swing panel in the middle section of the box. In the lower part of the box there are interlocking apparatus relays and terminal sleeves; among the terminal sleeves there may be seen in the middle a new type for 2 cables for use with intermediate cables. The relay box, constructed in light oak, looks very nice, see Fig. 4 which shows the smart exterior of the box. The interlocking apparatus is supplied ready cabled from the factory, this also applies (with the exceptions stated) to the relay box. All connections between the interlocking apparatus and the relay box are located in the intermediate cables referred to, which are paper-insulated with bare lead-sheath with 60 wires in each cable. In this manner the fitting of the interlocking apparatus on the spot is considerably facilitated.

New Details of Construction

Among the new details of construction in the plant there may be mentioned:

1. Auxiliary release of the train roads is brought about by a press-button fitted on a rod which operates contact sets on a board behind the field con-

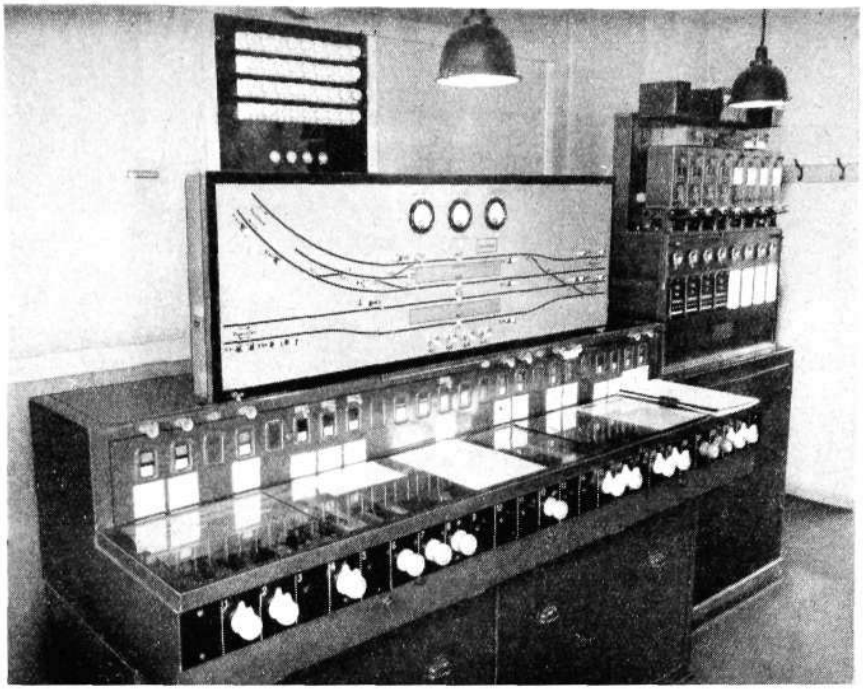


Fig. 6 X 6104
Signal cabin with interlocking apparatus and, behind, relay box; to the right, manual line blocking apparatus

cerned, above the track locking magnet contacts if any and on the same plane as these, see Fig. 7. The contacts are of the same type as those used in the unenclosed relays. The press-buttons themselves may be seen in Fig. 2 and 6 in the upper corner of the interlocking apparatus, above the board for the signal levers in question. In a previous construction of auxiliary contacts, where they were fitted above the magnet parts of the field, the contacts were often in the way when exchanging magnet coils.

2. Some of the point lock magnets are supplied with built-in rectifiers, so that A.C. may be used for the insulated sections for safety against untimely switching, for which purpose alone they may be used. In this way the special track relays are saved.

3. On the track diagram a train track pilot lamp is set up which lights up when release of the track has taken place. At the end of the diagram there is a switch, so that this lamp, if desired, may be replaced by the usual track control.

4. Wear plate for levers: As the paint — and field number — is always much worn at the handles of point and signal levers, efforts have been made in some plants to apply a wear plate of special material. Hansonit sheet (laminated pressed material) was first tried, with the engraved figures and divisions between the apparatus fields standing out white on black background. But this material, made from a kind of milk product, was too much affected by the temperature so that it cracked; it should be mentioned that the sheet was made in sections which spread over 16 fields. Later, trials were made with 2 mm Turbonit sheets in lengths covering 8 fields. This material which is not affected by the temperature stands very well. However, both with this material and with the Hansonit sheet the latch of the handle tends to make a score in the plate; therefore if such material is to be used, there should be left so much space around the shaft of the handle that these latches will be inside the hole.

5. Signboards: for point and signal levers the signboards are made of white Hansonit with engraved figures which stand out black on the white background. This has proved satisfactory and gives a clear and attractive effect.

At the terminal sleeves, below the terminal sheet iron boxes, a slanting wooden board on the floor has a black Hansonit plate with white figures fitted as signboard. The painting on the terminal sleeves, formely used, was often hidden by the cables led in.

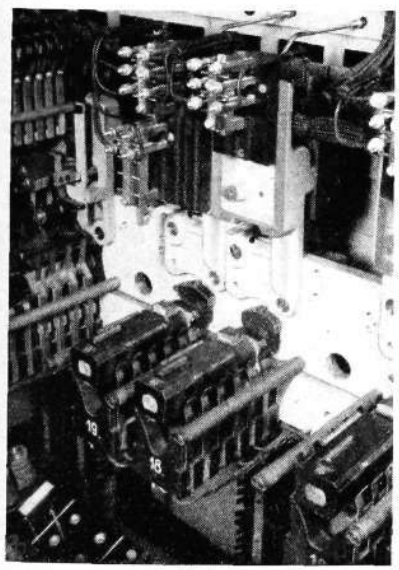


Fig. 7 X 4359
Back view of the shaft contact part of the signal levers

At handle 18, at the top, the contact group for emergency release is seen, at handle 19 there are, in addition, contacts which are controlled by a track locking magnet

DK 621.395.722

HAVERINEN, V E: *New Toll Exchange at Helsingfors.* Ericsson Rev. *22* (1945) No 3 pp. 130—147.

Up to 1935 toll traffic in Finland was handled by two toll exchanges, one belonging to a private undertaking and the other State-owned. In 1935 the State bought out the private undertaking, but considerations of space made it necessary to continue handling toll traffic over the two exchanges.

As it was extremely difficult to ensure efficient operation with a toll exchange split up in two places and as, in addition, there was anticipated a considerable increase in toll traffic owing to the Olympic Games planned for 1940, the Board of Posts and Telegraphs began in the autumn of 1936 to consider projects for a new toll exchange and in 1938 entrusted Telefonaktiebolaget LM Ericsson with the delivery of the requisite exchange material. The new toll exchange is described in this article.

DK 621.395.623.8:621.395.721

THAMES, GÖSTA: *Loud-speaker Telephone.* Ericsson Rev. *22* (1945) No 3 pp. 148—154.

As a feature in efforts to rationalize work in offices and similar places of employment, various telephone systems with speech transmitted by a loud-speaker device have been introduced in recent years for intercom telephone traffic. The loud-speaker device, which ensures comfort in telephoning and facilitates work, has without doubt contributed in high degree to these telephone systems becoming widely adopted. There was, however, no similar device for the telephone instruments connected to the private branch switchboard until Telefonaktiebolaget LM Ericsson recently put on the market a new type of telephone instrument, designated loud-speaker telephone, which is described in the present article.

DK 656.257

JENSEN, K A M: *Valby Station, a New Safety Plant in Copenhagen Local Railway Traffic.* Ericsson Rev. *22* (1945) No 3 pp. 155—160.

During the war no electric safety installations were built in Denmark besides those which were already decided upon and ordered in 1940. The latest and most up-to-date is Valby Station which was put into service in September 1941.

The safety plant replaced an older electric safety plant, which had been in operation since 1911, and it was supplied by Signalbolaget, Stockholm, in conjunction with LM Ericsson A/S, Copenhagen, and Dansk Signal Industri A/S, Copenhagen. The plant is built up on the principle introduced by the Danish State Railways for the construction and lay-out of safety plants and is the first of the new plants of this kind delivered by LM Ericsson.



Fig. 8 X 4460
Voltage indicator for use when testing and fault repairing

Generally it may be said that with a view to replacements, painting is avoided as far as possible on parts that may require exchanging; The indication is either painted alongside the place in question or special signboards are used that may be easily removed; thus for the interlocking apparatus resistances, a black Hansonit sheet is fitted right across the resistance.

6. In the interlocking apparatus a voltage indicator is installed for use when repairing faults and the like. The voltage indicator, see Fig. 8, consists of a telephone lamp fitted in a handle with a test pin. By turning this test pin the voltage indicator may be adjusted for 136 V as well as 34 V, and, in addition, there is a »zero» position. The voltage indicator is arranged for connection right in the middle of the interlocking apparatus; if the cord is long enough it may therefore be used in both interlocking apparatus and relay box. This type of voltage indicator has since been adopted in several other plants.

7. Cable lead-in: As it will probably be preferable, to avoid danger of fire, to have the jute-winding taken off the cables, immediately after they are led in to the lower room of the signal cabin, the armouring and the jute-layer are removed and the cables are then drawn as bare lead-sheathed cables. Moreover, to allow for stray currents from the traction line return circuits, precautions have been taken so that the bare cables do not touch each other which, of course, has involved complicated work when drawing the cables in this lower room. The cables are not given any extra length in this lower room as was formerly the case, but they are drawn as direct as possible to the terminal sleeves.

Finally it should be stated that an extremely good work has been done on the part of the contractors with regard to the planning of the details of the plant and, in addition, the work of erection has been an excellent piece of skilful workmanship. For the sake of completeness it may be added that the safety plant has proved quite satisfactory in operation and during its four years of service there have been extremely few faults.

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No 4
1945


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On cover: Inside view of LM Ericsson's chemical laboratory: microscopical examination of iron, steel and metals

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Conference Telephone

G THAMES, TELEFONAKTIEBOLAGET L M ERICSSON, STOCKHOLM

U.D.C. 621.395.97

The conference telephone or manager's telephone as it has also been called has come more and more into employment as an accessory for ensuring rapid telephone communication between a chief and his nearest collaborators. Telefonaktiebolaget L M Ericsson has now placed on the market a new type of telephone installation, the design and functioning of which are described in this article.

Telefonaktiebolaget LM Ericsson has for many years been supplying conference telephone plants. These were not furnished with amplifiers, however. As amplifier practice has now made such progress that the risk of breakdown is exceedingly slight, it has been considered that the time has now come to replace the old conference telephone by a fresh one based on amplification of the speech by means of a valve amplifier. Among the advantages gained, besides better sound quality, is that all telephone conversations, even those established by a private telephone exchange, may be carried on by means of a microphone and loudspeaker, as is the case with the loudspeaker telephone, described in Ericsson Review No 3/1945. In addition to the purely telephone qualities, great care has been devoted to the mechanical and aesthetic appearance, with the result that the conference telephone in its present form fulfils very exacting demands.

LM Ericsson's conference telephone plant consists of one or more manager's tables which, besides being connected to each other and to telephone instrument extensions, may be connected to P.B.X. both of L.B.-systems and of manual and automatic C.B.-systems. The manager's table comprises also microphone, loudspeaker and manager's telephone instrument.

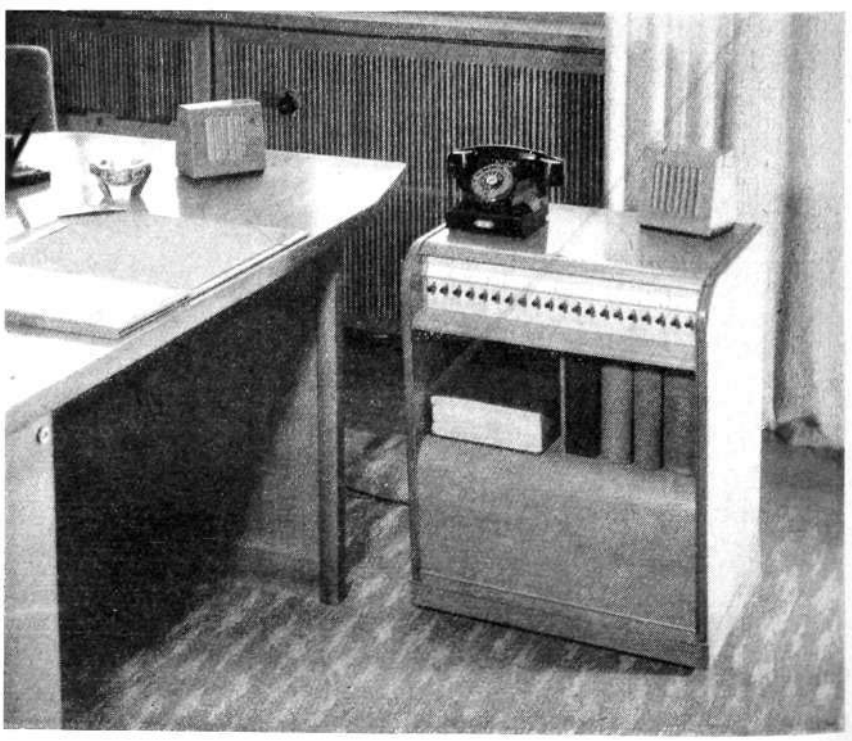


Fig. 1
Conference telephone
on the desk, microphone; at right, manager's table with manager's telephone instrument and loudspeaker

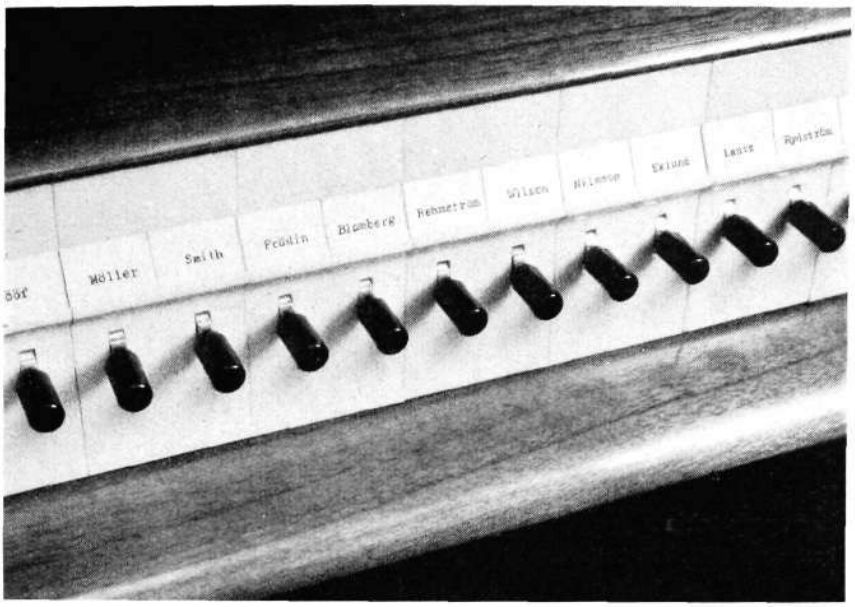


Fig. 2 X 6118
Row of switches on manager's table
a sub-instrument is called by putting down the switch corresponding to the extension

Functioning

All conversations, even those connected over the P.B.X., are normally carried on by microphone and loudspeaker. These are connected in together, so that no talk-listen key restricting freedom of movement during conversation needs be employed. Nor is there any echo suppressor, a device which as is known allows no speech to pass in either direction, should the speakers happen to speak at the same time. If on any occasion the manager does not want other persons present in the room to listen to the conversation he may — even while the call is proceeding — use the telephone handset and carry on the call in the ordinary manner. The microphone and loudspeaker will then be disconnected automatically. Change-over from handset to microphone and loudspeaker is also possible in the course of conversation.

All calls are secret, that is an extension cannot overhear a call unless connected in by the manager. The manager can always see how many sub-instruments are connected in. Each sub-instrument has its own lamp which lights up when the extension is connected.

The manager calls a sub-instrument by putting down the switch corresponding to the extension, see Fig. 2. This transmits a periodic buzzer signal to the sub-instrument. The sound is extremely characteristic and clearly distinguishable from other signals. At the same time the microphone indication lamp on the manager's desk lights up. When the sub-instrument handset is lifted the signal ceases and the conversation may begin. Above the switch there lights up a lamp behind the label bearing the name of the extension.

At the close of the call the switch is restored to off position and its lamp goes out, after the sub-instrument handset has also been replaced. If the lamp continues to shine after the call is finished this shows either that the switch has not been restored or that the extension has not replaced the handset.

Should the manager receive no answer to his call, it is possible for him to transmit a holding marking to the sub-instrument star indicator by throwing the switch to its upper position. The called person will then see on coming back to his place that the manager wants to be called up.

The manager's table is called when the sub-instrument handset is lifted. There is then heard in the table *one* discreet buzzer signal and the lamp above the extension's switch lights up. The call is answered by throwing the switch downwards.

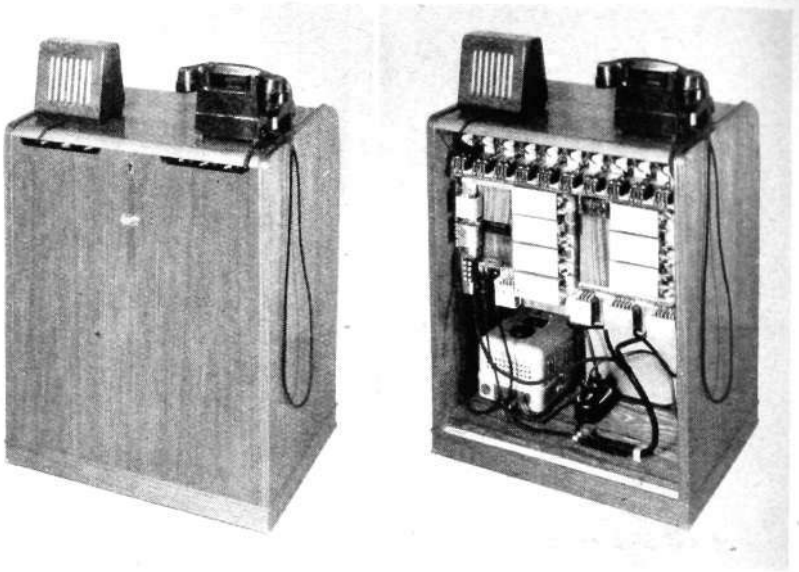


Fig. 3 X 6121
Manager's table
back view; right, with back removed

Call between two manager's tables is made in similar manner to that described above. The only difference is the method of marking in the called table. Instead of annunciator indication, the lamp above the switch lights up.

Call via the P.B.X. is obtained by first pressing the left-hand button on the manager's instrument and, after buzzer tone is heard, dialling the number in the usual way. If the right-hand button is also pressed there is obtained a stronger amplification of the incoming speech, which may be desirable with long distance calls. When the call is terminated, the middle button only needs to be pressed an instant and the line is cleared.

Incoming calls over the P.B.X. are signalled by a creak-buzzer in the manager's instrument, on which the left-hand button is then pressed when the call is to be answered.

If during these calls information requires to be obtained from one of the manager's table extensions, the manager has only to throw the corresponding switch. The line to the P.B.X. is then held and there is no possibility of the conversation between the manager and the extension being overheard on this line. When the enquiry is completed the switch is restored and the call over the P.B.X. can continue.

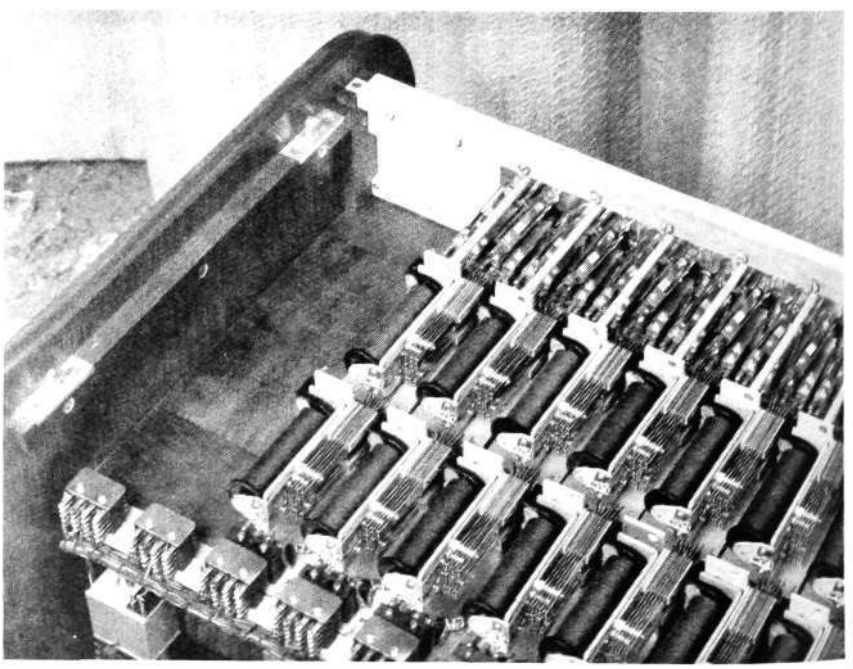


Fig. 4 X 6120
Line unit in upper part of manager's table
The top of the table has been removed and at the upper left may be seen cover plates replacing line units not required

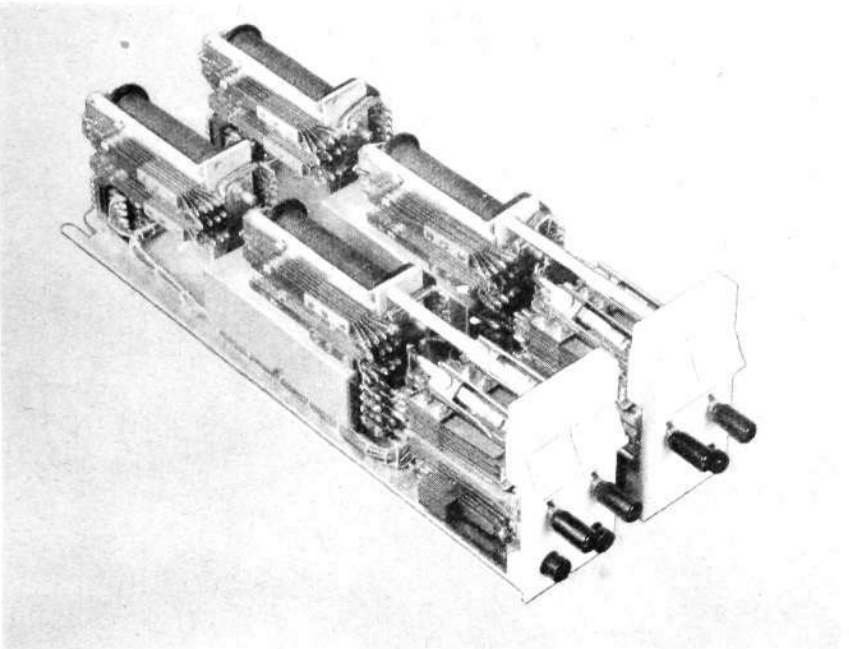


Fig. 5 X 6119
Line unit
with extra press-buttons for service signals below the switches

Several extensions can be connected at one time for conference. These all have conversation connection between themselves and with the manager. In order that the conference facility shall not be limited to the manager's table extensions alone, the table may be furnished with one or two *conference lines*, connected to the internal telephone switchboard. These enable the manager to connect in one or two persons not connected to the manager's table, for conference with the other extensions.

The conference line switches, unlike the other switches, have their home position upwards. When a person is to be called for conference the conference line switch is thrown to middle position and call with the manager's instrument is had in the ordinary way over the P.B.X. When the called person answers the switch is thrown to bottom position, which is also done for those extensions that are to participate in the conference.

Construction

Particularly great attention has been devoted to the outward appearance of the parts comprised in the manager's equipment. Consequently the manager's table, microphone and loudspeaker very well match the furnishings of an up-to-date office.

Manager's Table, Types AEC 10—18

The manager's table, which has a frame of polished walnut, is fitted with castors so that it can easily be moved to a convenient position within reach of the manager's desk.

A simple movement removes the back and top of the manager's table making the equipment accessible, see Fig. 3 and 4. At the top the line units are fitted and below them the place equipment. The amplifier and the unit for current supply are located in the lower part of the table. The space below the line unit is intended for holding telephone directories etc., see Fig. 1.

The table is made in two sizes, with place for 10 and 15 line units. As each unit comprises equipment for two lines the maximum capacity of the table will be 20 or 30 lines respectively, besides the manager's ordinary line to the P.B.X. Should, however, the requirement of lines be less, those line units that are not required may be replaced by blank plates, see Fig. 4. The number

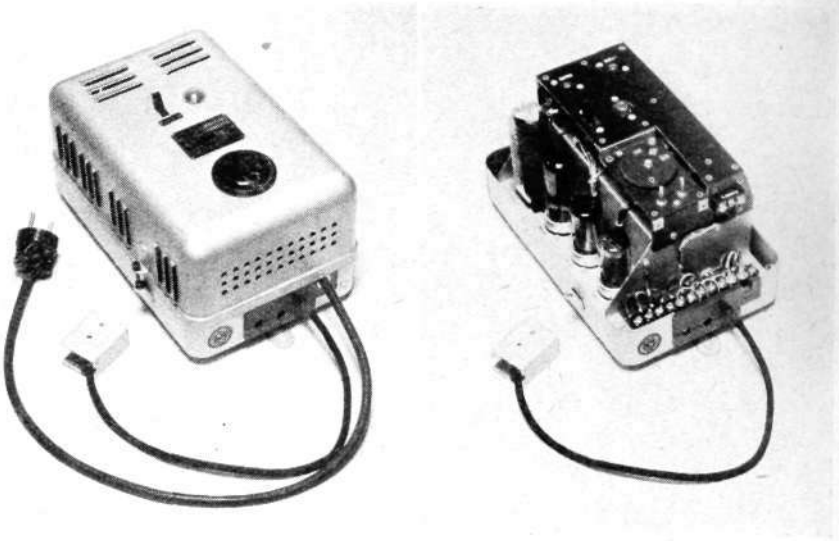


Fig. 6 X 6102
Amplifier ZGA 1002
left, with, and right, without cover

of lines in the table may then later be increased as required up to full capacity without any wiring work being necessary in the table. The line unit is provided at the rear with a 20-pole plug corresponding to a jack in the place equipment. Thus the unit will be connected to the common relay equipment immediately it is inserted in its place in the table, where it is fixed to a bar by means of a screw in the upper part of the front plate. This front plate is of ivory-white moulded material and constitutes fixing for switch and lamps.

As stated, a line unit comprises equipment for two lines. These may be of three kinds:

extension line = line to a sub-instrument
conference line = line to an intercom telephone switchboard
junction line = line to another manager's table

According to the nature of the lines there are the following types of line unit:
BEF 9401, line unit for two extension lines;
BEF 9501, line unit for one extension and one conference line;
BEF 9502, line unit for two conference lines;
BEF 9601, line unit for one extension and one junction line.

The place equipment permits of the connection of 20 and 30 lines respectively, 9 of which may be junction lines and 2 conference lines. Thus with their interchangeable line units the mechanical construction makes possible plentiful variation in the line equipment of the manager's table. The small amount of fitting required to alter the number and character of the lines enables an LM Ericsson's conference telephone installation to be smoothly adapted to the changes usually occurring as time goes on in an undertaking's organisation.

The manager's table may also be equipped with devices for service signals and the like. Some of the line units in such case are provided with press-buttons and lamps, see Fig. 5. Appropriate text such as »Engaged», »Wait» and »Come in» is engraved on the front plate above the buttons.

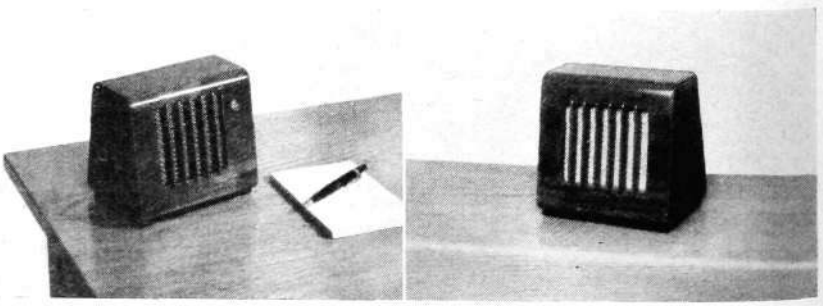


Fig. 7 X 6007
Microphone RLC 1001 (left) and loudspeaker RLE 1001 (right)

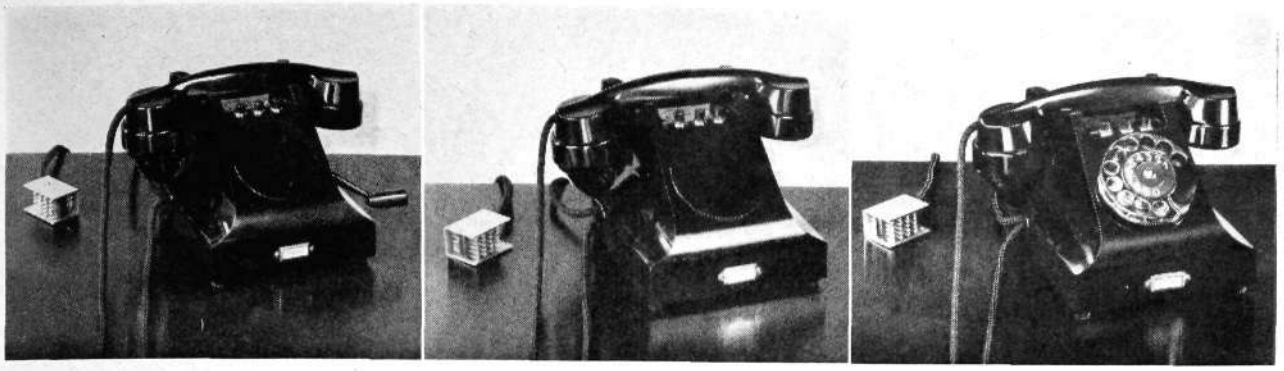


Fig. 8 X 7395
Manager's telephone instruments
left, DAH 9901 for L.B.-system; middle, DBH 2401 for manual C.B.-system; right, DBH 2501 for automatic C.B.-system

The other devices directly connected to the place equipment are amplifier, manager's instrument, terminal box and requisite mains connection unit. Connection of these is by plug and jack, as with the line units.

Amplifier, Microphone and Loudspeaker

The amplifier, with its microphone and loudspeaker, see Fig. 6 and 7, is of the same construction as the corresponding apparatus for the loudspeaker telephone. The amplifier — a balanced two-way amplifier with one amplifier stage for each microphone and loudspeaker circuit — differs only in that it is supplemented with a connecting cord and a 20-pole plug. The cases of the microphone and loudspeaker are made of the same wood as the manager's table.

Manager's Telephone Instrument

The manager's instrument also, Fig. 8, displays great similarity with the loudspeaker telephone instrument and is operated in the same way as it. The manager's telephone may be for connection to L.B.-system or manual or automatic C.B.-system.

Further particulars of amplifier, microphone, loudspeaker and manager's telephone instrument will be found in the article on the loudspeaker telephone in Ericsson Review No 3/1945.

Sub-instruments

The sub-instruments placed at the extensions may be of several kinds: for one or more lines to the manager's tables, or for line to manager's table and line to telephone switchboard.

Common to all types of instruments is that they are table models with bakelite cases and that they are provided with star indicators. Multi-line instruments have in addition as many press-buttons as lines connected.

Call from the manager's table is signalled by a buzzer tone in the receiver and call from the switchboard by a creak buzzer or a bell.



Fig. 9 X 4390
Sub-instruments
left, DEK 1301 for 1 line; middle, DEH 2901 for 2 lines; right, DEH 2902 for 3 lines

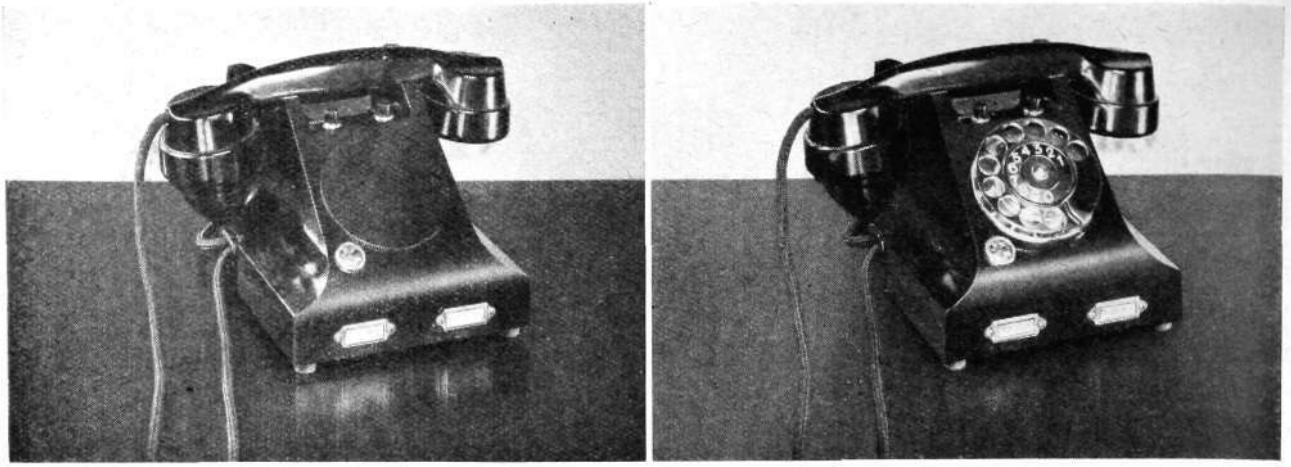


Fig. 10 X 7396
Telephone instruments

left, DBH 2601 for line to manager's table and manual C. B.-switchboard; right, DBH 2701 for line to manager's table and automatic C. B.-switchboard

Instruments with Lines to one or more Manager's Tables

These instruments, see Fig. 9, are obtainable for connection to one, two or three manager's tables. A manager's table is called when the handset is lifted and, if the instrument has more than one line, the corresponding button is pressed. Incoming calls are signalled in multi-line instruments by receivers inside the instrument. To enable the extension to know which manager's table the call comes from, the corresponding star indicator is actuated by the buzzer signal.

Instruments with Lines to Manager's Table and to P.B.X.

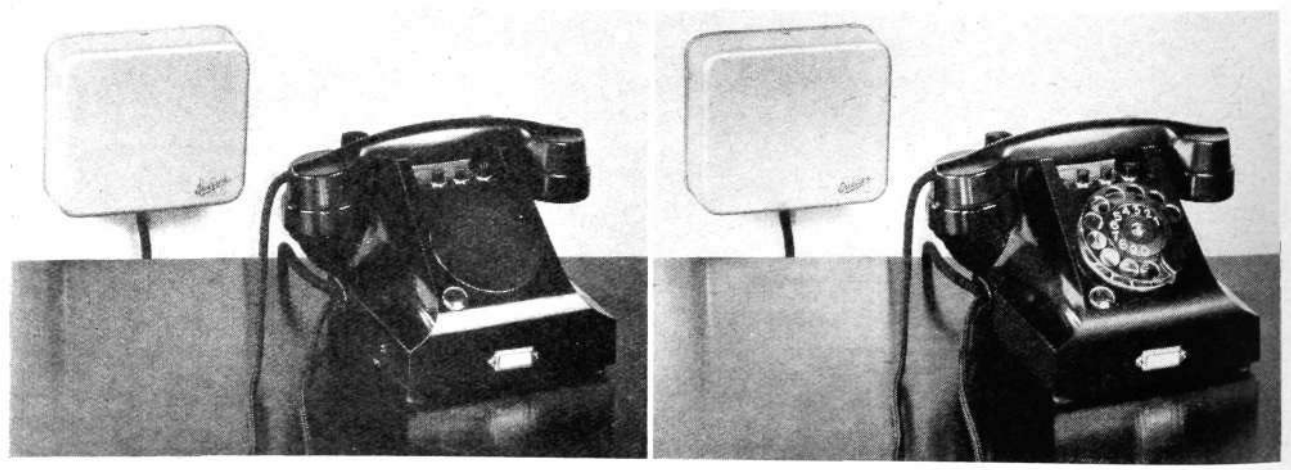
When an extension has also a line to the P.B.X. it may be convenient to unite this line and the line to the manager's table in one and the same telephone instrument.

Fig. 10 shows the appearance of such an instrument, which is provided with two press-buttons, that on the left for connecting in the line to the P.B.X. and that on the right for connecting in the manager's table line.

Call from the P.B.X. is signalled by a creak buzzer in the instrument and call from the manager's table is heard in the receiver. Signal on one line is given even if call is proceeding on the other. If the manager's table calls the instrument while conversation is going on the manager's call is heard faintly in the receiver. The extension does not need to disconnect the first call before answering the manager's call: immediately he presses the right-hand button the earlier call is held. Return to the first call takes place when the left-hand button is pressed right down, which releases the right-hand button and disconnects the manager.

Fig. 11 X 7397
Secretary instruments

left, DBH 5001 for lines to manager's table and to manual C. B.-switchboard; right, DBH 5101 for lines to manager's table and to automatic C. B.-switchboard



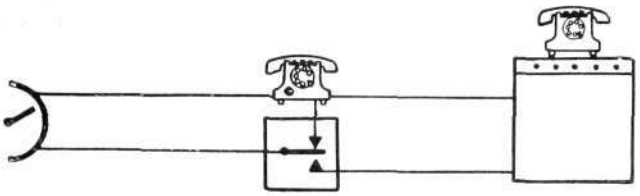


Fig. 12 X 6116
Diagram for secretary instrument
from left, P.B.X. secretary instrument with switching relay, manager's table and manager's instrument

Secretary Instrument

This instrument, Fig. 11, is used to relieve the manager from calls which may be just as well answered by a secretary. The manager's line to the P.B.X. is connected via a switching relay to the secretary instrument, which also has direct lines to the P.B.X. and the manager's table, see Fig. 12.

The secretary instrument is furnished with star indicator and three press-buttons, the left-hand one for answering calls on the manager's line, the middle one for holding calls on its own line and the right-hand one for connecting in the direct line to the manager's table.

The instrument functions in the following manner:

Call from the P.B.X. on the secretary's own line is signalled by a creak buzzer in the instrument and is answered by lifting the receiver. Call to the P.B.X. is made in the same way. If call comes in on one of the other lines while the secretary has a call on her own line she can hold her own call by keeping the middle button pressed while answering the incoming call.

Call from the manager's table is signalled by a buzzer tone in the receiver and is answered by lifting the handset and pressing the right-hand button. If the secretary should be in conversation on one of the other lines, the call is heard faintly in the receiver in the same way as described above for the two-line instruments DBH 2601 and 2701. Call to the manager's table is made in the same way.

Incoming calls on the manager's line from the P.B.X. are signalled by a bell in the wall terminal. They may be answered by the secretary after the left-hand button has been pressed. If enquiry is to be made of the manager the right-hand button is pressed, putting the secretary in communication with the manager in the usual way. During the enquiry the line to the P.B.X. is held by a resistance in the instrument and the third party cannot overhear the conversation between the manager and his secretary. On termination of the enquiry, return to the first call is made when the left-hand button, which during the time has been kept pressed, is pressed right down, this releasing the right-hand one. Should the manager wish to take the call himself he presses the left-hand button on the manager's instrument. The call is then transferred to him by the switching relay and the secretary cannot listen to it.

The manager always has priority over his line to the P.B.X., through the switching relay disconnecting the secretary instrument as soon as call is made by the manager. The secretary then has no possibility of breaking in on the line or listening to the call.

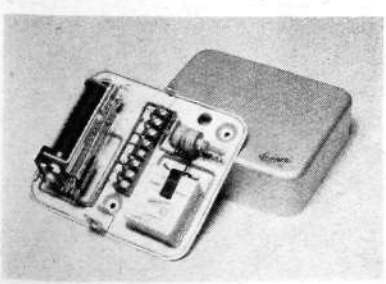


Fig. 13 X 4367
Switching relay KFB 1011

Signal Repeater

If the secretary is only to take the manager's calls when he is not in his room, a signal repeater is connected to the manager's instrument. The signal repeater, Fig. 14, located in the manager's table, connects over calls on the manager's line to the secretary after the second ring signal. All subsequent calls on the manager's line are then signalled to the secretary until the manager next uses his instrument himself, which then disconnects the secretary's instrument. The signal repeater is described in Ericsson Review, Special number 1945 and No 3/1945.

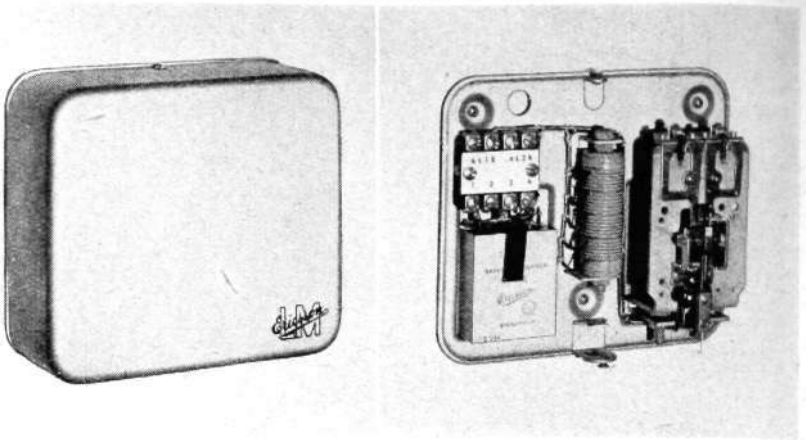


Fig. 14
Signal repeater KFB 1001
left, with and, right, without cover

Line Network

The distribution box, Fig. 15, which is joined to the manager's table by a multi-wire cable, contains all requisite terminal screws for connecting up the network. This is built up in extremely simple fashion. All the extension lines are two-wire, with the exception of the junction lines which are four-wire.

Current Supply

For the operation of the installation no other power source is required than the electric lighting mains. To these the amplifier and the mains connection unit are connected via a wall tapping in the bottom of the table. The amplifier, which works with both D.C. and A.C. is, like the mains connection unit, adjustable for all customary mains tensions. The mains connection unit, see Fig. 16, on the other hand, can only be connected to A.C. mains. In the case of D.C. mains, therefore, a converter must be used.



Fig. 15
Terminal block AEY 1001
with cover removed

The mains connection unit contains transformer, rectifier, chokes and condensers. It delivers both 24 V D.C. for the relay equipment and the sub-instruments' current feed, and 30 V A.C. for the manager's table lamps. In this way it has been possible to make the rectifier smaller than if the whole installation were run on D.C.

However, the mains connection unit can be entirely dispensed with if 24 V D.C. can be obtained from another source, *e. g.*, from a telephone switchboard accumulator. In such case the lamps are also fed from this.

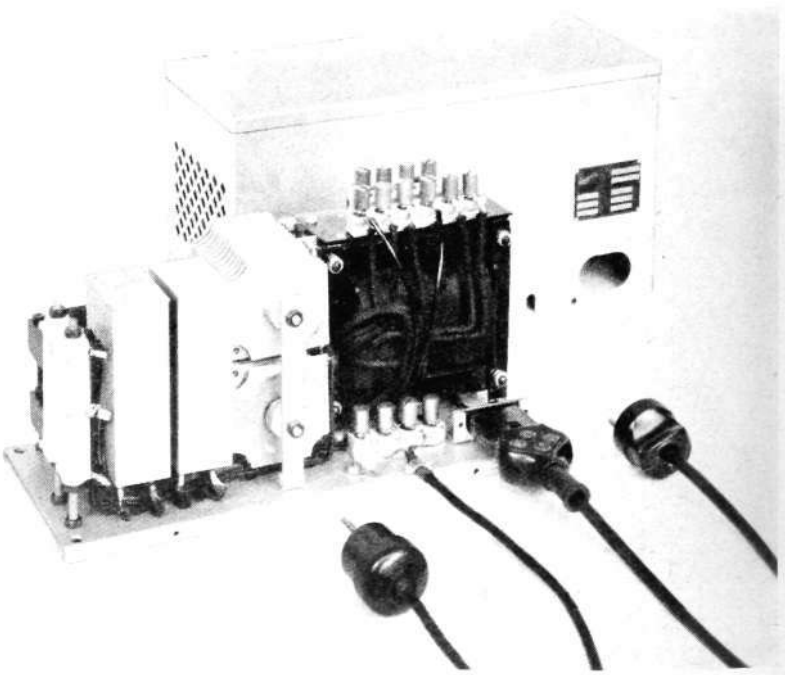


Fig. 16
Mains connection unit 233460

L M Ericsson's Mine Signalling System

O WALLNER, FAGERSTA BRUKS AB, KLOSTERVERKEN, LÅNGSHYTTAN

U.D.C. 654.939.1

Mine signalling installations formerly in general use were rather primitive though they did serve their purpose. As a rule they consisted of mechanical signal devices operated by lines or wires running in the mine shafts. Nevertheless, with present-day demands on safety, such installations can no longer be regarded as satisfactory.

In recent years, therefore, more up-to-date systems, chiefly mine telephones with or without visible auxiliary signals, have been installed. Telefonaktiebolaget L M Ericsson has supplied for one of the mines belonging to Fagersta Bruks AB a signal system which appears to meet every demand on reliability of operation and simple operation. A brief account will be given here of the constructive design and method of operation of this system. The aim of the article is to present general points of view respecting installation that came to notice during the execution of the system.

Execution

The signal system is furnished with both visible and audible signals and it consists of a 10-number signal board with differently coloured number lenses, Fig. 1, and a bell located at the winchman's place. The requisite relays and a transformer 127/24 V have been fitted in a sheet metal cabinet, Fig. 2, set up in the winch-house.

At each stopping place in the mine there is an operating board, Fig. 3, fitted with two power current lamps for green and red light, knife-edge switch for emergency stop-signal, press-button for »Hoist wanted» and a 10-line selector device, so designed that the selector wiper returns to home position immediately on release. On the ledge a bell is fitted to give signal for locking to the loader. This signal is given by the winchman on receipt of corresponding signal from the mine.

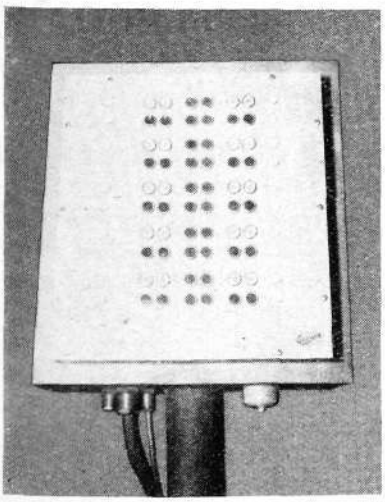


Fig. 1 X 4336
Signal board

Down in the mine the installation is made with bare lead-sheathed cable EPB 40×0.5 and EDBL 4×1.5. The fourth conductor is designed for fixed light points at the stops. A sheathed 2-pole switch with cut-outs for these is fitted along with the operating boards. The lay-out of the system may be seen in diagram on Fig. 4.

Functioning

In principle, the installation works in the following manner.

Say the hoist has to be called to stop No. 7 to go to stop No. 2. At stop No. 7 the button »Hoist wanted» is pressed. This lights up the green signal lamp numbered 7 on the winchman's board and the bell rings. At the same time all green power-current lamps in the operating boards at all stops light up. The winchman sends the hoist to stop No. 7 and restores the signal by means of a button on his board.

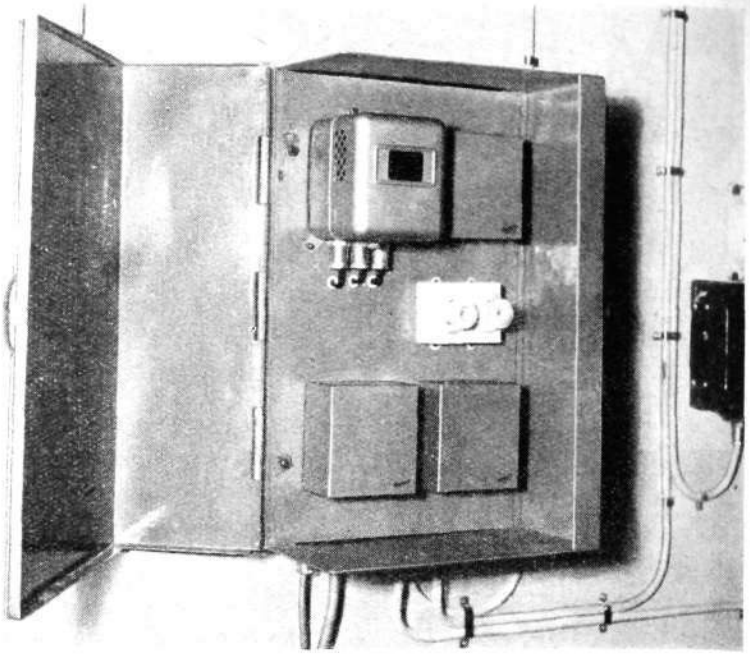


Fig. 2 X 6113
Sheet-metal cabinet with transformer and relays

When the hoist reaches the stop indicated, the person calling it throws the emergency stop signal if loading is to be done. This lights the red signal lamps numbered 7 on the winchman's board and a red power current lamp so placed that it can easily be seen from any spot in the winch-house. At the same time the red power current lamps at the different stops light up.

When loading is completed the emergency stop signal is released, the selector wiper is moved to No. 2 and signal is given. The white lamp lights up at the winchman's place and the bell rings. The winchman starts the hoist after app. 15 seconds, the time required for the user to step into the hoist.

The hoist must not be called when green or red lamps are shining in the operating boards at the stops.

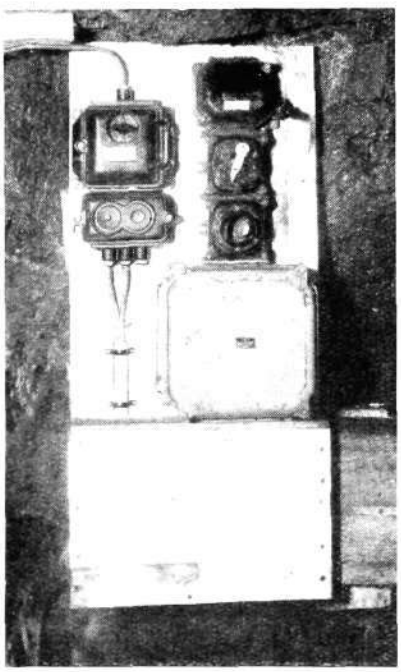


Fig. 3 X 4364
Operating board

left, 2-pole switch, below two power current lamps with green and red lights; right, knife-switch and below 10-line selector device and press-button »Hoist wanted«

Fitting

As stated, the installation is executed with EPB 40×0.5 or 30×0.5 for weak current and EDBL 4×1.5 for power current. The cables are in themselves sensitive to mechanical strain and stretching. Normal laying with clamps could not be done, therefore, owing to the long lengths of vertically laid cable — up to 75 m. To ensure a mechanically satisfactory protection the lines have been laid in $2'' \times 6''$ planks with milled grooves, see Fig. 5.

The risk of dragging stress has been avoided by making the dimensions and shape of the grooves such that the cable must be forced into the groove. Tests have shown that the friction counteracts with a good margin all tendency to slipping in the groove which might cause displacement or stretching of the lead sheath. It has also been found on test that swelling of the timber due to humidity has no appreciable effect on the dimensions of the groove; there is therefore no danger of the cable being deformed or injured owing to lateral pressure. The planks are covered with screwed covers of $1\frac{1}{2}'' \times 6''$ boards. With the cable thus completely covered, it may be considered adequately protected against external action.

The joins of the planks are reinforced by clamps at the back. To prevent lateral displacement the joins have been still further strengthened by metal plates $^3/_{16}'' \times 4''$ screwed on at the sides. In addition the lines are protected

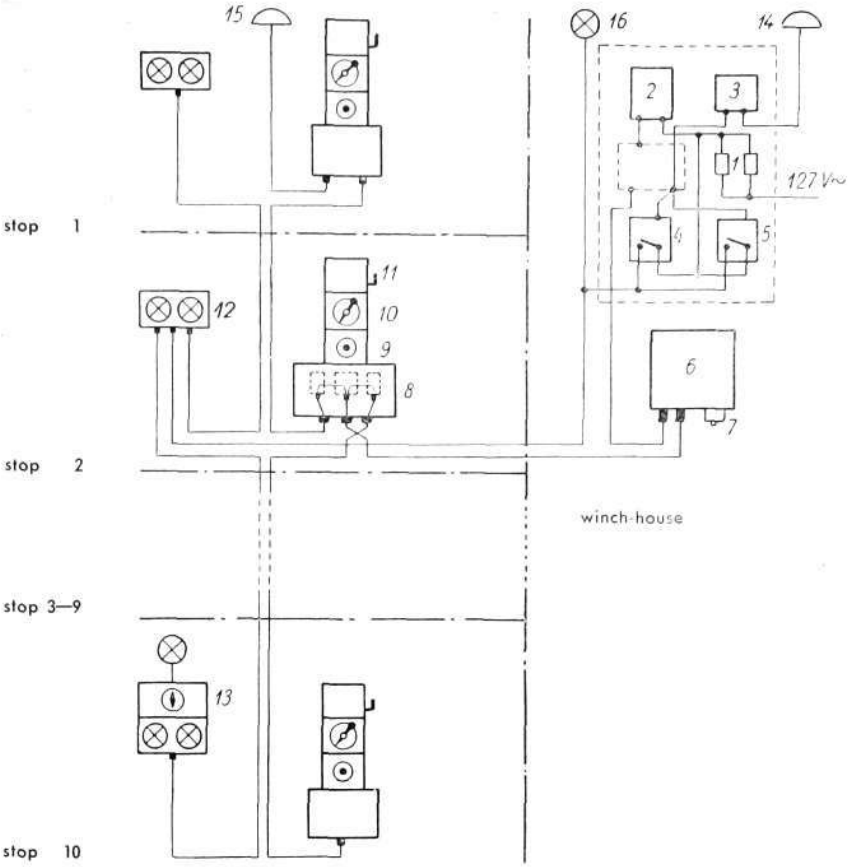


Fig. 4 X 6111

Lay-out diagram of mine signalling plant

1 fuses
2 transformer RES 11101
3 relay RN 228792/2 for bell
4 relay RN 228759/3 for red lamp
5 relay RN 228799/3 for green lamp
6 signal board
7 button for re-locking signal
8 terminal boxes
9 press-button »Hoist wanted»
10 10-line selector
11 knife-switch »Emergency stop»
12 power current lamps
13 switch
14 bell in winch-house
15 bell for re-locking signal
16 red power current lamp in the winch-house

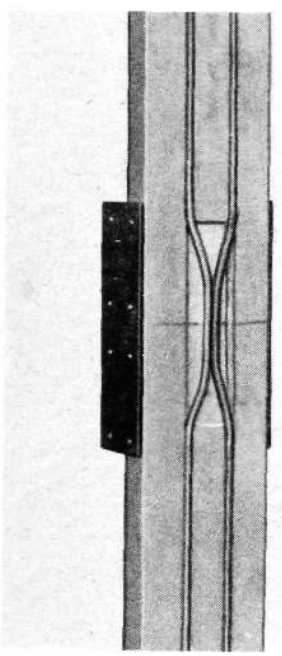


Fig. 5 X 4365

Laying of cables in planks with milled grooves

To prevent lateral displacement the joins have been reinforced by metal plates screwed on to the edges. At the plank joins the cable is laid in a loop to prevent stress on the cable in case of change in position

against wear at the joins by planing the groove away about 10—15 cm at each plank end. The cable has been laid in a small loop to take up any change in position that may arise despite all precautions.

When laying the cable in the planks it was lowered in loops so arranged that the cable's own weight did not exceed the »migration limit» of the lead sheath. The cable sheath may easily break at the bends, so that the greatest care and attention is necessary. It was in fact this part of the laying that caused the greatest difficulty of execution.

Particular attention was devoted to making all bushings and connecting points absolutely tight as all apparatus are exposed to drip water. On the other hand there is no particular risk of condensation in the mine, the temperature remaining fairly constant all the year round. The terminal boxes, type NCL, are built in ladders of special make in cast iron cabinets of standard construction, see Fig. 6.

General Observations

For a new installation the planning should always be thorough and well considered. Numbers for all signals are included in the signal board. There are, of course, in most mines signals which are not concerned solely with transport and hoist operation, *e. g.*, signal for locking hoists, signal for change-over from passenger to ore conveyance, blocking signal etc. A signalling system like that described above would lose much of its safety and accessibility if signal codes with bell had to be used. There would then arise the same unsafe factor as with older installations. A code consisting of a number of signals may be given or received incorrectly. A well-planned system with visible and audible signalling, possibly supplemented by mine telephone, can and ought to fulfil all demands for reliability and simple operation, without risk of

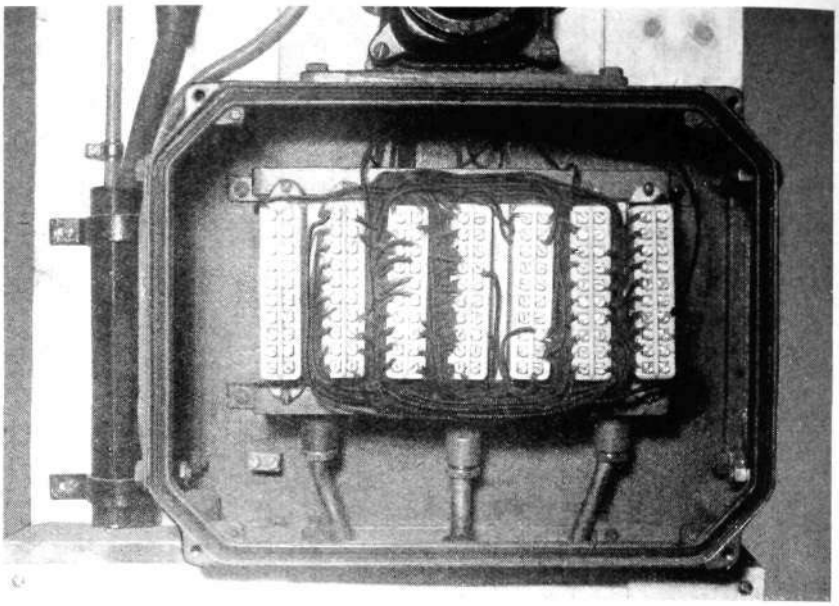


Fig. 6 x 6114
Terminal boxes type NCL, built in to cast iron cabinet

wrongly understood signals. It should be possible to supplement the plant with supervisory current and signal for leakage to earth or between conductors on the same system as is applied for fire-alarm systems.

In mines of great depth the operating tension selected should be higher than 24 V. It was found, in practice, that the signal from levels deeper than 200 m did not reach destination owing to voltage drop. This serious disadvantage has been eliminated, however, by connecting several conductors in parallel.

The mine signal plant described above has only been in service a short time but has proved to possess many advantages over older systems. Those employed in the mine also express entire approval of it.

Private Telephone Intermediate Switchboard for Semi-Automatic Distribution of Incoming Calls

E NILSSON & E LARSON, TELEFONAKTIEBOLAGET L M ERICSSON, STOCKHOLM

U.D.C. 621.395.25

For telephone subscribers the traffic to whom is chiefly composed of enquiry and order calls the need often arises to distribute the calls in a simple and rapid manner to the various groups within the common organization. Telefonaktiebolaget L M Ericsson have designed a semi-automatic distribution switchboard which meets this need. The design has been worked out in conjunction with the re-organization of the Swedish State Railways sleeping berth booking office at Stockholm.

LM Ericsson's new semi-automatic distribution switchboard with local distribution of incoming calls is particularly well adapted for telephone booking of cinema and theatre tickets, for enquiry service in big stores and warehouse premises, card index offices etc. The distributing telephone operator is always in a position to get into communication with the proper person in the quickest and easiest manner.

By means of the distribution operator a connection in progress can be transferred to another person or department within the organization. Thus with only one call it is possible for orders or enquiries to be dealt with by a number of departments or areas.

The Build-up of The System

To ensure economic adaptability the system is built up of units comprizing selectors and detachable connecting devices, suited to the number of incoming lines or order positions.

A maximum of 60 lines and 30 order positions may be connected to the switchboard. The lines may be of C.B. or L.B. system. In the State Railways switchboard the order positions are divided into two groups and so arranged that with varying traffic the positions may alternate between the groups.

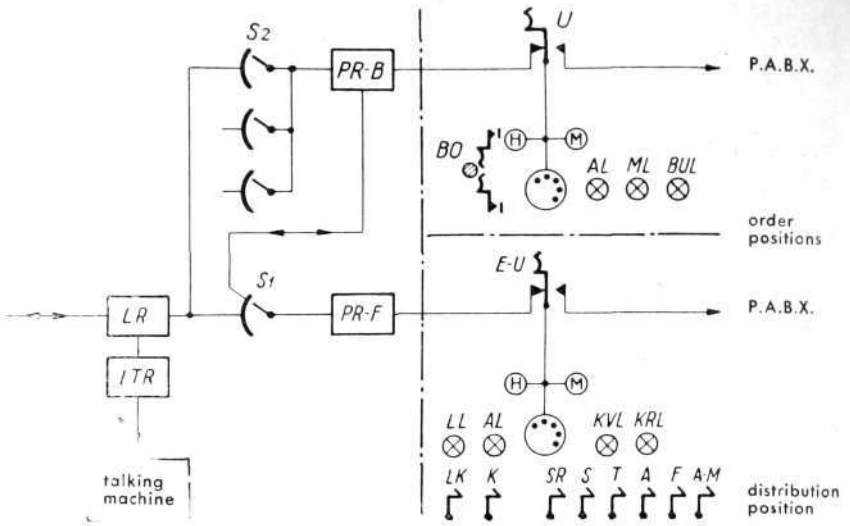
To shorten the connecting time, crossbar selectors with direct marking are used, *i. e.*, the bar magnet in the crossbar switch corresponding to the line to be connected to the selector bridge is actuated, after which the selector bridge is energised and causes connection without any hunting taking place. (The operation of the crossbar switch is described in more detail in the article in Ericsson Review No 2/1945 »*The Employment of Crossbar Selectors in bypath Systems*».) The connections are executed with the smallest possible number of manual operations. For incoming traffic the calls are automatically connected to the distribution position while at the same time indicator lamps show disengaged and busy order positions. The distribution position becomes free immediately the distribution is effected.

At times when there is a rush of traffic it is not possible to avoid waiting and if the calling subscriber receives ringing tone only he is likely to be irritated and makes a new call. To avoid this the calls may be connected to

Fig. 1 X 6110

Trunking scheme for semi-automatic distribution switchboard

A cancelling button
AL call lamp
A-M key for automatic or manual connecting of incoming calls to distribution position
BO group selecting key
BUL busy lamp
E-U key for switching the operator's telephone from the switchboard to a P.A.B.X.-line
F release button for distribution position
H receiver
ITR connecting relays for talking machine
K connecting buttons for the lines and order positions
KRL ringing supervision lamp
KVL waiting supervision lamp
LK test button
LL test lamp
LR line relay
M transmitter
ML line indicating lamp
PR-B position relays for order positions
PR-F position relays for distribution position
S signal button
S_1 connecting selector for distribution position
S_2 connecting selectors for order positions
SR ringing button for outgoing calls
T key for switching the operator's telephone from calling to called part
U key for switching the order position from the incoming line to an outgoing P.A.B.X.-line



a talking machine if the distribution position or all order positions are busy. The machine answers with the name of the organization followed by »please wait».

The trunking scheme, Fig. 1, shows the build-up of the system.

Construction

The line equipments *LR*, the selector *S1* and the relays *PR—F* of the distribution position are fitted in a rack. The relay sets *PR—B* and selectors *S2* for the order positions require one rack per 10 order positions. Each rack takes up a space of $175 \times 580 \times 2700$ mm.

The lines and the order positions are connected to the selector *S1*. All bridges in this selector are connected to the distribution position.

In the selector *S2*, however, each of the 10 bridges is disposed for one order position and the multiple is multipled to the lines along the selecting bars. Thus the 10 order positions can reach the 10 lines over one selector and 10 calls can be carried on simultaneously through the selector. For each additional group of 10 order positions or 10 lines the number of crossbar selectors is increased. For 60 lines and 30 order positions there will then be $6 \times 3 = 18$ crossbar selectors.

The distribution operator has at her disposal a distribution apparatus, see Fig. 2, which is equipped with separate push button keys for all the lines and order positions, signal and test lamps, operating push button keys, speaking set and dial for traffic with another automatic switchboard.

On the left side of the apparatus is the equipment for lines and on the right side the equipment for the order positions and below some operating push button keys. There are besides in the right-hand lower part the two-way lever keys *A—M* and *E—U*, control lamps and dial.

In way *E* of the key *E—U* the distribution position is connected to the distribution switchboard and the way *U* connects to another automatic switchboard. In way *A* of the key *A—M* automatic connection of calls to the distribution position is obtained, speaking connection being obtained without manual intervention. In the way *M* connection is obtained when the key of the calling line is depressed.

At the moment of connection the operator hears a tone in her receiver. The call should not be answered until the tone ceases. The connection is established only by pushing the button corresponding to the wanted order position. When the connection is carried out the distribution position is released and the control of the connection is dealt with by the order position. The distribution operator has visual control as long as the distributed call is not answered. During that time the distribution position can be connected to the order

position and the operator can call the order position's attention or transfer the call to another order position.

When the distribution operator removes the plug of her speaking set, the incoming calls are automatically connected to a limited number of attended order positions.

The order positions are equipped with operating keys, call lamps, marking lamps and busy lamps, telephone instrument or head sets with speech switch and acoustic calling device.

The key *BO* is, for the State Railways installation, designed as a 3-way lever key by means of which the order position may with varying traffic be alternated between the two order groups. When the order position is attended the key must be thrown to one or the other of its outer positions and the distribution operator will then have from the character of the visual test an indication of the group the position is connected to.

The call lamp *AL* of the order position lights up on call and goes out when the call is answered.

The separate or common acoustic call device is actuated on call and keeps on with periodical signals until the call is answered.

The indicating lamp *ML* which is fitted when the order position is to have visible indication as to who or which group of equivalent lines is making the connection, lights up on call and remains lit while the conversation is going on.

The busy lamp *BUL*, which is fitted when the order traffic is distributed over two groups, lights up in the positions of the one group when all positions of the other group are engaged. The busy lamp may also be placed at the supervisor's position so that the latter may have indication when the different groups are overloaded. When the order position has an incoming or outgoing call, enquiry calls can be made to other order positions. The establishment of enquiry connections is done by the distribution operator. The call can be transferred to another order position.

Power Plant

The distribution switchboard requires a power plant for 24 V similar to those employed for small automatic switchboards. If an ordinary automatic switchboard power plant is available this can be used.

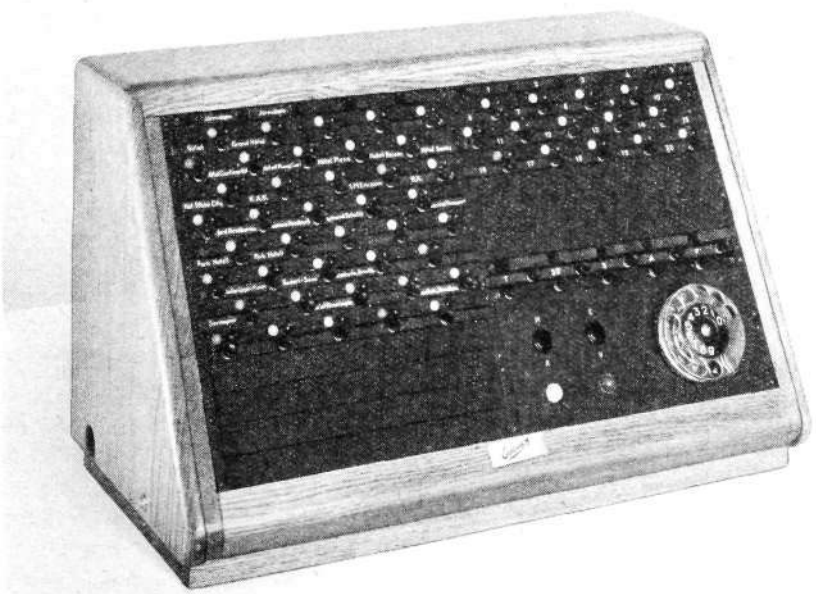


Fig. 2 X 6115
Distribution apparatus for semi-automatic distribution switchboard

Functioning

Incoming Traffic

Connection to Distribution Position

The selector *S1* is actuated for both incoming and outgoing calls, so that connection is made to the distributing position. The incoming traffic is connected either automatically or manually, this being determined by the key *A—M*. On automatic connection no manual operation is required for connection to the operator. For manual connection the call lamp lights up and connection to the operator is made by depressing the button *K* belonging to the calling line. Audible call signal is received at same time as the call. Test lamps *LL* light up automatically for attended order positions that are disengaged.

For blind calls the distribution position is disconnected by the release key *F*.

Distribution of Incoming Traffic

On call, causing the test lamps to light up automatically, connection is made to order position by depressing the button *K* of the wanted position. The calling line is switched over to the selector *S2*. The distribution position and the selector *S1* are restored automatically and the test lamps go out. In the distribution position the call lamp of the called order position displays flashing light until the call is answered.

In the order position the call lamp *AL* is lit up and in addition there is periodic acoustic signal. On answer the call lamp *AL* is extinguished and the periodic calling signal ceases.

If the operator tries to connect to a busy or not attended order position the call remains in the distribution position until the operator connects it to a disengaged order position.

Release

When the order position handset is replaced the relay set of the order position and selector *S2* are restored.

Distribution Position Busy

When the distribution position is busy and set for automatic connection, any fresh call must wait outside the position. The lamp *KVL* lights with a steady glow. The calling line is switched over to the talking machine which answers automatically with the name of the organization followed immediately by »please wait». As soon as the position becomes disengaged one of the waiting calls is connected.

Order Positions Busy

If all order positions are busy, flashing light is given by the lamp *KVL*. Any calls then coming in must wait outside the distribution position, even though this may be disengaged. The calls are connected to the talking machine in same way as described above. The call lamps of the waiting lines light up, so that the operator has an indication of the number of calls waiting which cannot be dealt with at once.

Call to Order Position Left Unanswered

The order position call lamp in the distribution position has flashing light until the call is answered. If this does not happen in reasonable time the operator takes back the call to the distribution position by pressing the button for the order position concerned. By means of the signal button *S* the operator can send out a louder signal to the order position or she may transfer the call to another order position.

Night Connection

When the distribution position is not attended, all incoming calls are connected automatically to a limited number of order positions.

Outgoing Traffic

Call from Order Position

On call from the order position connection to the distribution position takes place over selector *S1*. For this routing the test lamps *LL* do not light up but instead the lamp *KRL* gives flashing light.

Handling of Outgoing Traffic

The operator presses test key *LK* belonging to the group of lines wanted and passes on the call to a free line by pressing its key. Marking for setting out selector *S2* to this line is obtained over selector *S1*. The first ringing signal is sent out as long as the button is held depressed. Renewed ringing signal is transmitted by the *SR* button. The lamp *KRL* lights up with steady glow when the ringing signal is transmitted.

If the operator wishes to restore the marking of selector *S2*, the *A* button is pressed which cancels the connection established. The operator holds the calling order position and can make a fresh connection.

For this traffic routing the operator must disconnect herself by means of the release button *F*, which may be done either before or after answer is received. The selector *S1* is restored.

If the operator tries to connect to a busy line an audible notification signal is received.

Release

When the order position handset is replaced, the order position relay set and selector *S2* are restored.

Enquiry and Transfer

Enquiry Call and Its Handling

Enquiry call may be made when a connection is established between a line and an order position by making an impulse with the dial. The order position will then get connection with the distribution position over selector *S1*. The test lamps *LL* light up automatically for disengaged and attended order positions. The operator connects the enquiry call to the required order position by pressing the button of the position. The enquiry call is established over the enquiry contact sets of selector *S2*. The distribution position and selector *S1* are restored automatically. In the distribution position the call lamp of the wanted order position continues with flashing light until the call is answered.

The call lamp *AL* lights up in the order position to which the enquiry is addressed and periodical audible call signal is heard. On answer, the lamp goes out and the calling signal ceases.

During the enquiry call the enquirer by means of an impulse from the dial may have connection alternately with the enquired order position and with the line. The enquiry connection is restored if the enquired order position replaces the handset.

After making enquiry call, the order position handset may be replaced before answer comes from the operator. When the operator answers the call she will then be in direct speech connection with the outgoing line.

Transfer of Call

On enquiry the call is transferred to the enquired position when the enquirer replaces the handset. The transfer can be effected both before and after answer from the position enquired of. When the enquirer replaces the handset the order line concerned is restored. The location of the line, previously connected, in the selector *S2* is marked for the enquired order position and the taking-over occurs immediately.

Interlocking Plants at La Coruña and Santiago

H INSULANDER, L M ERICSSONS SIGNALAKTIEBOLAG, STOCKHOLM

U.D.C. 656.257 (46)

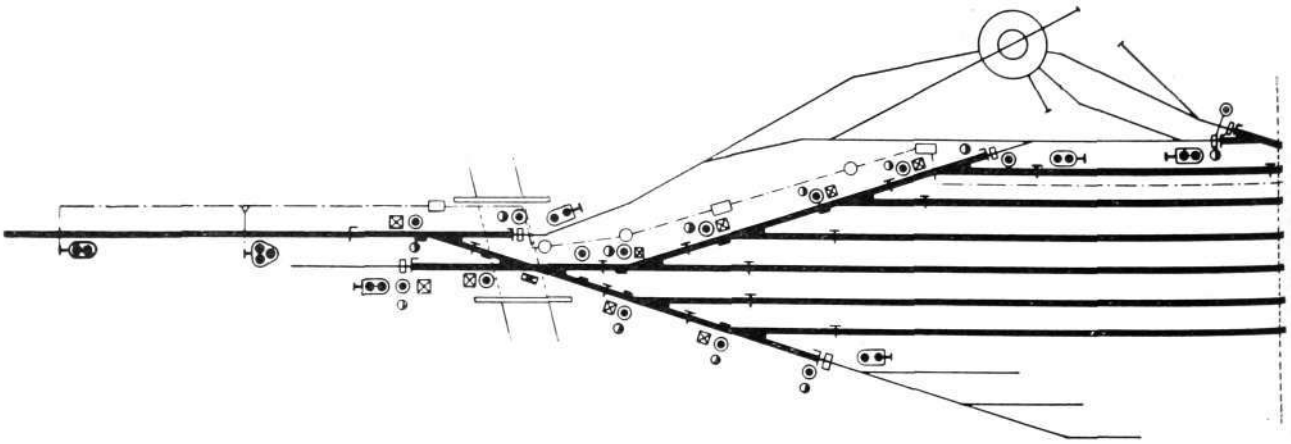
During 1944 Compañía Española Ericsson, Madrid, completed the supply of interlocking plants for the La Coruña—Santiago Railway. La Coruña is a port in north-west Spain and Santiago, or to give it its full name Santiago de Compostela, is a university town situated 50 km south of La Coruña on the road between La Coruña and the Atlantic port of Vigo on the west coast of Spain. The railway line is of recent construction and constitutes part of the programme drawn up by the Spanish Government for the building of new railways in Spain.

All the interlocking plant on this line has been supplied by Compañía Española Ericsson. The installations at the two terminal stations, at La Coruña and Santiago de Compostela, are electrical while the installations at all the intermediate stations are of mechanical construction. These latter have been largely constructed on Swedish patterns with apparatus of the lever type. The installations at the two terminuses, which are entirely electric, will be described more fully here.

Fig. 1 X 7101 X 7393
Station lay-out of La Coruña

- apparatus case
- cable distribution box
- cable branching box
- point or scotch-block lamp
- point machine
- local switch for point
- signal point lamp at double crossing points
- insulation between 2 track circuits
- terminal insulation
- shunting signal
- distant signal or exit signal, 2-light
- exit and shunting signal, 3-light
- main home signal
- signal cabin

The interlocking plants at La Coruña and Santiago, the material for which was entirely manufactured in Spain at the workshops of Cia Española Ericsson at Getafe, are of the »all-relay» type, which was adopted in view of the great advantages this offers compared with other electric types. The »All-relay» interlocking machine has the characteristic that all interlockings between tracks, points and signals etc. are ensured by the employment of relays. Thus there is no mechanical interlocking between switches or locking of the switches. Owing to this it is possible to give the interlocking machine itself extremely small dimensions as compared with other electric interlocking machines, with the further result that a large station area can be controlled from one apparatus. At the same time the surveyability of the apparatus is in no



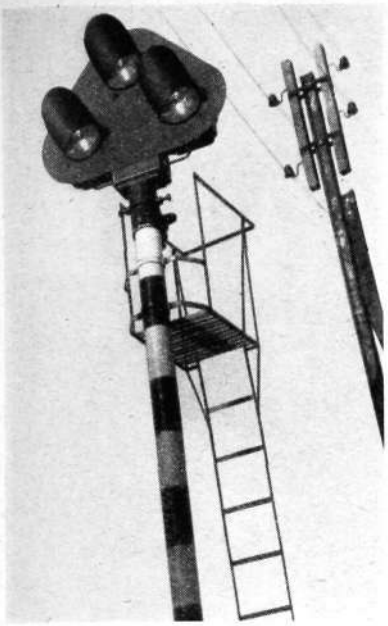


Fig. 2 X 4571
Home signal
the upper signal shows green, the two below show red light

way affected by the small dimensions; extremely good facility is provided for observing the actual situation on the station area from the indicating devices, in this case the lamps on the illuminated track diagram. Thus by the employment of apparatus of this system it is possible to control a much larger area than is the case with apparatus of other systems.

By the adoption of track circuits, together with automatic track locking and track unlocking, the safety for these installations can also be carried to the farthest limit. Faulty operation, therefore, cannot produce an accident but only interruption in running. The installations are moreover so formed that any faults immediately make themselves known.

The relay interlocking machine enables control to be automatised to a high degree. For example, it is possible to carry out the switching of all points etc. for laying a certain train route by throwing a single switch or pressing a single button. This is of great importance on large stations with dense train traffic as it considerably facilitates the work of the signalman. Nevertheless this method had not been employed in the two installations at La Coruña and Santiago.

Colour-light Signals

The signals employed in these installations are colour-light signals of the type common in Sweden. They are completely without movable parts. Thus for a signal which can show different colours, each colour has its separate light opening. The lens system is on the American principle, *i. e.*, with double lenses, with the outer lens uncoloured and the inner one coloured. The signals may show three different aspects: red indicating danger, green meaning clear and violet announcing that shunting is permitted. On some of the signals, *e. g.*, the home signals, the last aspect, shunting permitted, is missing and on others, the shunting signals, the green or clear is as a rule not included. These latter therefore can only show danger or shunting permitted.

Fig. 2 shows a home signal. As may be seen it has three light openings, two below on the same level and one above them. The two lower lights show red. For extra security the red light has been doubled on the home signals. The upper light shows green, which in this case means entrance clear. In Fig. 3 may be seen two signals at Santiago. The one on the left, an exit signal, has three light openings showing green, red and violet light respectively. The right-hand signal, which is a shunting signal and thus cannot show signal for train exit, has the signal aspects red and violet. The signal lamps are easily accessible by means of ladders and platforms on the poles. This greatly facilitates maintenance work, consisting chiefly of changing lamps and cleaning.

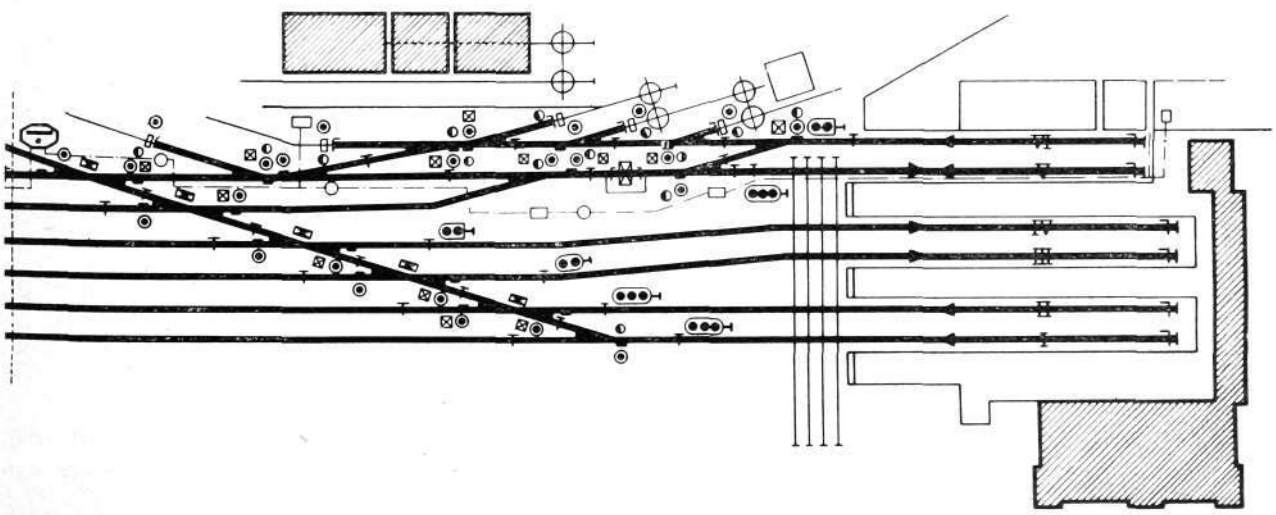




Fig. 3 X 6128
Colour-light signals
left, exit signal; right, shunting signal

Track Circuits

As stated the track systems at these stations are entirely insulated, *i. e.*, all tracks on which trains run or may run are provided with track circuits. A track circuit consists of a section of track, the rails of which are insulated from other rails and from each other, with a current source at one end of the section and a relay coil at the other. The current passes from the current source through one rail over the relay coil to the other rail and through this back to the source. Thus the relay is normally energised. When a train enters the section the current is led from one rail via the train axles to the other and back to the current source. The relay coil will then be deprived of current and the relay falls. The fact that the relay has fallen indicates that the track is not free for traffic. Obviously the relay may fall because of fault but such an indication would only mean an interruption of traffic and would involve no danger.

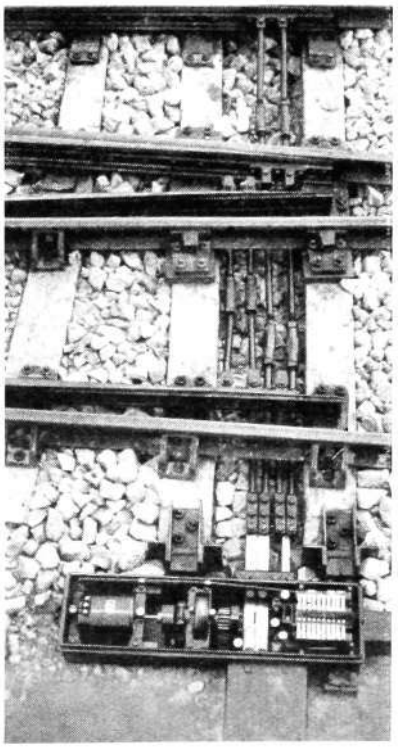


Fig. 4 X 4370
Point machine
with cover removed

The track circuits also serve other purposes, including that of preventing a point operated centrally from being changed under or immediately before a vehicle. Therefore a centrally operated point cannot be changed if the track in and in front of the point is not free from vehicles, this being controlled by the track circuit relay concerned. The track circuits also collaborate in the automatic train route locking and the automatic train route releasing. When a signal for the entrance or exit of a train is set at »clear», all points and scotch blocks of the train route are locked in appropriate positions, while all other signals which might permit a train or shunting movement in the train route or in dangerous proximity to it are locked at danger. This is the automatic train route locking. Immediately the train has passed the signal set at clear the signal changes automatically to danger owing to the action of the track circuit, but the train route remains locked until the whole train has passed the points included in the train route. First then is the train route released so that the points are again open for switching. This is the automatic train route releasing. It can also be arranged at the relay interlocking machine that the train route is released successively as the train proceeds.

Automatic train route locking and releasing is also employed with other types of interlocking machines, but they can never be so completely utilised as with the relay switchgear.



Fig. 5 X 6130
Scotch block
provided with driving device. To the right of the driving device may be seen the lamp that indicates the position of the scotch block

Point Operation

All the track points included in the track sections are provided with point machines. By means of these the points may be changed centrally, *i. e.*, from the interlocking machine or, with authority from the interlocking machine, locally by the operation of a contact device at the points. Fig. 4 shows a point machine with the cover removed at one end of a double crossing point. The point machine is furnished with built-in point tongue lock — a device by means of which it can be checked that the distance between the tongue and the supporting rail does not go beyond a fixed maximum. On Fig. 5 may be seen a scotch block which is also provided with a driving device. To the right of the driving device can be seen the lantern which informs the staff at the station of the position in which the block is. Between the driving device and the lantern lower down in the illustration is the contact device by which the driving device can be operated locally. A lamp shines in this when local operation has been authorised from the interlocking machine. The contact device itself is operated by the foot.

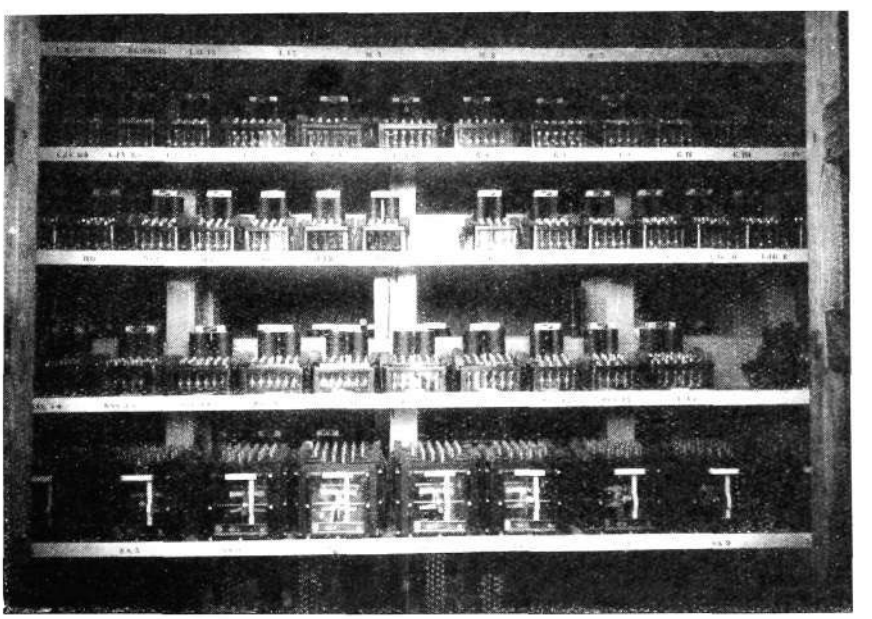


Fig. 6 X 6127
Relay shelves in the signal cabin

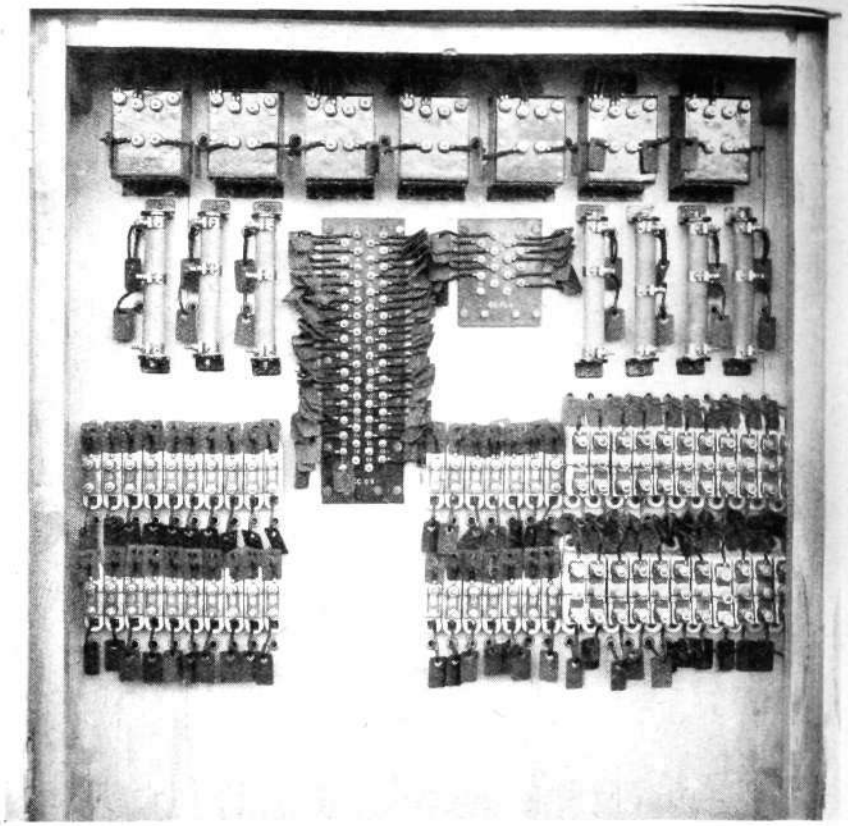


Fig. 7 X 6125
Inside of apparatus case out in the station area

Top row, transformers and, below, adjustable resistances and terminal blocks

Fig. 6 shows an inside view of the ground floor of the signal cabin. Relays have been set up on the five shelves. The lowest shelf houses the point position control relays, which are A.C. current relays with three positions. Each outside position indicates a corresponding position of the point. The middle position is assumed when the point is not closed, *e. g.*, while it is being switched over. On the other shelves D.C. relays are placed. Throughout the whole station area there is naturally a cable network leading from the interlocking machine to all track circuits, signals, point machines etc. Certain of the devices are placed in cases out in the station area. Fig. 7 shows an inside of such a case. It will be seen that in Spain there is retained after completion a kind of label on all wires, unlike the custom in Sweden.

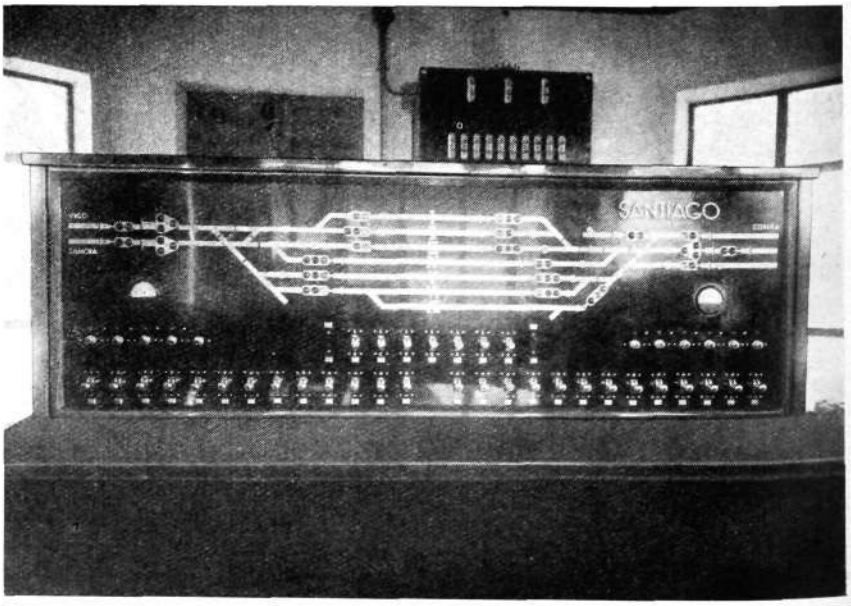


Fig. 8 X 8123
Interlocking machine at Santiago

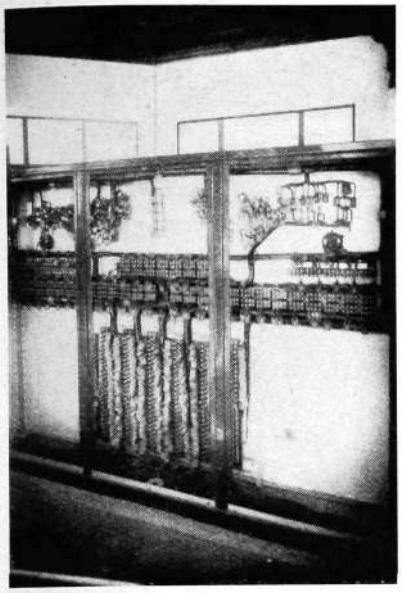


Fig. 9 X 4339
Interlocking machine at Santiago
rear view

Interlocking Machines

The interlocking machines are made as desk apparatus. Thus the signalman can execute all operations from his seat in front of the apparatus. The appearance of the control apparatus at Santiago may be seen from Fig. 8 and 9. As shown by Fig. 10 there is an illuminated track-diagram, placed above the control apparatus, with three lamps for each point. One of these stands just at the branching point of the track, the two others a little way off, one in each track. The first lamp is lit when the point is not released for local operation. Each of the others lights up when the point has taken up the corresponding position. When the point is to be included in a train route, therefore, two of the lamps are lit, namely that corresponding to the position in the train route and the lamp at the point of intersection. While the points are being switched the two lamps showing position do not shine. The rather larger lamps placed singly in the track as seen on Fig. 10 indicate when they are shining that the track in question is free from vehicles (track circuit relay is attracted) and when not shining that there are vehicles on the track. Therefore, when a train is to proceed over the station area all lamps must be shining at the places where the train is to pass. Only when that is the case can the signal be set at »clear». As may be seen the signals are repeated on the track plan.

Signals, points and scotch blocks are all operated by means of small spring switches, see Fig. 11. These switches normally always take up a middle position. From this middle position they may be thrown, when points are concerned, to two other positions, up and down. From these two positions they have automatic spring return to middle or home position. The two positions up and down correspond to plus and minus positions of the point. If the point is in minus position and the switch is moved over to plus position for a moment, the operating relay of the point receives an impulse, if there is nothing to prevent it. The operating relay attracts and switches the point over to plus position. The operation of the relay is such that it is self-holding, so that only a short impulse is required for point switching. It is essential that the control devices for points and signals should be so made that after being switched over they should automatically return to their home or neutral position. In this way the possibility has been kept open of changing over all points with a single switch, *e. g.*, for a train route. If a certain position of the point must correspond to an equivalent position of the switch this would mean when switching for a train route the switches of all the points included

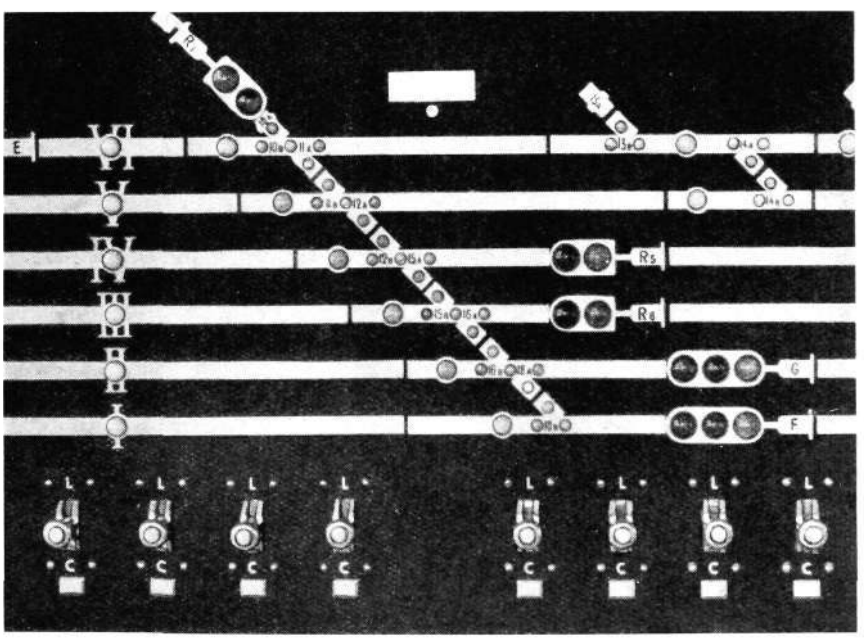


Fig. 10 X 6124
Section of track diagram on interlocking machine

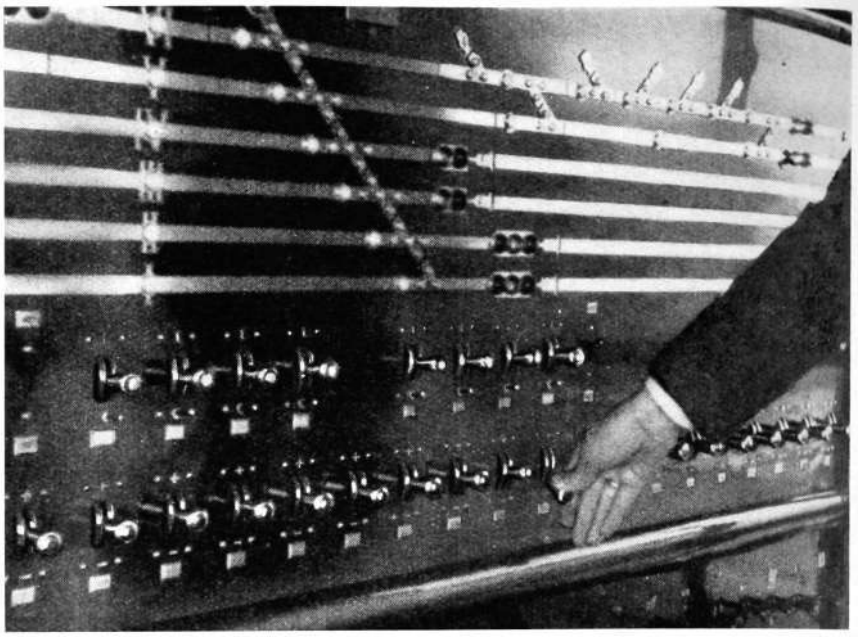


Fig. 11 X 6129
Switching over of a point
is done by operating a spring switch on the interlocking machine

in the route would have to be thrown to the position corresponding to the point position. While it takes very little time to switch over these switches, owing to the impulse operation, yet the saving in time is appreciable if it is possible to switch over a train route by a single movement, instead of having to check whether each separate point switch concerned in the train route is in the position corresponding to this train route.

The appearance of the interlocking machine may be seen on Fig. 8. On the illuminated track diagram the tracks are marked by metal strips fixed on a green enamelled sheet-metal ground. The track diagram reproduces the lay-out of the station area, somewhat skeletonized. All existing signals are repeated on the track diagram with exactly the appearance they have in reality. At each end of the track diagram, instruments are fitted, one indicating the supervisory current voltage, normally 24 V, the other the intensity of current for the motor current to the point machines. Below the track diagram there are arranged two rows of switches for operating points and signals and for giving authority for local switching.

In the room where the interlocking machine is installed there are also located devices for the supply of electric energy to the installation. The power delivered is three-phase 220/127 V. In the relay room, located immediately below the control room, in addition to relays and cable boxes for the outgoing cables, there are housed transformers for track diagram, relays, point machines and signals.

New Svenskradio Wireless Receivers

C FREDIN, SVENSKA RADIOAKTIEBOLAGET, STOCKHOLM

U.D.C. 621.396.62

Svenskradio's characteristic form — a fine result of the creative fantasy of artists and radio technicians — gives these receivers an external appearance which is not only attractive aesthetically but also acoustically correct. The sound in the latest of models is also unusually pleasing and of sterling quality from the lowest to the highest volume. Among the new features may be noted localized short-wave, a simple and effective solution of the problem of tuning in on the short-wave bands.

When, last year, the estrade model was introduced, many customers were rather sceptical about this bold step. Nevertheless it was soon found that even the more conservative accepted this pioneer shape with enthusiasm. The pleasing fact was gratefully received by the technicians, who had found in the estrade model an excellent sound screen with particularly good acoustic properties. Otherwise the requirements for good sound quality have usually conflicted with demands for an attractive appearance.

Loud-speaker development is constantly making progress. Svenska Radioaktiebolaget who, with the exception of the permanent magnets, make their own loud-speaker down to the smallest component can adapt the character of the sound flexibly to the shape of cabinet and keep pace with the latest experience in the domain of amplifier technique. By means of new specialized machines, centrifugals and hydraulic presses, cones are produced which fulfil the highest demands respecting eveness and precision. The thickness of the cones diminishes towards the outer edges and they are provided with relief-stamped concentric rings. Acoustic measurements, checked at the sound laboratories both of LM Ericsson and the Royal Swedish Telegraph Administration, show very fine results.

One of the most important details in the connection of the receiver is the negative feed back of the low frequency amplifier, which in the Svenskradio receiver is shaped in a special manner. Besides the increase in register and decrease in distortion which accompany the negative feed back, the shape of the voice frequency curve in sound regulation is corrected so that the listener will receive intelligibly even on the weakest pianissimo the bass register so important for the tone beauty of the sound.

On a number of our receivers there is a switch for various degrees of negative feedback. This has been provided with the idea that the sound may occasionally require correcting to suit acoustic conditions prevailing. For this reason the switch has been called *acoustic selector*.

As the general listener has more and more discovered the benefits of obtaining familiarity with other programmes than their local or national programmes, short-wave reception has come to the forefront owing to the great facilities it offers. For several years more expensive models of receivers have been available which are stable and free from microphone action, are easy to tune in and with the station names easy to read. Svenskradio's new system, *localized short-wave*, fulfils these exacting demands in a still better way but can — and

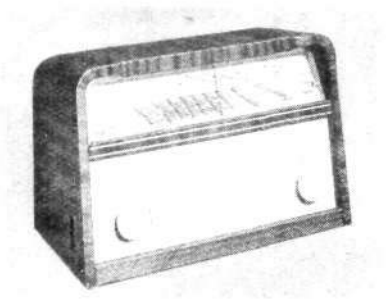


Fig. 1 X 4302
Svenskradio 1453

here we have a great innovation — owing to its small dimensions and moderate price, be introduced in receivers in the lower ranges of price.

Svenskradio's loud-speaker tapping, with output impedance for telephone receiver together with loud-speaker cut-out facility, presents advantages that are highly appreciated by short-wave listeners whose hobby is reception from long distances. Of course the other members of the family or the neighbours may not always appreciate broadcasts from say South America at 2 o'clock in the morning, however attractive they may be.

Record-changers have become more and more automatic. Now the troublesome and frequently neglected job of changing needles is dispensed with. The sapphire-needle microphone with its finely ground sapphire will play thousands of records without changing. When finally it wears out, it is a simple and inexpensive matter to replace it. An ingenuous suspension device makes the needle microphone insensitive to up and down vibrations, which contributes to keeping needle noise down to such a low level.

Table Models

An improved edition of Svenskradio 1443, as described in Ericsson Review No. 3, 1944, has been given type designation *Svenskradio 1453*, see Fig. 1. This popular model has now been furnished with a bigger loud-speaker having 200 cm² cone area and has thus attained an unusually high standard in respect of sound quality. The price for 1453, made in highly polished birch, elm or mahogany, is not excessive.

Svenskradio 1454 is a 6-valve receiver with very outstanding reception properties, especially in respect of long distance reception of short-wave. With its 6 valves, 6 circuits and 7 wave-length ranges, large loud-speaker and acoustic selector, 1454 is the receiver for all classes of listeners from the music-lover to the station chaser.

Svenskradio 1454, see Fig. 2, is supplied with a highly polished cabinet of birch, elm or mahogany.

The construction of the most interesting feature in the design of this receiver, popularly called *localized short-wave*, calls for more detailed description. The design is based on distribution of the short-wave range 16—51 m over five

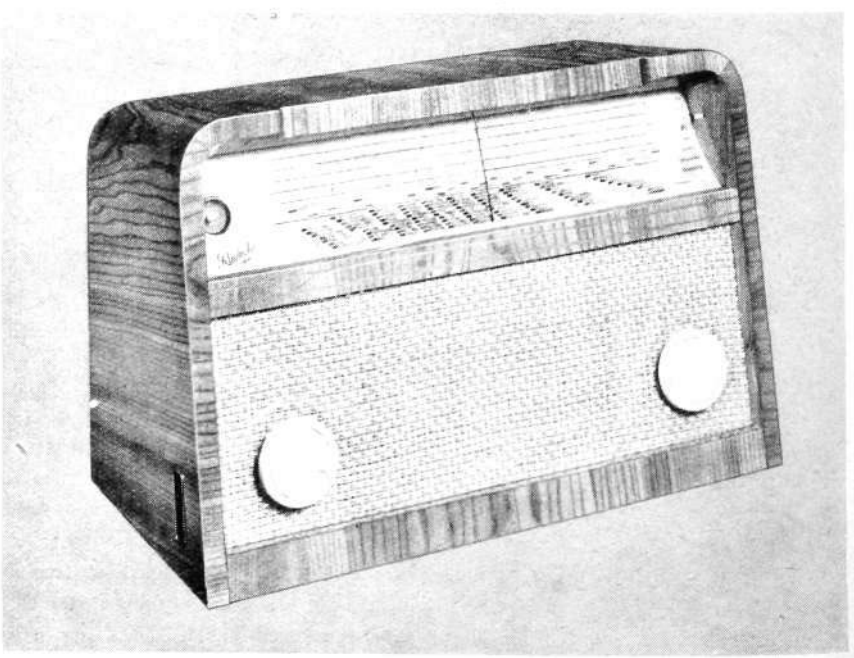


Fig. 2 X 6107
Svenskradio 1454
the controls are, from left to right, current switch, volume-tone control knob and combined station knob and wave-length switch

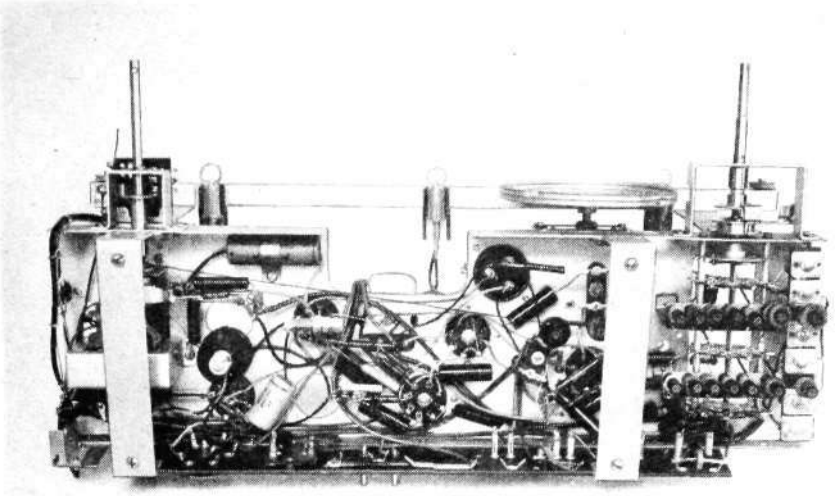


Fig. 3 X 6108
Chassis for Svenskradio 1454 LV

smaller sectional ranges. In switching between these sectional ranges, suitable inductances both for signal and oscillator circuits are selected. On the other hand the capacitances comprized in the circuits, consisting of an adjustable capacitance and parallel connected with it series connected capacitances, one fixed and one variable, are common to all short-wave ranges.

The system is possible because an extremely short drawing of lines can be applied, so that the capacitance between lines and earth is brought down to a minimum. The trimming circuit units will in manufacture be so equal in relation to each other that capacitance trimming, except for the common trimming capacitances which smooth out inequalities in valves and external line drawing, can be eliminated. By means of this simple arrangement the costs are diminished and the trimming is simplified to a high degree, while at the same time an unusually high grade of accessibility is gained. Among other advantages may be mentioned that short-circuiting of coils not connected in is unnecessary. As these are without any appreciable parallel capacitance, their resonances lie in frequencies outside the short-wave range. Moreover, on account of the small ranges, it is possible to make the oscillator coil with

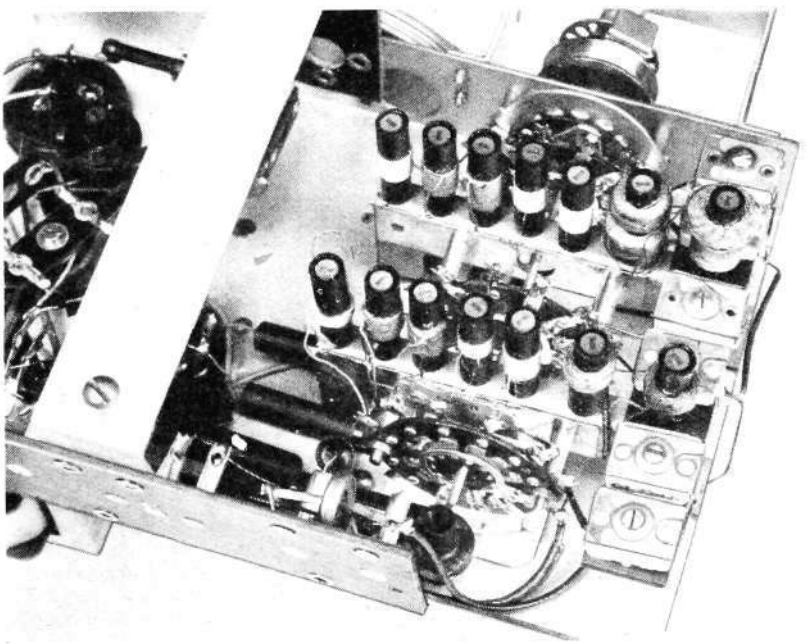


Fig. 4 X 6109
Trimming circuit system for Svensk-radio 1454
switches, coils and condensers are assembled to one unit

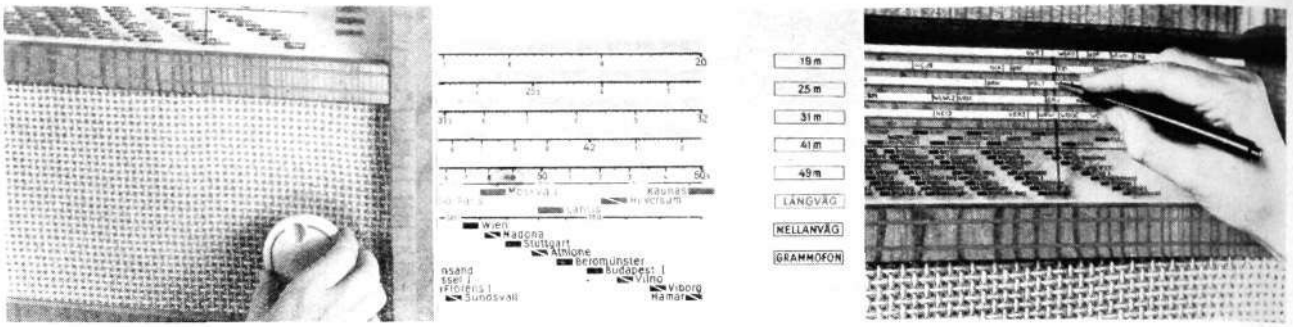


Fig. 5 N 7383

Sectional views of Svenskradio 1454

left, station knob with recess just fitting the first finger, a feature which enables one to cover the whole scale rapidly; middle, short-wave scale is divided into five section scales altogether 180 cm long; right, special calibration strip on which it is possible with a pencil or crayon to mark out, »localize», favourite stations

centre tapping instead of separate feedback winding. Fig. 4 shows a trimming circuit system in which switches, coils and condensers are assembled to one unit.

The above stated capacitance variation, equivalent for each sectional range, is executed in the following manner. On the oscillator side, to obtain high frequency stability, a relatively large parallel capacitance of app. 100 pF is employed. A shortening condenser for 100 pF is connected in series with the variable condenser oscillator section. The whole variation will be 100—170 pF. Within this range it is possible to have an oscillator which both oscillates well and has high frequency stability.

The capacitance variation in series with the shortening condenser will be — as function of the rotation angle — quite large to begin with becoming towards the close, when the shortening condenser's effect is decisive, smaller and smaller. In this way there is obtained a scale where the deviations at the beginning of the line are close but at the end very wide apart. The curved form of the rotary condenser naturally is of influence, in this case a type suitable for the purpose has been employed. Another improvement has been obtained by the oscillator section having a specially cut curved shape for the medium-wave range.

It is just on those parts of the wave-length rulings where the stations are at a maximum distance apart, as long as for medium-wave, that the short-

Fig. 6 N 7387

Connecting diagram for Svenskradio 1454 V

for A. C.; 6 valves including rectifier, 6 tuned circuits; wave-length ranges 16—20, 20—25.8, 25.8—32, 32—42.3, 42.3—51, 194—580, 690—2000 m; output 4 W.

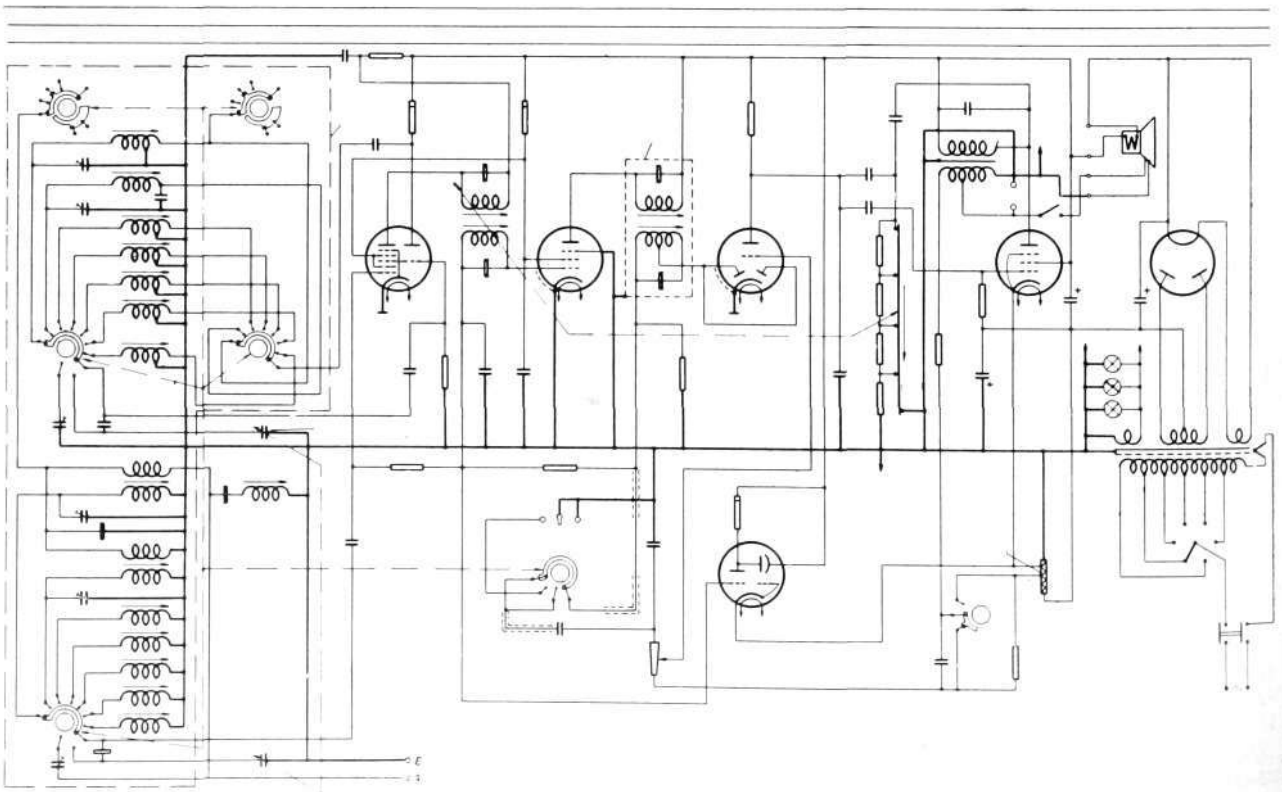




Fig. 7
Svenskradio 1457

X 4363

wave bands 19, 25, 31, 41 and 49 m are placed, see Fig. 5 in the middle. Owing to the ratio between the short-wave bands being app. 1.28 ($19.25 \cdot 1.28 = 25$; $25 \cdot 1.28 = 32$ and so on) these can be placed right below each other on the wave-length rulings while the sectional ranges, except for a small »overlap» at 40 m, fit each other precisely.

With Svenskradio combined switch-station selector, see Fig. 5 at left, it is therefore easy to move from band to band without needing to fumble for another knob or key. On account of the convenient position of the band indicator close to the rulings there is no need to move the eye from the scale.

Above each short-wave ruling there is a strip on which favourite stations can be marked with pencil or crayon, Fig. 5 right. The gearing ratio between the rotation of the station knob and the movement of the index is constant so that tuning in according to the reading will be as easy as with medium-wave.

Despite the concentration on the broadcasting station bands there is ample space for stations between the bands which so frequently occur nowadays. Tuning in and reading of these will of course be less convenient but far from difficult. Localized short-wave has advantages in this respect over what is known as »band spreading» where the stations between are as a rule tuned in on a single range with all the drawbacks of this system.

Stand Modell

A small radio gramophone, *Svenskradio 1457*, again completes the Svenskradio series after some years' absence. Its clean and stylish lines, Fig. 7, are based on the estrade idea.

On the front of the radio gramophone will be found in addition to the tuning knob a radiogram switch. The easily operated receiver has a splendid range. A loud-speaker of the latest design, HP 1021, ensures agreable sound.

The signals from the sapphire-needle microphone go through an R—C filter and a triode in the intermediate frequency valve so that with the low frequency amplifier input they receive the same low frequency characteristics as the wireless part.

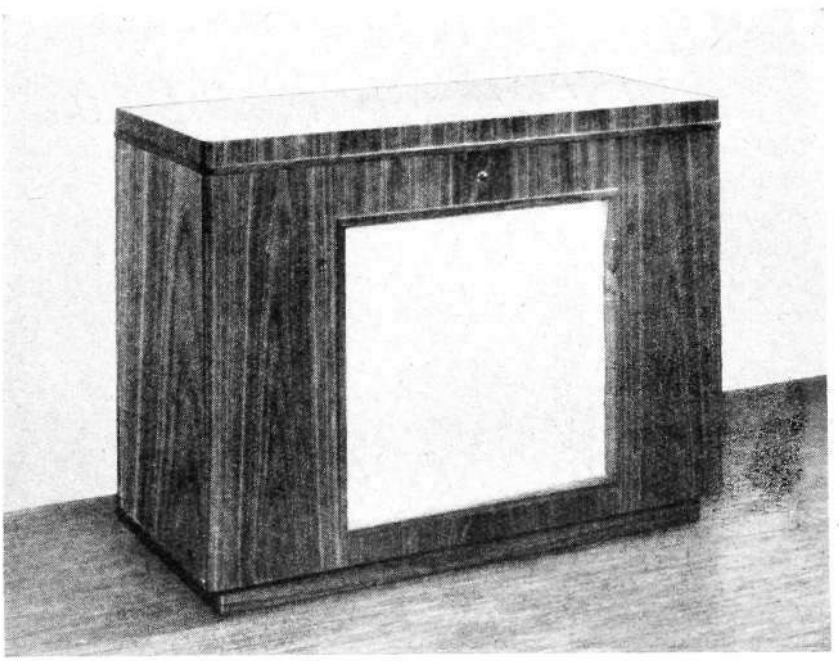


Fig. 8
Svenskradio 1458

X 5901

	1453 V (LV)	1454 V (LV)	1457 V (LV)	1458 V (LV)
Technical particulars				
Sensitivity at 50 mW output μW	10 (20)	10	10 (20)	10
Number of tuned circuits incl. oscillator circuit	6	6	6	7
Wave-length ranges:				
short-wave m	15—51.5	16—20 20—25.8 25.8—32 32—42.3 42.3—51	15—51,5	13.6—18.8 18.8—30 30—51.7
medium-wave m	187—580	194—580	187—580	187—580
long-wave m	682—1960	690—2000	682—1960	690—2000
Short-wave scale length mm	300	1800	360	975
Intermediate frequency kc/s	144	467	144	467
Maximum output W	3.5 (1.5)	4 (2)	4.5 (4)	9 (8)
Power consumption W	54 (75)	62 (75)	62 (105)	70 (145)
Starting up time s	15 (30)	15 (30)	15 (40)	15 (30)
Loud-speaker (permanent HP, field-fed HF)	HF 618 (HP 918)	HF 621 (HP 921)	HP 1021 F	HP 924 (HP 924) HF 616 (HP 716)
Loud-speaker's effective cone area cm²	200	300	300	335+135
Tone control — band width regulation	×	×	×	×
Acoustic selector	—	×	×	—
Radiogram switch	—	—	×	×
Register buttons	—	—	—	×
Local button	—	—	—	×
Connection for pickup	×	×	Automatic record player with sapphire	Automatic record player with sapphire
Connection for extra loud-speaker, 20 ohm	×	×	×	×
Number of tensions switchable	6	6	6 (5)	6 (5)
Valve equipment				
High frequency valves	—	—	—	6 K 7 GM
Mixing valves	6 J 8 G	MECH 21 (6 J 8 G)	6 J 8 GM	6 J 8 G
Interm. frequency valves	6 K 7 GM	6 K 7 GM	6 J 8 GM	6 K 7 GM
Detector and low frequency valves	6 Q 7 GM	6 Q 7 GM	6 Q 7 GM	6 Q 7 GM
Phase reversing valve	—	—	—	6 J 8 G
Final valve	6 V 6 G (25 Z 6 G)	6 V 6 G (25 L 6 G)	6 V 6 G (MUBL 21)	2st.6V6G(25L6G)
Indicator valve	—	6 UG 5 G	6 UG 5 G	6 UG 5 G
Rectifier valve	5 Y 3 G (25 Z 6 G)	5 Y 3 G (25 Z 6 G)	5 Y 3 G (MUY 21)	5 Y 3 G (25 Z 6 G)
Scale illuminating lamps	3 st. 6.5 V; 0.15 A	3 st. 6.5 V; 0.15 A	3 st. 6.5 V; 0.15 A	5 st. 6.5 V; 0.15 A
Dimensions				
Height mm	306	350	875	730
Width mm	470	526	536	975
Depth mm	242	265	470	422
Weight				
Apparatus with valves, net kg	10.5 (8.8)	12.1 (10.6)	37	60
Apparatus complete, packed kg	13.1 (11.4)	15.3 (13.8)	49	90

The record changer, described earlier in Ericsson Review, changes 8 records large and small mixed together. A simple movement gives pause of different lengths between each record or alternate records, repeat or change immediately to next record.

Svenskradio 1457 is provided with a small record case. The radio gramophone is made in light and dark elm or mahogany.

Svenskradio 1458, Fig. 8, is an exclusive and at the same time worthy exponent of the best that can be produced. Externally the model differs little from its predecessors, the stylish radio gramophone 428 and 438 so well known on the radio market. However, the radio part has undergone a number of changes and improvements. Among these the first to be noted is the »Local button» which makes it possible — even when the lid is down — by simply pressing a button to vary between two programmes, may be gramophone or some remote station and »Local station».

The high frequency amplifier increases the receiver's range and gives it an undisturbed reproduction, free from valve noise and image frequencies. The carefully assembled loud-speaker combination, fed by a correctly dimensioned power amplifier, gives full scope to the performances of the sapphire-needle microphone and the radio part.

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U.D.C. 621.396.62

FREDIN, CURT: *New Svenskradio Wireless Receivers.* Ericsson Rev. *22* (1945) No 4 pp. 187—193.

Svenskradio's characteristic form — a fine result of the creative fantasy of artists and radio technicians — gives these receivers an external appearance which is not only attractive aesthetically but also acoustically correct. The sound in the latest of models is also unusually pleasing and of sterling quality from the lowest to the highest volume. Among the new features may be noted *localized short-wave*, a simple and effective solution of the problem of tuning in on the short-wave bands.

U.D.C. 621.395.97

THAMES, GÖSTA: *Conference Telephone.* Ericsson Rev. *22* (1945) No 4 pp. 162—170.

The conference telephone or manager's telephone as it has also been called has come more and more into employment as an accessory for ensuring rapid telephone communication between a chief and his nearest collaborators. Telefonaktiebolaget LM Ericsson has now placed on the market a new type of telephone installation, the design and functioning of which are described in the article.

U.D.C. 654.939.1

WALLNER, O: *L M Ericsson's Mine Signalling System.* Ericsson Rev. *22* (1945) No 4 pp. 171—174.

Mine signalling installations formerly in general use were rather primitive though they did serve their purpose. As a rule they consisted of mechanical signal devices operated by lines or wires running in the mine shafts. Nevertheless, with present-day demands on safety, such installations can no longer be regarded as satisfactory.

In recent years, therefore, more up-to-date systems, chiefly mine telephones with or without visible auxiliary signals, have been installed. Telefonaktiebolaget LM Ericsson has supplied for one of the mines belonging to Fagersta Bruks AB a signal system which appears to meet every demand on reliability of operation and simple operation. A brief account will be given here of the constructive design and method of operation of this system. The aim of the article is to present general points of view respecting installation that came to notice during the execution of the system.

U.D.C. 621.395.25

NILSSON, EMIL & LARSON, ERIK: *Private Telephone Intermediate Switchboard for Semi-Automatic Distribution of Incoming Calls.* Ericsson Rev. *22* (1945) No 4 pp. 175—179.

For telephone subscribers the traffic to whom is chiefly composed of enquiry and order calls the need often arises to distribute the calls in a simple and rapid manner to the various groups within the common organization. Telefonaktiebolaget LM Ericsson have designed a semi-automatic distribution switchboard which meets this need. The design has been worked out in conjunction with the re-organization of the Swedish State Railways sleeping berth booking office at Stockholm.

U.D.C. 656.257 (46)

INSULANDER, HÅKAN: *Interlocking Plants at La Coruña and Santiago.* Ericsson Rev. *22* (1945) No 4 pp. 180—186.

During 1944 Compañia Española Ericsson, Madrid, completed the supply of interlocking plants for the La Coruña—Santiago Railway. The railway line is of recent construction and constitutes part of the programme drawn up by the Spanish Government for the building of new railways in Spain.

All the interlocking plant on this line has been supplied by Compañía Española Ericsson. The installations at the two terminal stations, at La Coruña and Santiago de Compostela, are electrical while the installations at all the intermediate stations are of mechanical construction. These latter have been largely constructed on Swedish patterns with apparatus of the lever type. The installations at the two terminuses, which are entirely electric, will be described more fully in the article.