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CCIF Recommendations for the Handling of Trunk Calls

A. LIGNELL, DIRECTOR OF TELEPHONES, STOCKHOLM

In Europe telephone operation is mostly in the hands of State administrations, though there are private telephone undertakings in a number of countries. To ensure satisfactory International joint working, therefore, uniform provisions for the establishment of calls are an indispensable necessity. With this object the International Consultative Committee for Telephony (CCIF) has drafted certain recommendations and working instructions intended for application to international telephone traffic. The contents of these recommendations are discussed from the point of view of operation.

Long international telephone circuits are expensive installations and require to be fully utilised if the rates for calls are to be kept within reasonable limits. Circuits which are badly utilised in respect of actual charged time of calls, due to unsatisfactory operating devices and service, naturally involve higher rates for calls if they are to return interest and redemption on the capital engaged and provide for operating and other expenses than do circuits in which the quality of the operating devices and the service are such as to ensure full utilisation of the circuits.

With present international rates for calls, losses of time in establishing connections, apparently insignificant in themselves, may represent appreciable amounts in the long run when traffic is extensive. In international as in national trunk operation distinction must be made, both for economic reasons and for the handling of the traffic, between short and long circuits. Short circuits in view of the small cost of the lines are comparable with purely local traffic and can thus, like them, be arranged for automatic operation on zone and time bases for charging calls. In such case the expense of operators is eliminated, which in short distance connections with manual ordering of the calls plays a greater part than do the costs of lines and exchanges. In the longer circuits on the other hand the cost of lines is the most important economically, the costs of exchanges and operators being in comparison of less importance. The utilisation of the circuits, *i. e.*, the utilisation of the lines for actual charged duration of call is therefore of predominating importance.

CCIF in its recommendations has therefore emphasised the importance of devices at the local and trunk exchanges being of such quality that they allow of speedy establishment of international calls and increased yield on the international lines. All technical devices which facilitate the work of the operator and make it possible for her to reduce the time of service between calls are therefore to be recommended.

An international call makes use of the subscriber's line, the exchange equipment at both ends and one or more international lines, as well as two or more operators for making the connections. On the other hand, a local call only takes up two subscribers' lines and the exchange equipment concerned, the connecting of the lines taking place automatically or with little work on the part of the operator.

Besides the great difference in cost for technical devices necessary for the two types of call, the international call is more difficult to deal with than the local call, both in respect of the time occupied and the handling. The local call may be connected without any particular work or consumption of time while the international call, if it cannot be established because the called subscriber's line is busy with a local call, must be held in abeyance thus entailing considerable loss both as regards utilisation of the line for charged call units and consumption of operator's time. Moreover it may be asserted without any great fear of contradiction that an international call is as a rule of greater importance than a purely local connection.

Basing on these considerations, CCIF in its recommendations has declared that a local call ought to be cut off to allow of an international call and in »Instruction pour les opératrices du service téléphonique européen» has prescribed such cutting off, if the exchange technical equipment permits. The condition for not requiring that a subscriber's line engaged by a local call be cut off in favour of an international call would be that the international lines were so inexpensive that diminution in their utilisation would not have so much effect on the fixing of the rates. At present, however, the cutting off of local calls in favour of long distance communications is a necessity for economic operation.

The time elapsing between the ending of one call and the starting of another is dependent on two different operations: the time taken up on the trunk line for the necessary service communications between the exchanges — provisions regarding this are to be found in »Instruction pour les opératrices du service téléphonique européen» — and the time taken up in putting the two subscribers into connection with each other. The work during this latter period does not affect the trunk lines but it is the most troublesome and time consuming and the possibility of arriving at good utilisation of the lines depends mainly, therefore, on what can be done at the close of one call to establish communication rapidly between the caller and the called for the next call. To achieve this end requires that the trunk operator's work in setting up the call be facilitated as much as possible and that the time occupied by her in speaking with the subscriber should be as short as possible. It is with a view to this that the CCIF service instructions respecting the blocking of the subscriber's line and the preparation of the call have been drafted.

By blocking the subscriber's line is meant, according to the »Vocabulaire téléphonique international» published by the CCIF, to *reserve* the subscriber's line for completing an international — or trunk — call. The subscriber's line should, therefore, after connection to the trunk position be marked »trunk engaged», whereupon operators with other calls for that subscriber's number, can see without loss of time that the line is reserved. Blocking in conjunction with preparation, by which the subscriber is advised of a forthcoming international or trunk call is, according to CCIF, desirable for fixed calls (person to person call or call with prior advice to a given instrument) which constitute about 50 % of international calls. By prior advice there is the advantage that the wanted person can get ready to speak, it is not necessary for him to be sought at the moment the call is ready for connection and the time taken in establishing the call is reduced. Blocking is also necessary to expedite the service when a waiting call is on the line and can proceed with or without notification. Even blocking without notification tends to accelerate establishment of the call.

It may be of interest to consider more closely the exchange devices most suited to the CCIF recommendations for accelerating the establishment of international calls and increasing the return on international lines. The operating devices at the international positions should, as already stated, be such as save the time of the operator. The process of notification and the connection of the subscriber's line to the international line is facilitated by cord groups, with which the subscriber's line by means of a simple switch can be connected to the international line when the turn of the call comes. The same applies to cordless positions. The trunk operator herself should have the means of breaking in on a local or zone call which is going on. In automatised networks the selection of the subscriber should be by keyset which takes less of the operator's time than a dial. Manipulation of the cords during the operation should as far as possible be avoided, being replaced by a switch.

Handling of Calls

The various cases which may arise in the establishment of an international or a trunk call are indicated below, and for these different cases the devices are indicated which may be considered suitable for carrying out the recommendations of CCIF.

The Wanted Subscriber's Line is Free

The trunk operator should be sure that the line is disengaged if no busy indication is received. If the operator must find this out by calling on the line, the establishment of the call is delayed in every case and a mistake may arise because at the moment there happened to be a temporary pause in the conversation proceeding.

Then the subscriber's line, on connection to the operator's position, should be blocked for other trunk calls. For, if the subscriber's line be not blocked when an international call is awaited or proceeding, other trunk operators wanting that subscriber's number may cause interruption both during a possible blocking time and during the ensuing call. Enquiries by the telephone staff as to what kind of call the subscriber is engaged with, etc., cause confusion in the service both for operators and for callers and moreover they take up the time of operators; operators' enquiries while a call is proceeding will interrupt and confuse the speakers as well as add to the duration of the call, thus increasing the cost to the users. These interruptions entail considerable inconvenience for calls on the longer international and trunk lines. Moreover, in such case international and trunk calls can be heard from any of the exchange trunk positions, which endangers the maintenance of telephone secrecy.

For the above reasons a subscriber's line which is connected for a local call should be marked busy for the trunk operator by a *local* indication, and a subscriber's line which is blocked or busy with an international or a trunk call should be marked busy by a *trunk* indicator. Separate indicators for international and trunk calls on the one hand and local calls on the other are thus a necessity.

The Called Subscriber's Line is Busy with a Local Call

The trunk operator, on connecting the subscriber's line to her position, should be able without delay to decide whether the subscriber is engaged on a local call. Should this not be possible, which is the case when one indication sign is used for both trunk and local calls, then enquiry must be made of the speakers. As in this instance the subscriber is locally engaged, the time occupied in establishing the subscriber's international connection is prolonged. If, on the other hand, the operator can ascertain for herself the nature of the call on which the subscriber is engaged, she should, as a local call is in question in this case, cut off the call after a brief intimation and connect the subscriber's line to the international or trunk line, in full accordance with the CCIF recommendations. Moreover, the subscriber's line on being connected to the operator's position, should be blocked for other trunk calls as stated above.

For these reasons separate indications for trunk and local calls are a necessity and the trunk operator should be in a position to cut off any local call in progress.

The Wanted Subscriber's Line is Busy with International or Trunk Call

The trunk operator should, when she has plugged in the subscriber's line to her position, know for herself whether the subscriber is busy with an international (trunk) call. Should this not be possible, because a common indicator is used for both trunk and local calls, then the subscribers must be asked, with the inconveniences referred to above. In addition the time taken up by the call on the line served by the operator is detrimentally affected by the delay caused in ascertaining from the subscriber that the line is busy with an international (trunk) call.

Person-to-Person Call

As stated earlier a préavis call should be prepared for, after which the subscriber's line should be kept reserved at the operator's position up to the moment for connecting the call. Special trunk engaged indication is therefore necessary..

A Call is Waiting on the Line

The »Instruction pour les opératrices du service téléphonique européen» prescribes that if a call is waiting on the line, it should be possible to set up the new call *immediately* the preceding one comes to an end. For this purpose all operations which can be carried out in advance should be done while the preceding call is going on, in order that caller and called for the new call can be put into connection for the new call without waste of time.

It should be possible to connect the subscriber's line to the operator's position without at the same time signalling the subscriber. If signal goes out automatically on connection of the subscriber's line to the operator's position the subscriber gets a call without being able to converse. If the advance preparation has not been completed then the subscriber is needlessly troubled.

The subscriber's line after connection should also be reserved for the international or trunk call in question for the reasons given.

Consequently signalling from the trunk position should be manual, not automatic on connection. Moreover there should be special trunk indication.

As may be seen from the foregoing, to enable the CCIF recommendations to be fulfilled the following operating devices are necessary:

1. separate indication for trunk and for local calls, which not only accelerates service and reduces work for operators, but also ensures the necessary order in the service, with conversation undisturbed by operator's enquiries;

2. the trunk operator herself should, after brief notification to the subscribers, be able to cut off a local — or possibly suburban — call which may be going on;

3. signalling from the trunk position should be manual, not take place automatically on connecting in.

To avoid the inconvenience which blocking of a subscriber's line may be supposed to cause the subscriber, it is advisable besides to have a device which, during the blocking period, leaves the blocked line open for local traffic in both directions, providing the trunk operator herself can cut off any local call connected while the subscriber's line is blocked for trunk traffic. In such circumstances the local call could be cut off without much loss of time and the blocking could not be said to cause inconvenience to the subscribers.

At the plenary meeting of CCIF in Copenhagen in 1936 there was formulated, on the basis of a proposal presented, a new question to the following effect: »Would it be advisable to alter the instructions »Dispositions permettant de donner aux communications interurbaines la priorité sur les communications urbaines» in such a sense that international calls could be established with the *least possible delay,* while at the same time simplifying as far as possible the technical devices at the local and trunk exchanges?» Here it is a question of whether CCIF would consider it advisable to alter its recommendations applying to the handling of international calls in favour of simplifying, and thereby cheapening, the equipment of local and trunk exchanges. This is of course highly desirable, but if such simplification were to lead to appreciable economic and other disadvantages in international traffic, both for the administrations and for the users, which on present costs of the longer international and trunk lines would seem to be inevitable, it is to be hoped that the priority over internal traffic which international regulations accord to international traffic may be maintained when judging the question, taking into consideration economic utilisation of the lines, good service in handling of the calls and undisturbed exchange of international communications.

Methods for Reducing the Number of Spares in Local Telephone Networks

N. SIDENMARK, TELEFONAKTIEBOLAGET L.M. ERICSSON, STOCKHOLM

Of the total installation cost of a local telephone plant about 60 % is represented by the network, 25 % by the exchanges and 15 % by the telephoneinstruments. Consequently, in order to arrive at economical construction of a telephone plant it is necessary in the first place to determine the most economical system of construction for the network. A saving of 10 % on the network means 6 % on the whole plant while, e. g., 10 % on the exchanges means only 2.5 % on the plant. Nevertheless, the main interest in studies of the economy of telephone plants has, strangely enough, been confined to the exchanges. The networks have been more or less neglected. However, the importance has lately been more and more realized of economical construction of the network for the finance of a telephone enterprise, and detailed investigations in the matter have been put in hand. The following pages contain a description of the methods used for the reduction of the number of spares in local networks constructed on the Ericsson system.

One of the most important perhaps the decisive factor in respect of economical development of a local telephone network is the *ratio of utilisation, i. e.,* the relation of the lines utilised by subscribers to the total number of installed lines. In order to obtain a high ratio of utilisation the network has to be developed in such a way that there will be a minimum of spares at any given moment, *i. e.,* that the development of the net will be coordinated as closely as possible to the curve showing the increase in subscribers. In order to realize this coordination in practice it is necessary in the first place to determine fairly exactly the future increase in subscribers for a certain period, and secondly to choose a network system which allows of a small number of spares and permits of extension by stages. Only if these conditions are satisfied will it be possible to obtain a high ratio of utilisation and, consequently good economy, see Fig. 1.

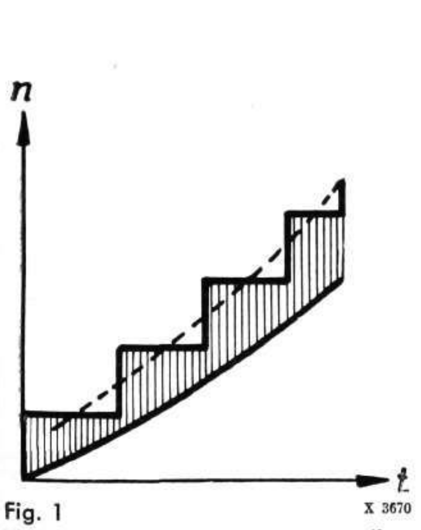


Fig. 1
Number of subscribers and installed lines in the main cable network as a function of time

For the calculation of *increase in the number of subscribers* many methods have been proposed and many rules have been established. But no matter how exact the method chosen, there must always remain a relatively wide margin of error, and the longer the period for which the project is made, the more uncertain, naturally, will be the result. Therefore it is advisable to restrict the length of this period as much as possible. Formerly, the networks could be projected for periods of 20 years or more, now periods longer than 5 years or at the most 10 years are rarely chosen. In this way the increase in the total number of subscribers can be determined with a satisfactory degree of accuracy.

However, when constructing a network it is not sufficient to fix the total increase in subscribers but a predetermination of this increase in every point or every little part of the net is also necessary. In practice, it is impossible to make this predetermination exactly, as even for so short a period as 5 years so many unexpected things can occur that the survey for the network must not be based on these estimated figures alone.

Thus, there is no other possibility except the construction of the network on *some definite system* which does away with these difficulties. The networks should be not rigid but more or less elastic, *i. e.*, the spares should not be attached to each separate point in the network but should be available for large parts of the same. Many principles have been applied for obtaining nets with this property, *e. g.*, distribution »piling up», circular cables, connection in parallel, double network, one rigid and the other flexible, or different combinations of these systems all of which are mainly directed to reduction of the number of spares in the net. The more elastic the system selected, the greater the saving in spares. Then the problem is to balance this saving against other economic and technical factors such as the reduction of the lengths of the subscribers' lines, the obtaining of a clear numbering scheme etc.

As regards construction of the network by *stages*, it is well known, however, that important savings can be achieved by running a great number of lines from the outset, the cost per line thereby being lower than if each line were run independently of the others. This fact is illustrated by Fig. 2 which shows the variation in the cost of laying underground cable in conduits (exclusive of the costs of the conduits and the conduit laying). Thus, the price per one pair and 100 m of small cables is several times higher than the equivalent price for large cables. This can also be applied to other network details. Therefore, it is not an advantage to have the network development curve quite parallel with the curve showing the increase in subscribers, and the development stages of the network should be calculated in advance on economic principles. A general rule for the determination of these stages is that the most economical system of network construction is that which results in the lowest costs when these are reduced to the time zero. The stages of construction are calculated separately for the underground conduits, the main cables, the secondary cables etc. After the stages have been decided on, attention should be given to the necessity of executing all details of the network consistently in a manner suited to this construction by stages.

The Ericsson Network-Construction System

This system is mainly based on the distribution principle. The city in which the local network is to be installed is divided into a number of interdependent

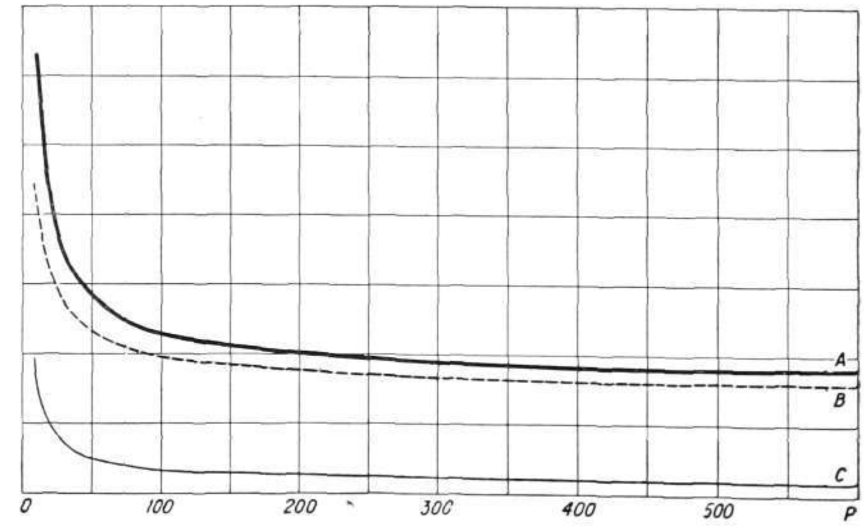


Fig. 2 X 5337

Cost per pair and 100 m of laying underground cable (exclusive of the cost of the conduits) as a function of the number of pairs

A total cost
B cost of material
C cost of labour

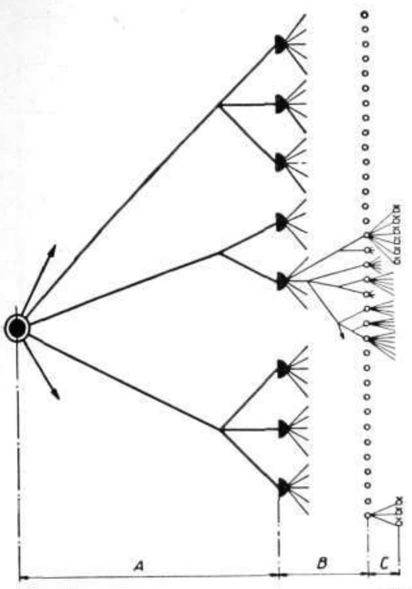


Fig. 3
Skeleton diagram of the Ericsson network-construction system, without buffer cabinets

- exchange
- cable-distribution cabinet
- end-distribution point
- subscriber's instrument

distribution areas, a distribution cabinet being placed in each area. These cabinets are the central points around which the network is constructed. Cabled lines, constituting the *main cable network* are run from the exchange to the distribution cabinets. From the distribution cabinets lines, also in cables, constituting the *secondary cable network* are run to end distribution points in each distribution area.

The main cable network generally consists of underground conduit cables or armoured cables, and sometimes — though rarely — of aerial cables. This applies also to the secondary cable network, in which, however, aerial cables are used to a somewhat greater extent. Both the main and secondary cables are terminated and sealed — each cable separately — in terminal boxes mounted in the distribution cabinet. Jumpering by means of special jumper wires is then carried out between the terminals of the main terminal boxes and those of the secondary terminal boxes. In the end distribution points, set up on walls or poles, the secondary cables are also terminated and sealed in terminal boxes of the same general construction as those in the distribution cabinets. The subscribers' lines are connected to the end distribution points by means of single pair lead-covered cables, open wire or insulated wire, these constituting the *subscribers' line network*.

Thus, on its way from the exchange, a subscriber's circuit starts from the protecting strip in the exchange building, runs in the outgoing main cables and enters the distribution cabinet, is there jumpered over from a main terminal box to a secondary one, continues in the secondary cables to the end distribution box, is there connected by means of a gland to the single pair cable or the open wires to terminate at the subscriber's set. For the rest, the Ericsson construction system is illustrated on Fig. 3. From the above it will be seen that the main cable network, the secondary cable network and the subscribers' line network are quite district from each other. This permits of *different numbers of spare lines in the three networks*, thereby achieving appreciable savings.

As a rule the subscribers' line network is at first developed only in proportion to the number of subscriptions received. An exception is sometimes made for large buildings where the administration may be sure of having fairly soon subscribers in every flat. Such buildings are provided at the time of their erection with a complete subscribers' line network extending to each flat. Apart from such special cases, spares are not intentionally provided in advance, and the subscribers' line network should consequently follow the curve of the subscriber increase closely and be utilised to 100 %. However, owing to removals by subscribers or the termination of subscription contracts, several of the lines which were originally utilised will become vacant, and after some years of service a subscribers' line network will always comprise a rather large number of spares. This cannot be avoided. If the subscribers' lines have been run in open wires it may sometimes pay to remove same for use elsewhere on some future occasion. This is seldom economical for lines in singlepair cable. As a rule the unemployed lines are left in place, since there always is a good possibility of obtaining a new subscriber in the premises where the previous one had a telephone.

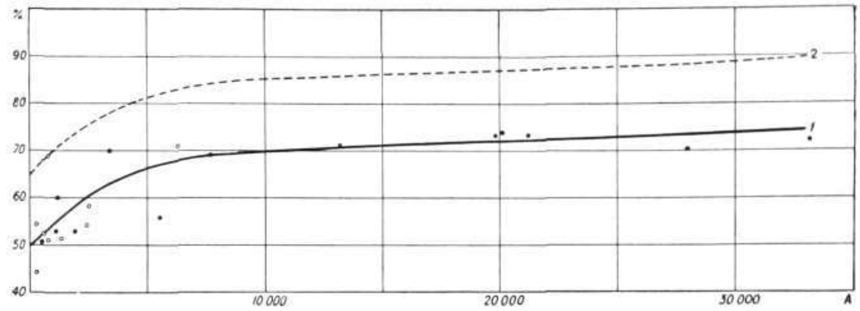
On the other hand, the secondary and the main cable network cannot be developed in exact proportion to the number of subscriptions received. Spares must be provided in advance in order to meet demands occasioned by the future increase in subscribers. If the networks were not distinct from each other, the number of these spares would naturally be the same in both networks. Thanks to the jumpering facilities in the distribution cabinets this is

Fig. 4 X 5338

Ratio of utilisation for some plants in Sweden, Mexico and Poland (1935 and 1936) as a function of the number of subscribers

1 actual ratio of utilisation

2 probable ratio of utilisation with buffer cabinets



not necessary, and one network can be developed quite independently of the other.

The secondary cable network should be developed in such a way that the subscribers' lines, which are the most expensive, may be as short as possible. This can only be realized by placing the end distribution points rather near each other, *i. e.*, a great number of end distribution points of relatively small capacity will be necessary. Now, the smaller the capacity chosen, the more uncertain the number of spares necessary in each end distribution point. This involves a rather large margin in the construction of the secondary cable network. Furthermore, the spares required in the end distribution points should be estimated in order to allow for removals of existing subscribers and the quick connecting up of new ones. As a result the secondary cable network will always contain a relatively large number of spares. It has been found in actual practice that the total sum of these spares should be 75 % of the number of subscribers estimated for at the end of the predetermined period. This means 43 % spares in the total of the secondary cable lines or a ratio of utilisation of 57 %. It is not, however, necessary to complete the secondary cable network to its full extent immediately, this can and should be done by stages which have been calculated in advance to be the most economical. Investigations show that the secondary cable network should be developed in two stages at least. Taking an average for the different years of the period, the spares in the whole secondary cable network would amount approximately to 100 % of the actual number of subscribers, giving a ratio of utilisation of 50 %.

Similarly to what is stated above respecting the secondary cables, the main cable network should be developed in such a way that the more expensive secondary lines may be as short as possible. This can be realized only by restriction of the size of the distribution areas. In projecting these areas consideration should always be given to the subscriber density. This having been done attention should be paid, however, to the desirability of using cable units as large as possible when running the main cables. In this way the best economy both in main cables and in conduit costs will be attained. Research has shown that the most economical cable size for main routes is 600 pairs and that extensions run to each distribution cabinet should in general be 100 pairs at a time. Actual practice shows also that the main cable network will generally be extended in such a way that in the whole network there will always be spares amounting to 40 % of the actual number of subscribers, corresponding to 28.5 % spares of the total of installed main cable lines or to a ratio of utilisation of 71.5 %. As examples, the spares in the main cables for some plants may be cited, *viz.*, in Sweden, Poland and Mexico during the period 1935/1936, see Fig. 4. It will be seen from these that the ratio of utilisation is about 70 % except for the smaller networks, which have a somewhat lower ratio of utilisation. The variations in the number of spares in the main cables of a network during a long period are shown in the following table which refers to the inner district of Stockholm from 1921 to 1936.

year	subscribers	spares	total	spares in relation to		ratio of utilisation
				subscribers %	lines %	
1921	100 408	28 441	128 849	28.3	22.1	77.9
1922	97 960	35 594	133 554	36.3	26.7	73.3
1923	95 952	39 137	135 089	40.8	29.0	71.0
1924	89 487	49 263	138 750	55.1	35.5	64.5
1925	92 712	47 748	140 460	51.5	34.0	66.0
1926	97 061	45 257	142 318	46.6	31.8	68.2
1927	99 647	42 242	141 889	42.4	29.8	70.2
1928	102 864	43 156	146 020	42.0	29.6	70.4
1929	107 679	42 486	150 165	39.5	28.3	71.7
1930	111 564	42 931	154 495	38.5	27.8	72.2
1931	117 143	40 217	157 360	34.3	25.6	74.4
1932	119 914	44 001	163 915	36.7	26.8	73.2
1933	121 669	45 866	167 535	37.7	27.4	72.6
1934	121 756	48 284	170 040	39.7	28.4	71.6
1935	124 385	49 355	173 740	39.7	28.4	71.6
1936	129 577	49 763	179 340	38.4	27.7	72.3

The result of the introduction of cable distribution cabinets has been as follows:

	average number of spares in relation to		ratio of utilisation
	subscribers	lines	
secondary cable network	100 %	50.0 %	50.0 %
main cable network	40 %	28.5 %	71.5 %
saving	60 %	21.5 %	21.5 %

However, this first somewhat approximate saving in the spares has not been found sufficient and there have been evolved methods for further reduction in the spares. In networks constructed on the Ericsson system, two such methods have been employed, *viz.*, connections in parallel and introduction of a supplementary distribution stage in series with the cable distribution cabinets.

As regards the secondary cable network both methods have been used, either by connecting ten pair and distribution points in parallel two by two, or by subdividing the distribution area into smaller districts and placing sub-cabinets in them. In the latter case, the cables from the end distribution points, then termed tertiary cables, are first grouped into sub-cabinets where they are jumpered over to secondary cables, these cables being run from the sub-cabinets to the usual distribution cabinets.

In the main cable networks only connections in parallel have been used, these connections being made between adjacent cable distribution cabinets. The second method with the insertion of a supplementary cabinet has on the other hand been applied only in exceptional cases, these collecting cabinets or kiosks being rather unwieldy, if they are to accommodate all the lines from the different cable distribution cabinets. It is only recently that this method has been applied and then only in modified form, *i. e.*, merely a limited number of the lines from each common distribution cabinet have been taken into the collecting cabinet, termed *buffer cabinet*. This cabinet may then be made of a size convenient for installation and operation.

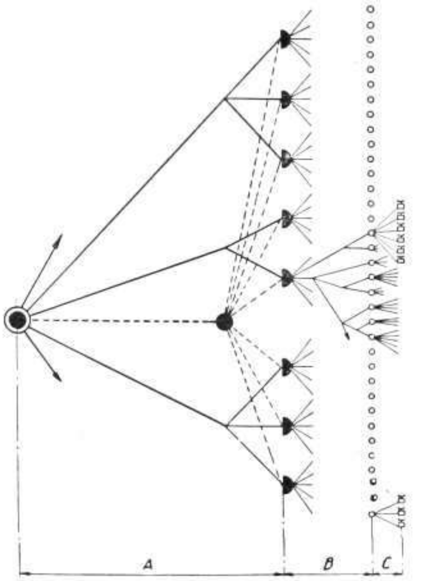


Fig. 5
Skeleton diagram of the Ericsson network-construction system, with buffer cabinets

- ◉ exchange
- ● buffer cabinet
- ◗ cable-distribution cabinet
- ∘ end-distribution point
- ☏ subscriber's instrument

The Buffer-Cabinet System

The new method is based on the placing of buffer cabinets, Fig. 5 and 6, in certain points of the network where main cables from a number of distribution cabinets come together. One part of the main cables from the distribution cabinets subordinated to such a buffer cabinet is run direct to the exchange, as previously described. The rest of the main cables are connected via the buffer cabinet. The method is best illustrated by an example. For this purpose, we consider the area on Fig. 6. There are eight cable distribution cabinets in this area, and we shall now follow the development of the main cable network of same during a period of ten years, first without buffer cabinets, and later with these cabinets inserted. The increase in subscribers is shown in the following table.

subscribers										
year	1	2	3	4	5	6	7	8	9	10
cabinet 1	128	145	163	183	205	228	245	263	285	300
2	—	—	—	16	50	108	163	205	253	285
3	6	23	40	56	78	105	127	160	206	230
4	30	62	105	135	153	178	205	206	214	220
5	81	94	107	120	130	141	154	166	184	205
6	—	—	—	—	—	10	36	59	110	155
7	59	67	72	75	81	83	87	94	122	138
8	—	—	—	—	—	—	—	15	35	65
total	304	391	487	585	697	853	1 017	1 168	1 409	1 598

A graphic figure of the increase in subscribers is represented on Fig. 7.

For the development of the network the following two assumptions may be made:

1. between the exchange and the point where the buffer cabinet is to be placed the extensions are made in stages of 600 pairs, this cable size having proved the most economical on main routes, both in respect of reasonable cable cost and of the cost of the underground conduits;

2. between the buffer cabinet and the distribution cabinet the extensions are made in stages of 100 pairs at a time, this figure also having proved the most economical for distribution cabinets of a maximum of 300 pairs to be used here.

Basing on these assumptions, the development without buffer cabinets and with the same will proceed according to Fig. 8, which shows how the network increases each year for the two alternatives.
The advantages derived from the system with buffer cabinets are obvious. In the older system the spares are not available for distribution over the whole district concerned but are confined to each distribution cabinet. As a result, as soon as the subscriber increase in one of the distribution cabinets exceeds one hundred, even if the excess be only a few subscribers, then one hundred new pairs in the main cables will have to be reserved all the way from the distribution cabinet to the exchange. In this manner, it will be necessary to run new 600 pair main cables from the exchange to the buffer point in the following stages: the first cable the first year; the second cable the third year; the third cable the sixth year and finally the fourth cable the ninth year. Between the buffer point and the different distribution cabinets new 100 pair cables are run each time the subscriber increase exceeds one hundred in each separate distribution area.

In the system with buffer cabinets, a number of the main cables from the exchange, *viz.*, 300 pairs, is connected via these buffer cabinets and these are thus available for distribution to any one of the distribution cabinets in the district.

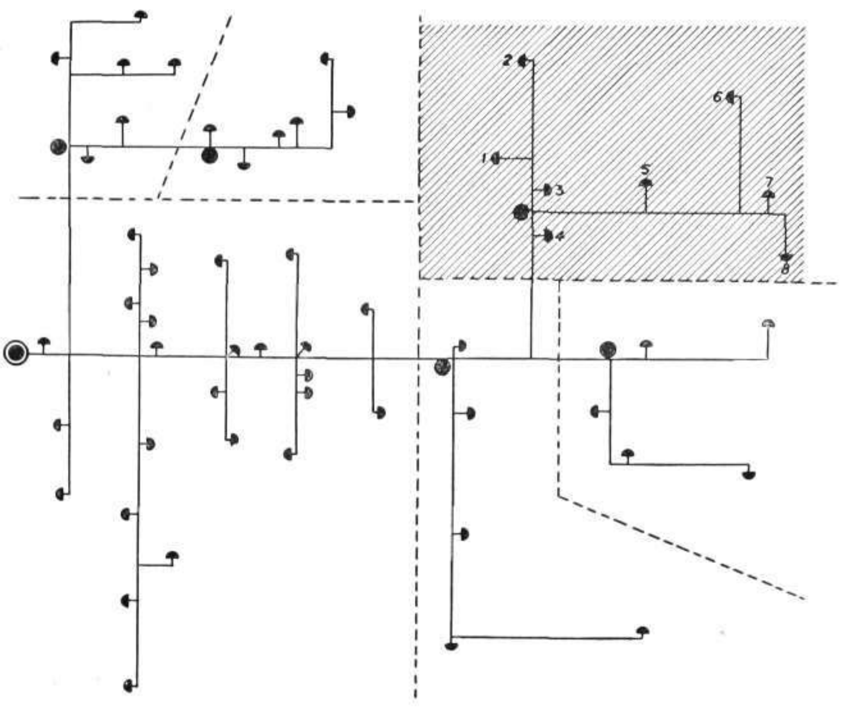


Fig. 6 X 5339

Plan of main cable network with buffer cabinets in the exterior sections

- exchange
- buffer cabinet
- cable-distribution cabinet
- end-distribution point
- subscriber's instrument

Consequently when the subscriber increase in one of the distribution cabinets exceeds one hundred, it will not be necessary to reserve 100 new pairs all the way to the exchange, it being sufficient to reserve this group only between the distribution cabinet and the buffer cabinet. Not until the hundred pairs concerned are almost fully taken up by subscribers, is a new group of hundred pairs connected up in the cables between the buffer point and the exchange. In this manner, new 600-pair cables will be run on this route in the following stages: the first cable the first year; the second cable the fifth year; the third cable the ninth year. A fourth 600-pair cable will not be necessary at all in the ten year period, since at the end of this period there will still be a considerable number of spares in the three previous cables. The requirement of 100-pair cables between the buffer point and the different distribution cabinets will be exactly the same as in the previous case, however.

The sequence of development on the system with buffer cabinets will be as follows. In the first 600-pair cable from the exchange *e. g.* 300 pairs are connected in suitable manner to the buffer cabinet, this number being sufficient for the whole period concerned. Also each first 100-pair cable from each distribution cabinet is connected to the buffer cabinet. Thereafter, as soon as one of the distribution cabinets has to be extended by 100 pairs, a new cable is run from the distribution cabinet to the buffer point and connected through over a direct cable to the exchange. Those subscribers who were previously connected via the buffer cabinet are jumpered over to the direct cable. Thus the 100-pair cable connected to the buffer cabinet becomes free to take up once more increases in subscribers until the next hundred is reached. Then the movement is repeated. Consequently no rearrangement of the joints, either on the 300-pair cable between the buffer cabinet and the exchange or on the 100-pair cables between the buffer cabinet and the distribution cabinets, is needed. Not until a distribution cabinet has been loaded to its maximum capacity, *viz.*, 300 pairs, has the corresponding 100-pair cable via the buffer cabinet to be rearranged for through connection direct to the exchange.

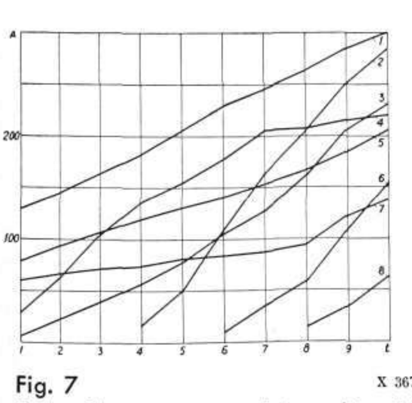


Fig. 7 X 3673

Subscribers connected to cable-distribution cabinets 1 to 8 during a ten-year period

Thus, the result of the new construction method will be a saving in cable circuits on the distance between the exchange and the buffer point, while the requirements of cable between this point and the different distribution cabinets will be exactly the same as in the construction method without buffer cabinets.

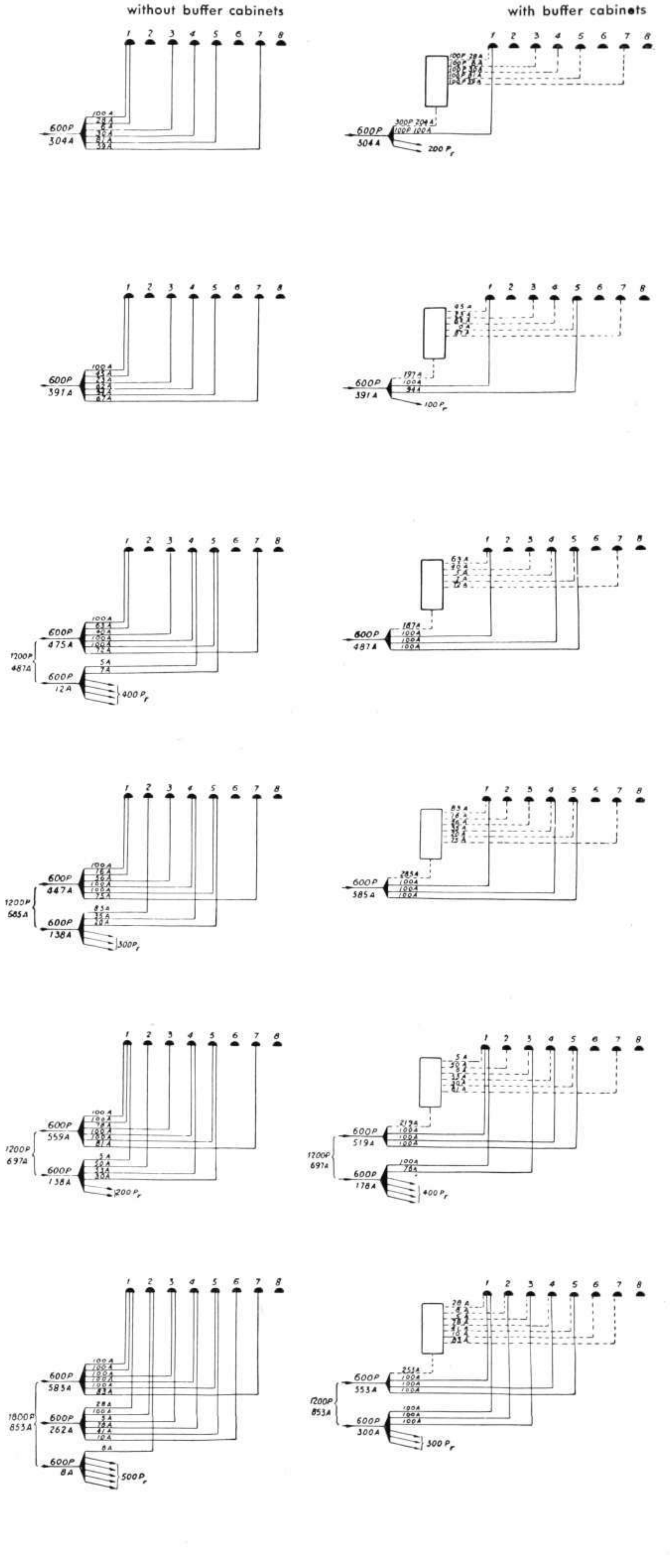


Fig. 8 X 5340

Development of the main cable lines connected to cable-distribution cabinets 1 to 8 during a ten-year period

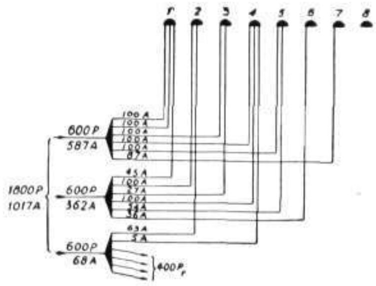
A subscribers

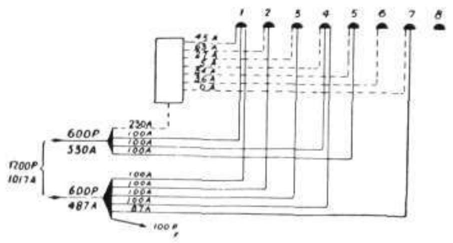
P installed lines

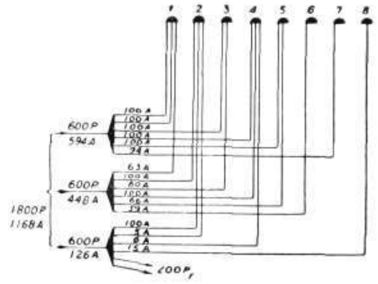
Pr spare lines

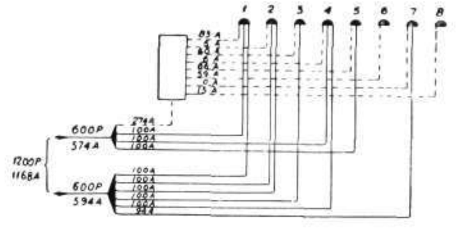
without buffer cabinets

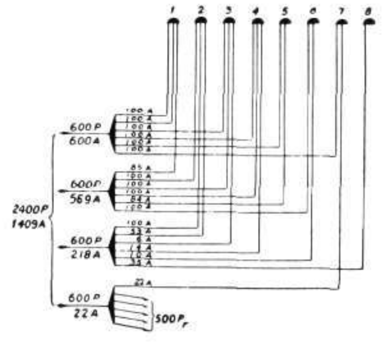
with buffer cabinets

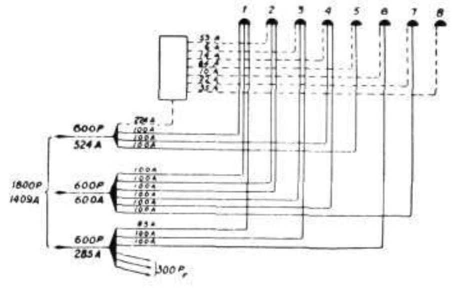


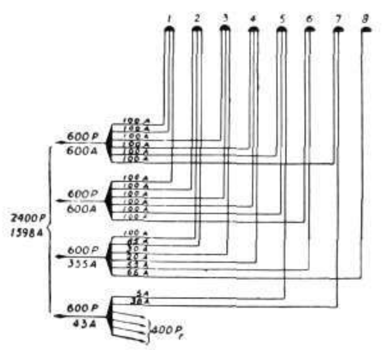


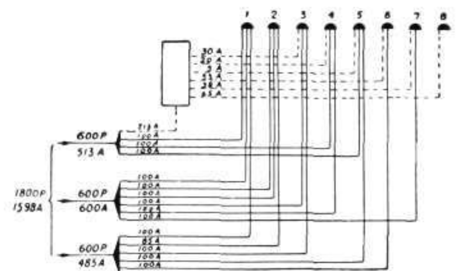












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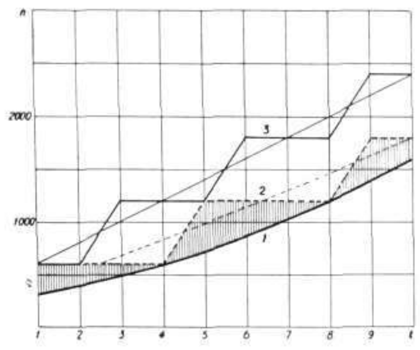


Fig. 9 X 3674

Number of subscribers and installed lines in the main cable network between the exchange and the buffer point

1 subscribers
2 installed lines, with buffer cabinets
3 installed lines, without buffer cabinets

Fig. 9 shows a diagram of the development of the main cables in the example chosen, without buffer cabinets and with them; it can be seen from this diagram how considerable a saving in main cables may be attained by the use of buffer cabinets. A purely theoretical calculation shows that the reduction of spares in the main cables between the exchange and the buffer point can amount to from 20 to 30 %. In the practice, for new networks which on the first surveying were destined for the introduction of buffer cabinets, this figure may amount to 20 %, and in older networks which have been completed without provision for buffer cabinets the insertion of these later can give a saving of up to 15 %. *Thus in a network developed on the Ericsson system the ratio of utilisation for the main cables from the exchange, which previously was about 70 % can by the use of buffer cabinets be increased to 85 %.* For comparison, a corresponding curve has been traced on the diagram, Fig. 4.

This increase of the ratio of utilisation results naturally in considerable savings which apply not only to the cable costs themselves but also the costs of the corresponding conduits and exchange equipment. Besides these savings other advantages are obtained thanks to the arrangement with two routes to each distribution cabinet, *viz.*, the one direct from the exchange and the other via the buffer cabinet. When cable faults occur it permits of obtaining a test loop of good quality and of jumpering over particularly important subscribers from one route to the other. On the other hand, there will be the extra cost for the buffer cabinets and the necessary manholes as well as the costs due to the introduction of a new connection point in all the lines run via the buffer cabinet and the costs arising in the jumpering over of each group of 100 pairs from a cable via the buffer cabinet to a direct cable. If these extra expenses are weighed against the savings mentioned it will be found that the farther from the exchange the buffer point is situated the greater the resulting gain will be. Consequently the method is most suitable in the outer sections of a network. On the contrary, in the central parts of the network, the insertion of buffer cabinets is, as a rule, not an advantage. Investigation has shown that the distance between the exchange and the buffer point for buffer cabinets of the above-mentioned magnitude should be at least 600 m. However, the method may also be easily used in small networks, *viz.*, if smaller buffer cabinets are used, the minimum distance then also being reduced.

Since the method with buffer cabinets has been in practice for only a short period, it is too early as yet to set up any general rules governing the dimensions suitable for the buffer cabinets, how many distribution cabinets should be connected to a buffer cabinet and how large a cable should be connected up to same. Therefore, before a buffer cabinet is installed an economic calculation should be made for each special case. Nevertheless, it may be suggested that buffer cabinets should not be installed for fewer than four distribution cabinets. Further, it has been found that the following numbers of lines from the exchange should be connected up in the buffer cabinet: 200 pairs for a buffer cabinet controlling four 300-pair distribution cabinetes, 300 pairs for six and 400 pairs for eight 300-pairs distribution cabinets. Finally, it may be mentioned that the method concerned has begun to be introduced in the Ericsson local networks in Mexico with good results already.

Reliability and Maintenance at the Stockholm Automatic Exchanges 1931—1935

A. LIGNELL, DIRECTOR OF TELEPHONES, STOCKHOLM

In Ericsson Review No 2, 1934, particulars of reliability and operating costs at the Stockholm automatic exchanges for the period 1931—1933 were given. Below are given similarly detailed particulars for the year 1935, with the yearly results for the period 1931—1934 included in the tables for the sake of comparison. As the exchanges by 1935 had been in operation for 12, 7 1/2, 7, 4 1/2, 3 3/4, and 2 3/4 years respectively, it is possible from the results obtained to form a trustworthy judgment of the operating reliability and the maintenance costs of the Ericsson automatic system.

Reliability

Table I shows the reliability in 1935. In all 756 286 calls made by subscribers themselves were checked during the year and of these there were 98.275 % without fault,

1.541 % fault of caller,

0.037 % fault of manual exchange operator,

0.147 % lost because of technical fault at the automatic or manual exchanges, on lines or instruments or for reason not localised.

Faults in technical devices and for reasons not localised — for all exchanges an average of 0.147 % — were, for the individual exchanges:

	calls checked	fault %	exchanged opened
Norra Vasa	95 178	0.076	January 1924
Kungsholmen	102 504	0.206	July 1928
Centralen	159 663	0.279	January 1929
Söder	151 982	0.047	July 1931
Södra Vasa	90 183	0.043	March 1932
Östermalm	156 776	0.173	April 1933

As regards »Centralen» the percentage, though even here exceedingly slight, is the greatest chiefly due to the fact that this exchange has the largest traffic with exchanges still operated manually.

Table II shows the reliability for all the exchanges for the years 1931—1935. In 1931 faultless calls amounted to 96.355 % of the number of connections checked; this percentage rose to 98.275 in 1935. The number of completed connections with answer rose in the same period from 79.179 to 80.229 %, the number of unanswered calls diminished from 8.518 to 8.075 % and the number of engaged subscribers rose from 8.658 to 9.971 %. Fault of subscriber which comprises the greater part of the fault percentage fell from 3.323 % in 1931 to 1.541 % in 1935, a natural consequence of the greater familiarity of the users with automatic traffic as time went on. Operator fault constituted about the same low percentage at the beginning as at the close of the period. On the other hand, fault in technical devices at automatic and manual exchanges, on lines and instruments and for reasons unlocated sank from 0.281 % in 1931 to 0.147 % in 1935. It should here be noted that this fault percentage diminished as manually operated exchanges were reduced in number and during the last three years, with the number

Table I — Reliability Check at Stockholm Automatic Exchanges 1935

exchange	opened	calls checked	faultless connections: calls established	faultless connections: number altered, vacant or cut off	faultless connections: no reply	faultless connections: busy	faultless connections: total	fault of subscriber	fault of operator	fault in technical devices or for cause not localised — localised: to home exchange	localised: to another exchange	localised: to line or instrument	localised: total	not localised	total
Norra Vasa	Jan. 1924	95 178	76 397	541	7 380	9 049	93 376	1 684	55	20	16	5	41	31	72
%			80.268	0.568	7.754	9.507	98.097	1.769	0.058	0.021	0.017	0.005	0.043	0.033	0.076
Kungsholmen	June 1928	102 504	79 901	531	9 249	10 675	100 356	1 905	32	107	17	4	128	83	211
%			77.949	0.518	9.023	10.414	97.904	1.858	0.031	0.104	0.017	0.004	0.125	0.081	0.206
Centralen	Jan. 1929	159 663	127 645	1 031	12 559	16 362	157 597	1 585	35	89	21	—	110	336	446
%			79.947	0.645	7.866	10.248	98.706	0.993	0.022	0.056	0.013	—	0.069	0.210	0.279
Söder	July 1931	151 982	122 871	824	10 827	14 719	149 241	2 602	68	35	7	1	43	28	71
%			80.846	0.542	7.124	9.684	98.196	1.712	0.045	0.023	0.004	0.001	0.028	0.019	0.047
Södra Vasa	Mar. 1932	90 183	70 576	604	8 060	9 183	88 423	1 669	52	14	6	4	24	15	39
%			78.259	0.670	8.937	10.183	98.049	1.851	0.057	0.016	0.007	0.004	0.027	0.016	0.043
Östermalm	Apr. 1933	156 776	124 893	946	12 998	15 421	154 258	2 204	43	60	34	30	124	147	271
%			79.663	0.604	8.291	9.836	98.394	1.406	0.027	0.038	0.022	0.019	0.079	0.094	0.173
total		756 286	602 283	4 477	61 073	74 409	743 242	11 649	285	325	101	44	470	640	1 110
%			79.637	0.592	8.075	9.971	98.275	1.541	0.037	0.043	0.013	0.006	0.062	0.085	0.147

Table II — Reliability Check at Stockholm Automatic Exchanges 1931—1935

year	connections checked	faultless connections: calls established	faultless connections: number altered, vacant or cut off	faultless connections: no reply	faultless connections: busy	faultless connections: total	fault of subscriber	fault of operator	fault in technical devices or for cause not localised — localised: to home exchange	localised: to another exchange	localised: to line or instrument	localised: total	not localised	total
1931 4 automatic exchanges 63 556 subscribers	241 466	190 078	1 113	20 568	20 906	232 665	8 024	99	247	55	14	316	362	678
%		78.718	0.461	8.518	8.658	96.355	3.323	0.041	0.102	0.023	0.006	0.131	0.150	0.281
1932 5 automatic exchanges 84 908 subscribers	434 403	345 113	2 720	35 231	38 207	421 271	12 019	152	334	90	16	440	521	961
%		79.446	0.626	8.111	8.795	96.977	2.767	0.035	0.077	0.021	0.003	0.101	0.120	0.221
1933 6 automatic exchanges 100 956 subscribers	644 830	520 214	4 102	48 375	58 957	631 648	12 037	231	322	73	21	416	498	914
%		80.675	0.636	7.502	9.143	97.956	1.866	0.036	0.050	0.012	0.003	0.065	0.077	0.142
1934 6 automatic exchanges 101 726 subscribers	690 277	551 271	4 183	54 677	67 088	677 219	11 714	320	310	84	44	438	586	1 024
%		79.862	0.606	7.921	9.719	98.108	1.697	0.047	0.045	0.012	0.006	0.063	0.085	0.148
1935 6 automatic exchanges 104 523 subscribers	756 286	602 283	4 477	61 073	75 409	743 242	11 649	285	325	101	44	470	640	1 110
%		79.637	0.592	8.075	9.971	98.275	1.541	0.037	0.043	0.013	0.006	0.062	0.085	0.147
1931—1935 total	2 767 262	2 208 959	16 595	219 924	260 567	2 706 045	55 443	1 087	1 538	403	139	2 080	2 607	4 687
%		79.825	0.600	7.947	9.416	97.788	2.004	0.039	0.055	0.015	0.005	0.075	0.094	0.169

of automatic exchanges unchanged, has remained practically unaltered. Of the 2 767 262 calls checked in the period 1931—1935 there were 4 687 faulty or 0.169 %, while 44.4 % of the faults were located and remedied in the course of the check.

The reliability as may be seen is extraordinarily good and has improved with the progress of automatisation. The age of the exchanges has not had any adverse effect whatever on the extremely good functioning of the automatic system.

Fault Frequency

Table III shows the fault frequency for the exchanges for each year of the five year period, totally, per 10 000 calls, per subscriber's line and per day.

Table IV gives the number of faults in the automatic system per 10 000 calls and per day for each exchange, both for the whole period and for the last year of the period for the sake of comparison. The number of faults per 10 000 calls has diminished and has in the last year of the period displayed a minimum which is evidence of the reliable functioning of the system and the effective maintenance. The fault figures are remarkably low and should be looked at in conjunction with the extraordinary reliability during the time. As witness of the efficiency of the maintenance it can be stated that during 1934 there were 93.6 % and during 1935 there were 93 % of the faults observed on the first investigation which were remedied. Thus there were

Table III **Fault Frequency at Stockholm Automatic Exchanges 1931—1935**

exchange	year	average subscribers lines during year	outgoing calls during year	faults during year: in automatic equipment				faults during year: in exchange devices outside automatic equipment		
				total	per 10 000 outgoing calls	per sub-scribers line	per day	total	per sub-scribers line	per day
Centralen	1931	14 944	51 872 910	1 579	0.30	0.11	4.3	1 568	0.10	4.3
	1932	16 495	68 719 323	1 979	0.29	0.12	5.4	865	0.05	2.4
	1933	16 083	74 284 443	2 906	0.39	0.18	8.0	687	0.04	1.9
	1934	16 178	80 935 756	2 034	0.25	0.13	5.6	523	0.03	1.4
	1935	15 986	87 043 355	1 557	0.18	0.10	4.3	501	0.03	1.4
Kungsholmen	1931	12 834	23 325 540	947	0.41	0.07	2.6	729	0.06	2.0
	1932	14 576	26 830 717	1 156	0.43	0.08	3.2	498	0.03	1.4
	1933	15 437	28 363 718	1 052	0.37	0.07	2.9	733	0.05	2.0
	1934	16 205	30 571 203	810	0.27	0.05	2.2	576	0.04	1.6
	1935	17 113	34 006 607	991	0.29	0.06	2.7	367	0.02	1.0
Söder	1931	—	—	—	—	—	—	—	—	—
	1932	25 911	47 450 109	1 960	0.41	0.08	5.4	872	0.03	2.4
	1933	25 594	46 786 226	1 484	0.32	0.06	4.1	764	0.03	2.1
	1934	25 416	48 624 102	1 269	0.26	0.05	3.5	427	0.02	1.2
	1935	25 930	51 190 806	989	0.19	0.04	2.7	356	0.01	1.0
Södra Vasa	1931	—	—	—	—	—	—	—	—	—
$^{1}/_{4}$—$^{31}/_{12}$	1932	19 719	26 014 350	701	0.27	0.04	2.6	564	0.03	2.1
	1933	20 072	35 001 584	1 262	0.36	0.06	3.5	488	0.02	1.3
	1934	20 370	37 882 211	958	0.25	0.05	2.6	357	0.02	1.0
	1935	20 631	40 236 161	797	0.20	0.04	2.2	292	0.01	0.8
Östermalm	1931	—	—	—	—	—	—	—	—	—
	1932	—	—	—	—	—	—	—	—	—
$^{1}/_{4}$—$^{31}/_{12}$	1933	16 629	29 181 490	1 102	0.38	0.07	4.0	600	0.04	2.2
	1934	16 972	41 129 454	890	0.22	0.05	2.4	292	0.02	0.8
	1935	18 201	44 789 725	734	0.16	0.04	2.0	283	0.02	0.8

Table IV Fault Frequency at Stockholm Automatic Exchanges 1931—1935

exchange	year	calls		faults per 10 000 calls in automatic equipment		faults per day			
						in automatic equipment		in exchange devices outside the automatic equipment	
		whole period	1935	whole period	1935	whole period	1935	whole period	1935
Centralen	1931—1935	362 855 787	87 043 355	0.277	0.18	5.5	4.3	2.3	1.4
Kungsholm	1931—1935	143 097 785	34 006 607	0.346	0.29	2.7	2.7	1.6	1.0
Söder	1932—1935	194 051 243	51 190 806	0.294	0.19	3.9	2.7	1.7	1.0
Södra Vasa	1/4 1932—1935	139 134 306	40 236 161	0.267	0.20	2.7	2.2	1.2	0.8
Östermalm	1/4 1933—1935	115 100 669	44 789 725	0.237	0.16	2.7	2.0	1.2	0.8

Table V Maintenance Costs at Stockholm Automatic Exchanges 1931—1935

exchange	year	average subscribers lines during year	cost of labour, including night work, holidays and off duty				cost of material		total maintenance cost	average per connected subscribers line and year						maintenance cost per 100 calls
			staff[1]										cost of material			
			male	female	working hours		within automatic system	outside automatic system		number of staff	working hours	cost of labour	within automatic system	outside automatic system	total maintenance cost	
						Kr.	Kr.	Kr.	Kr.			Kr.	Kr.	Kr.	Kr.	Kr.
Centralen																
	1931	14 944	13	5	42 122	63 589: —	5 435: —	8 789: —	77 813: —	0.00120	2.82	4: 25	0: 36	0: 59	5: 20	0: 150
	1932	16 495	13	5	41 602	63 630: —	3 285: —	5 096: —	72 011: —	0.00109	2.52	3: 86	0: 20	0: 31	4: 37	0: 105
	1933	16 083	13	5	41 750	62 322: —	1 004: —	2 010: —	65 336: —	0.00112	2.60	3: 88	0: 06	0: 13	4: 07	0: 088
	1934	16 178	13	4	41 251	61 632: —	4 440: —	2 019: —	68 091: —	0.00111	2.55	3: 81	0: 27	0: 12	4: 20	0: 084
	1935	15 986	14	5	42 933	64 842: —	538: —	6 308: —	71 688: —	0.00119	2.68	4: 06	0: 03	0: 39	4: 48	0: 082
Kungsholmen																
	1931	12 834	9	4	29 828	45 042: —	2 342: —	1 300: —	48 684: —	0.00101	2.32	3: 51	0: 18	0: 10	3: 79	0: 209
	1932	14 576	9	4	30 293	46 961: —	1 663: —	1 756: —	50 380: —	0.00089	2.08	3: 22	0: 11	0: 12	3: 45	0: 188
	1933	15 437	11	4	34 297	50 055: —	808: —	678: —	51 541: —	0.00097	2.22	3: 25	0: 05	0: 04	3: 34	0: 182
	1934	16 205	12	4	36 356	52 356: —	1 649: —	495: —	54 500: —	0.00099	2.24	3: 23	0: 10	0: 03	3: 36	0: 184
	1935	17 113	12	4	36 881	53 880: —	297: —	2 058: —	56 235: —	0.00093	2.15	3: 15	0: 017	0: 12	3: 28	0: 165
Söder																
	1932	25 911	14	5	46 249	66 689: —	1 765: —	5 934: —	74 388: —	0.00073	1.81	2: 57	0: 07	0: 23	2: 87	0: 157
	1933	25 594	14	5	46 931	65 255: —	861: —	1 238: —	67 354: —	0.00074	1.84	2: 54	0: 03	0: 05	2: 62	0: 144
	1934	25 416	14	5	46 105	66 229: —	2 984: —	1 008: —	70 221: —	0.00075	1.81	2: 60	0: 12	0: 04	2: 76	0: 144
	1935	25 930	12	5	41 380	60 017: —	364: —	2 437: —	62 818: —	0.00066	1.59	2: 32	0: 013	0: 09	2: 42	0: 123
Södra Vasa 1/4–31/12																
	1932	19 719	12	2	26 458	39 572: —	1 133: —	1 080: —	41 785: —	0.00071	1.34	2: —	0: 06	0: 05	2: 12	0: 161
	1933	20 072	12	4	38 323	53 106: —	233: —	927: —	54 266: —	0.00079	1.91	2: 65	0: 01	0: 04	2: 70	0: 155
	1934	20 370	12	4	39 656	53 591: —	1 927: —	909: —	56 427: —	0.00079	1.94	2: 63	0: 09	0: 04	2: 76	0: 149
	1935	20 631	12	4	39 436	54 420: —	385: —	1 143: —	55 948: —	0.00078	1.91	2: 63	0: 018	0: 06	2: 71	0: 139
Östermalm 1/4—31/12																
	1933	16 629	13	4	27 359	42 919: —	436- —	550: —	43 905: —	0.00102	1.65	2: 58	0: 03	0: 03	2: 64	0: 150
	1934	16 972	13	4	39 797	60 593: —	2 087: —	222: —	62 902: —	0.00100	2.34	3: 57	0: 12	0: 01	3: 70	0: 153
	1935	18 201	12	5	38 964	58 365: —	289: —	1 341: —	59 995: —	0.00093	2.14	3: 21	0: 015	0: 07	3: 29	0: 134

[1] *The male staff attend to the fault section and the distribution frames (which occupy 3 men at each of the above-named exchanges) and all work in the selector halls and other exchange equipment, as also the power house. The female staff is employed on cleaning the automatic devices taken out, and for cleaning of the premises (also for washing the floors).*

only 6.4 and 7 % of these faults respectively which disappeared without the location of the fault being determined and its cause removed.

»Norra Vasa» exchange is not included in the tables of fault frequency and maintenance, since calls from manual exchanges there were for a large portion of the period dealt with over manual B-positions, so that the results are not comparable. The reliability of this exchange, however, as shown by table I, is of the same quality as the other exchanges.

Maintenance

Table V shows the maintenance costs at the exchanges for each year of the period 1931—1935, totally, per subscriber and per 100 calls. The maintenance and operating staff at all the five exchanges during 1935, with an average of 97 861 subscribers, numbered 85 persons or per 1 000 subscribers 0.87 persons, 0.63 male and 0.24 women. During the same year the staff numbered, per one million calls,

Centralen	0.218 of whom	0.161 male and	0.057 female
Kungsholmen	0.471	0.353	0.118
Söder	0.332	0.234	0.098
Södra Vasa	0.398	0.299	0.099
Östermalm	0.380	0.268	0.112

During 1935 the following particulars applied on the average to all the exchanges, per subscriber and year

working hours	2.04
working costs	Kr. 2.98
maintenance costs (material and labour)	Kr. 3.13

The cost of maintenance (material and labour) per 100 calls was Kr. 0.119. If the average cost for reliability supervision at all exchanges, Kr. 0.020 per 100 calls, be added there is obtained a total maintenance and operation cost (cost for energy not included) of Kr. 0.139 per 100 calls.

Evidence of the accurate workmanship in the Ericsson automatic system and of the stable functioning of the 500 line selector system is the small need for trained fitters to ensure first class operation. The busy »Centralen» exchange with an average of 15 986 subscribers and about 2.2 calls per subscriber per hour in peak periods had thus in 1935 — the seventh year of operation — 0.161 male fitters for each million calls; the number of fitters per 1 000 subscribers was 0.880. For all the exchanges together these figures were 0.241 and 0.63 respectively. It should be observed that these fitters, in addition to all work in the selector halls, attended to the fault section of the exchange, work on the distribution frames, the power supply and night duty.

These operating results, however, do not only demonstrate the good functioning of the automatic system but are also evidence of an efficient and economic management of operation as well as of the staff's ability and interest in their work.

Table VI
Energy consumption for machine drive and battery charging at Stockholm automatic exchanges 1935

exchange	kWh per subscriber			cost per subscriber Kr.
	machine drive 220 V	battery charging 48 V	total	
Centralen	1.44	—[1]	—[1]	—[1]
Kungsholmen	1.20	2.68	3.88	0.230
Söder	0.73	2.14	2.87	0.165
Södra Vasa	0.66	2.26	2.92	0.166
Östermalm	1.02	3.06	4.08	0.235

[1] »Centralen» has a battery in common with the trunk and suburban traffic exchanges installed in the same building.

Measuring Accuracy in Adjustment and Checking of Electricity Meters

A. GARTNÄS, TELEFONAKTIEBOLAGET L.M. ERICSSON, STOCKHOLM

In the Ericsson Review No 1, 1936, a description was given of the most usual methods of adjustment for electricity meters. The present article deals with the different kinds of errors attached to the measurements by the various adjustment methods. In addition the limits are defined within which measuring accuracy lies, with special reference to the lowest error which in general can be guaranteed.

By *measuring accuracy* is meant the accuracy by which a magnitude — *e. g.* load — can be measured. The measuring accuracy is consequently subject both to *objective* and *subjective* error. To the former belong indication error in the instruments employed, error in measuring method, etc., and to the latter reading error, reaction error etc.

By *error* is meant the difference between the figure given by the measuring instrument and the true value. Incorrect indication is recorded as a rule in per cent. It is not, however, sufficient to give the per cent of error, it must be stated besides whether the error refers to the nominal value or to the true value corresponding to the reading. By *nominal value* is designated the figure given on the measuring instrument's cover plate. In similar way one can speak of nominal current, nominal voltage, nominal frequency and so on; for ammeters the nominal value is thus represented by nominal current, for voltmeters by nominal voltage, for wattmeters by nominal current and nominal voltage etc.

With am-, volt- and wattmeters, or with indicator instruments in general, the error is usually given in percentage of nominal value or, which amounts to the same thing, in percentage of full deflection. With kilowatt-hour, ampère-hour, kilovar-hour the indication error is normally recorded in percentage of the true value. Indication error may be positive as well as negative. If the figure given by the instrument is above the true value then the error is positive, and it is negative if the figure indicated is lower than the true value. When noting errors therefore it must also be recorded whether the error is positive or negative.

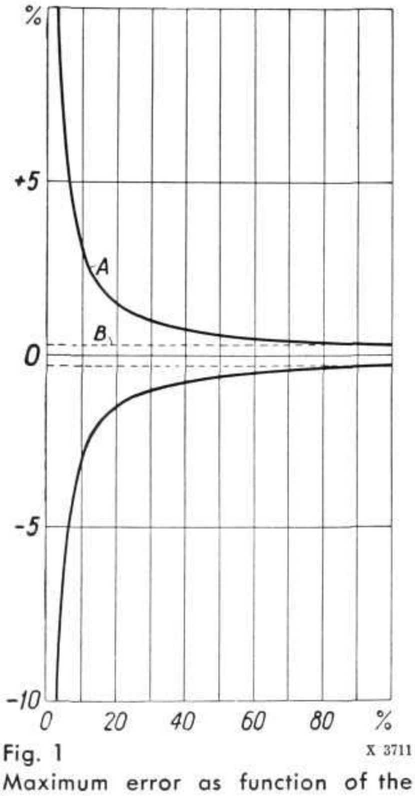


Fig. 1 X 3711
Maximum error as function of the true value

A maximum error ± 0,3 % of nominal value
B maximum error ± 0.3 % of true value

To explain the difference between the two ways of noting error, there are reproduced in Fig. 1 curves of the maximum error — the error in both cases is ± 0.3 % — the error in one cases relating to mark value and in the other case to true value. From the diagram it can be seen that a certain per cent of error displays an entirely different significance according as it relates to nominal value or to true value.

The demands on low error with electricity meters have in recent years appreciably increased. This applies particularly to electricity meters destined for metering large amounts of energy. It often occurs that the suppliers of electricity in their eagerness to furnish their clients with good meters, are so exacting regarding low error in their conditions of delivery that a responsible maker is compelled to forego the order, unless he can succeed in convincing the buyer of the unreasonableness of his demands.

The error can be divided into two main groups. The first comprises *systematic errors* by which is meant those errors which arise from the construction of the electricity meter and which vary with the current, tension, frequency, etc. The most common systematic errors are current error, tension error, frequency error, phase-shift error, temperature error and untrue suspension error. To the second group of errors belong *adjustment* errors, by which are meant those metering errors due to errors in the measuring instruments employed in adjustment (instrument errors), error in the method of adjustment employed (measuring method error), together with errors arising from faulty reading of the instruments used or from the reaction ability of the person carrying out the adjustment (reading and reaction error).

Adjustment with Stop-Watch and Wattmeter

The instrument errors to be reckoned with in this method of adjustment are wattmeter error and error in stop-watch. According to VDE norms the maximum indication error in a wattmeter class E, the highest, may attain $\pm 0.3\,\%$ of the full deflection (nominal load).

If the error of the wattmeter is determined by means of compensator and the correction curve plotted, the wattmeter's error is known to an accuracy of $\pm 0.1\,\%$ of nominal value (full deflection), provided always that the wattmeter correction curve is determined at the place of use, so that the meter is not exposed to disturbance in transport and that the same series resistance is used, while the same temperature prevails in the room as when the correction curve was determined. Otherwise the error may change very appreciably — for a class E instrument by 0.03 % per 1° C change of temperature and by up to 0.1 % if the series resistance is changed.

Reading error is in the most favourable cases $\pm 0.1\,\%$ of scale division. To attain this great precision in reading, the load must be kept constant, *e. g.* by use of a tension regulator, which maintains the voltage variation within $\pm 0.05\,\%$.

To check the time a stop-watch is used. The finger of a stop-watch does not move continuously but in jerks. In stop-watches where the whole dial is divided into 30 s and the balance wheel gives 10 oscillations/s the error may for this reason amount to ± 0.1 s. With other stop-watches with dial divided into 60 s and balance wheel making 5 oscillations/s, the corresponding error may attain ± 0.2 s.

The starting of the second finger may be done in various ways. With stop-watches not combined with ordinary time indication, the balance wheel is stopped when the second pointer is not moving but is released on metering. With those stop-watches, however, which are combined with ordinary time giving, the second finger is set in motion by connection of a geared drive to the watch mechanism as it is running. At the instant of starting and stopping, errors arise which can be estimated together to a maximum of $\pm 0.1\,\%$ for watch with balance wheel giving 10 oscillations/s and to 0.2 % for watches with balance wheel giving 5 oscillations/s. A well-regulated stop-watch's running time deviates from the true figure by 5—15 s/day, *i. e.* by about 0.01 %.

Another error arising in stop-watches is due to the second finger not being pivoted in the exact centre of the dial. Fig. 2 shows in a diagram a second finger dial. If the finger were pivoted at the true centre o it would after rotating 180° reach the figure 15 s, but as the finger is now pivoted at another point o_1 the finger after rotating 180° shows the figure $15 + \Delta'_t$

seconds. If the excentricity oo_1 is 0.2 mm and the diameter of the dial is 40 mm so that the revolution corresponds to 30 s then the maximum indication error Δ'_t is about 0.1 s. If the period of observation is selected so that the second finger can stop in the vicinity of the starting point this error can be reduced sufficiently to be neglected.

The maximum indication error of the stop-watch can thus, if a first-class watch is used, be brought down to about ± 0.2 s, which time consists of the sum of the starting and stopping error together with the error due to the jerky forward movement of the finger.

Another source of error in determining the time lies in observation and reaction errors by the person carrying out the adjustment. The operator has to note and calculate the number of revolutions made by the rotor disc and start the stop-watch the instant the rotor disc index passes a certain point, and stop the watch when the rotor disc has made a certain number of revolutions. This source of error is the most difficult to estimate. The observation and reaction errors in question vary with different persons and may moreover vary in the same person depending on the mental and physical condition in which he may be at the moment of noting the time. With tests made it has been found that, if the time of observation is not too long, the total of observation and reaction errors varies as a rule between 0.1 and 0.2 s if in readiness and between 0.2 and 0.3 s if not prepared for what is to occur. The sum of maximum observation and reaction errors can thus in the best cases be taken as being as low as 0.1 s at the beginning of the time taking and 0.1 s at its close, *i. e.*, a total of 0.2 s.

With a view to reducing observation and reaction errors when checking time, revolution counters have lately been used. These by means of a photo-cell with amplifier start the stop watch, count a certain number of revolutions of the rotor disc and thereupon stop the stop-watch. Good results have been obtained but the apparatus at its present stage is hardly suited for factory production adjustment. On the other hand the apparatus is exceedingly useful for accurate laboratory tests and for adjustment of standard meters.

Nothwithstanding the taking of all the precautionary measures mentioned above and leaving out of account temperature errors and running time errors, the maximum error of the wattmeter may reach ± 0.1 % of full deflection, the wattmeter's maximum reading error ± 0.1 scale divisions, the stop-watch error ± 0.2 s and the maximum obsevervation and reaction errors ± 0.2 s.

If the deflection read on the wattmeter be α scale divisions and the sum of the wattmeter's indication error and reading error be $\pm F_w$ scale divisions, the maximum error when determining the load will be $\Delta_t = \pm \frac{F_w}{\alpha}$ 100 %. If the time read on the stop-watch be t seconds and the sum of the stop-watch's indication error and observation and reaction errors be F_t seconds, then maximum error in fixing the time is $\Delta_t = \pm \frac{F_t}{t}$ 100 %. The total maximum error when determining the error of the electricity meter may thus attain $\Delta = \pm \left(\frac{F_w}{\alpha} + \frac{F_t}{t}\right)$ 100 %.

If the values given above be introduced in this equation the maximum error for the different values of wattmeter deflection α may be calculated. From Fig. 3, which shows the error as function of the wattmeter deflection α for different times, it can be seen that the maximum adjustment error may be brought down if the time of observation be extended; it is, however, a truth with a modification, for the observation and reaction errors often augment if the time of observation is prolonged over 120 s. Moreover it is difficult

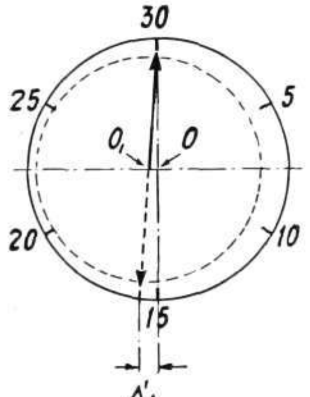


Fig. 2 X 3710
Watch face with excentrically pivoted finger

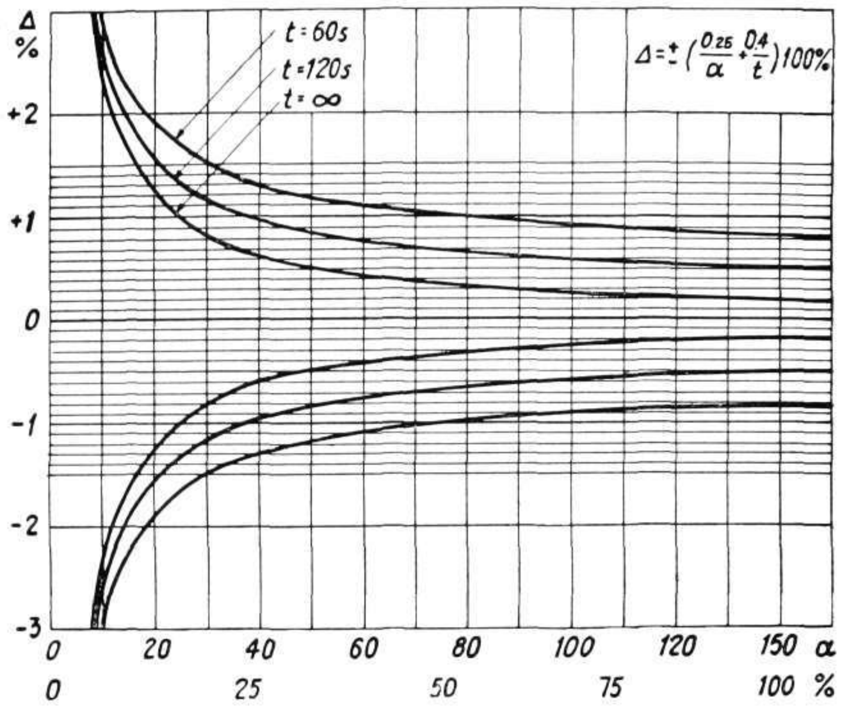


Fig. 3 X 5351
Maximum indication error as function of wattmeter deflection

to maintain the load constant for a lengthy period, which results in increase of the wattmeter's maximum reading error. We can thus take it that *the maximum adjustment error may amount to ± 0.5 % of the true value.*

The above applies when current and voltage are in phase with each other, *i. e.*, when $\cos\varphi = 1$, and when the wattmeter is read in the neighbourhood of full deflection. With $\cos\varphi = 0.5$ on the other hand, when the wattmeter's deflection keeps to around the middle of the scale, the maximum error increases at once to about ± 0.7 % of the true value and to about ± 1.2 % with $\cos\varphi = 0.2$. If a wattmeter is employed which can be overloaded so that it gives full deflection even with different phase shifts, the maximum error can still be set so low as to ± 0.5 % of the true value provided that the indication error $\Delta\,\delta_w$, arising from the angle error of the wattmeter is zero. This, however, is usually the case only when $\cos\varphi = 1$. If the angle error be δ minutes and the phase shift φ degrees then the indication error is $\Delta\,\delta_w = \frac{\delta \cdot \pi}{108}\,\mathrm{tg}\,\varphi\,\%$. With an angle error $\delta = 10'$ then $\Delta\,\delta_w = \pm\,0.5\,\%$ with $\cos\varphi = 0.5$ and $\Delta\,\delta_w = \pm\,1.4\,\%$ for $\cos\varphi = 0.2$. Basing on the angle error it can be understood that measuring with large phase shift may be accompanied by large error.

Even if an electricity meter is thus adjusted before delivery in accordance with what is stated above and the buyer later checks the meter, observing the same accuracy as the factory, it can happen that the values in the factory adjustment record and the buyer's check record differ by 1 %. If moreover the meter be checked with, *e. g.* $\cos\varphi = 0.5$ and $\cos\varphi = 0.2$ it can quite easily happen that the factory and the buyer's measures may differ by about 2 and 5 % respectively, if on the one wattmeter the angle error $\delta = 0'$ and on the other wattmeter the angle error $\delta = 30'$. To the adjustment errors dealt with above must also be added the system errors of the meter, which differ for different makes.

Adjustment with Standard Meter or with Standard Meter and Stroboscope

The maximum adjustment errors for electricity meters adjusted with standard meter or standard meter and stroboscope can naturally not be lower than when wattmeter and stop-watch are used, for the standard meter must be adjusted by wattmeter and stop-watch. To the standard meter's error must then be added the adjustment error due to the fact that the meter to be adjusted can never be set to the same speed as the standard meter. With the synchronous adjustment method employed by Ericsson this additional error does not exceed ± 0.3 %. The maximum adjustment error for electricity meters adjusted by the Ericsson synchronous method can thus reach ± 0.8 %. If a standard meter is employed, whose real indication error is ± 0 %, the maximum adjustment error for the meter to be adjusted with this standard meter will fall within the limits ± 0.3 %. If, however, the standard meter's real indication error be + 0.5 % the adjustment error will lie between the limits + 0.2 % and + 0.8 %, etc.; there is thus a difference of 0.6 % between the limits.

It should be noted that the maximum indication error can only with great difficulty be kept within the limits ± 0.5 % when the adjustment is done with wattmeter and stop-watch and that the error often falls outside these limits because of observation and reaction error combined with variation of load; it is however easy, when the standard meter has been adjusted, to keep the maximum indication error within the limits ± 0.8 % with synchronous adjustment. Moreover a much more even adjustment result is obtained, since the limits of error are not separated by more than 0.6 %, as long as the same standard meter is employed. In addition, one is to a high degree independent of variations in temperature and load, since the standard meter and the meter to be adjusted have the same coefficient of temperature, which is not usually the case with a wattmeter and an electricity meter. From this it is clear that adjustment with standard meter and stroboscope may result in a rise in the maximum error but the limits of error will be nearer each other and a more even adjustment result is obtained.

From the above, which applies generally for single- and three-phase meters and to a great extent also for DC meters, it is evident that it is useless to impose too high demands on the adjustment of electricity meters, since in general it is not possible, even with the best measuring devices, to determine deviations from the true value with greater accuracy than ± 0.5 %. To this it will certainly be objected by many that such great deviations seldom occur. This may be taken to be true in general, because it does not usually happen that all sources of error are add *i. e.*, have the same sign, but the errors often partially cancel out each other. On the assumptions given above, however, the result is that *the maximum adjustment error can amount to + 0.5 % of the true value.*

High-Frequency Attenuation of Open-Wire Circuits

T. BOHLIN, TELEFONAKTIEBOLAGET L. M. ERICSSON, STOCKHOLM

For the planning of long-distance telephone transmission networks it is necessary to calculate beforehand with suffient accuracy the attenuation of open-wire lines. This problem has already been studied in great detail. However, the results obtained are spread over many sources and it may thus be interesting to make a short survey of the subject.

The investigation which is probably of the greatest value is that made by *E. I. Green* partly on experimental lines built for this purpose and partly on lines operated by the American Telephone & Telegraph Co. The results of this investigation were published in 1930. At the same time *T. Wilson* made a study of the leakance of different types of insulators used on American long-distance lines. Later measurements have been made also in Europe, and here the effects of white-frost were also studied, which was not the case with the American investigations. Finally, certain laboratory tests by *M. Boella* at the university of Milan in 1931 may be noticed; the results of these tests correspond comparatively well with the values obtained by *Green* and *Wilson*, as will be seen below, but give some additional information of interest.

The American lines are to a great extent of the same design throughout the country, while in Europe and other parts of the world lines of several types are found, *i. e.*, lines with iron or wood crossarms and pins, with porcelain or glass insulators and with wire spacing varying from 20 to 40 cm and more. To produce a series of curves showing the attenuation as a function of the frequency for all these types of lines would not be desirable as there would always be cases where the curves would not be satisfactory; the clarity would also be reduced. It is possible, however, to produce curves in such a form that they are applicable to lines of any particular construction.

With a minor approximation the line attenuation may be written as the sum of two terms

$$\beta = \beta_R + \beta_G = \frac{R_\sim}{2} \cdot \frac{1}{Z} + \frac{G}{2} \cdot Z$$

where $R_\sim$ is the ohmic resistance per unit of length, used with its value for the frequency in question and thus including the eddy-current losses in the wires; G is the leakage conductance per unit of length and includes all other losses; Z is the nominal characteristic impedance of the line, normally 525 to 675 ohm or as an average about 600 ohm.

The two terms in the formula for the line attenuation are directly and inversely proportional to the characteristic impedance of the line but they depend also, one only on $R_\sim$, *i. e.*, the wire diameter etc., and the other only on G, *i. e.*, all factors determining the leakage conductance.

It is possible to assume that the characteristic impedance remains constant and equal to 600 ohm and then set up curves for β_R with different wire

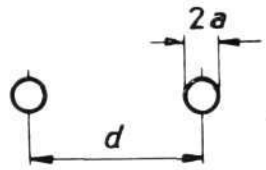


Fig. 1 X 3707
Location of conductors for transposed circuit

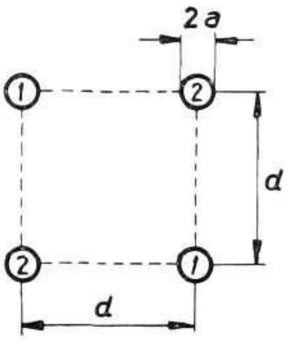


Fig. 2 X 3708
Location of conductors for twisted circuit

diameters and for β_G with different leakances. The attenuation of any line may then be obtained from these curves by calculating the characteristic impedance Z, adjust the curve values β_R and β_G in accordance herewith and add the two terms. The curves, Fig. 3 and 4, are obtained in this manner.

With satisfactory accuracy the characteristic impedance of transposed lines with the conductors in one plane, Fig. 1, may be written

$$Z \cong 120 \; {}^e\!\log \frac{d}{a} \text{ ohm}$$

where a = wire diameter in cm,
d = wire distance in cm.

For twisted lines with the wires at each end of a diagonal in a square, Fig. 2, the characteristic impedance is

$$Z \cong 120 \left[0.132 + {}^e\!\log \frac{d}{a} \right] \text{ohm}$$

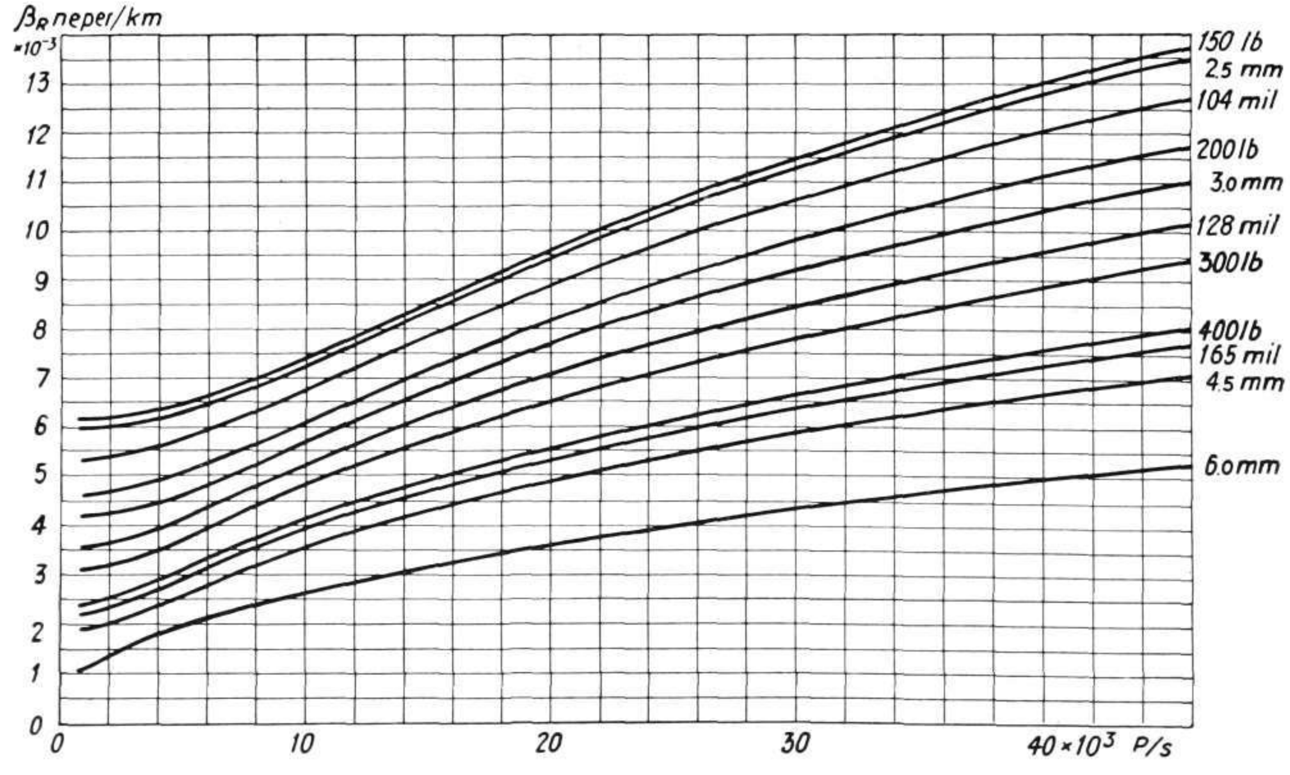
where a = wire diameter in cm,
d = side of square in cm.

These expressions do not take into account the internal field of the conductors or the additional capacity of the insulators. Within the range of interest in our case these errors approximately compensate each other. The curves for β_R are based on values of $R_\sim$ drawn from tables calculated by *P. O. Pedersen*. The curves are valid for lines of pure copper ($\varrho = 0.0175$ ohm/m/mm² at 15° C) and with a characteristic impedance of 600 ohm. For other values of ϱ and Z and for other temperatures β_R is corrected in accordance with

$$\beta_{(R t_0 \rho_0 Z)} = \beta_R \cdot \left[1 + \xi \frac{\rho_0 \left[1 + \alpha (t - 15) \right] - 0.0175}{0.0175} \right] \cdot \frac{600}{Z} \text{ neper/km}$$

where ξ = a coefficient obtained in Fig. 5,
α = temperature coefficient for DC (for copper 0.004),
ρ_0 = specific resistance for DC in $\frac{\text{ohm}}{\text{m} \cdot \text{mm}^2}$,
t = wire temperature.

Fig. 3 X 7109
Attenuation caused by conductor resistance
for telephone circuits of pure copper, characteristic impedance 600 ohm at 15° C



The correction holds good with insignificant errors for reasonable values of t and ρ_0 but gives errors of 5—10 % if the factor $\frac{\rho_0[1 + \alpha(t - 15)] - 0.0175}{0.0175}$ comes close to unit value.

The temperature t of the wire is generally that of the surrounding air and may be read from the meteorological records. During days with strong sunshine the temperature of the wire may rise slightly above that of the air but according to *Green* the difference is not greater than 5° C.

The curves for β_G are the results of measurements on short experimental lines. The leakance is concentrated at the insulators and consequently β_G is directly proportional to the number of insulators. The curves are valid for 20 pairs of insulators per kilometer, which is a normal value for European lines. They also hold good for a characteristic impedance of 600 ohm. If the number of insulators is not 20 and the characteristic impedance deviates from 600 ohm β_G may be corrected according to

$$\beta_{G(n,z)} = \beta_G \cdot \frac{n}{20} \cdot \frac{600}{Z} \text{ neper/km}$$

where n = insulators in pairs/km.

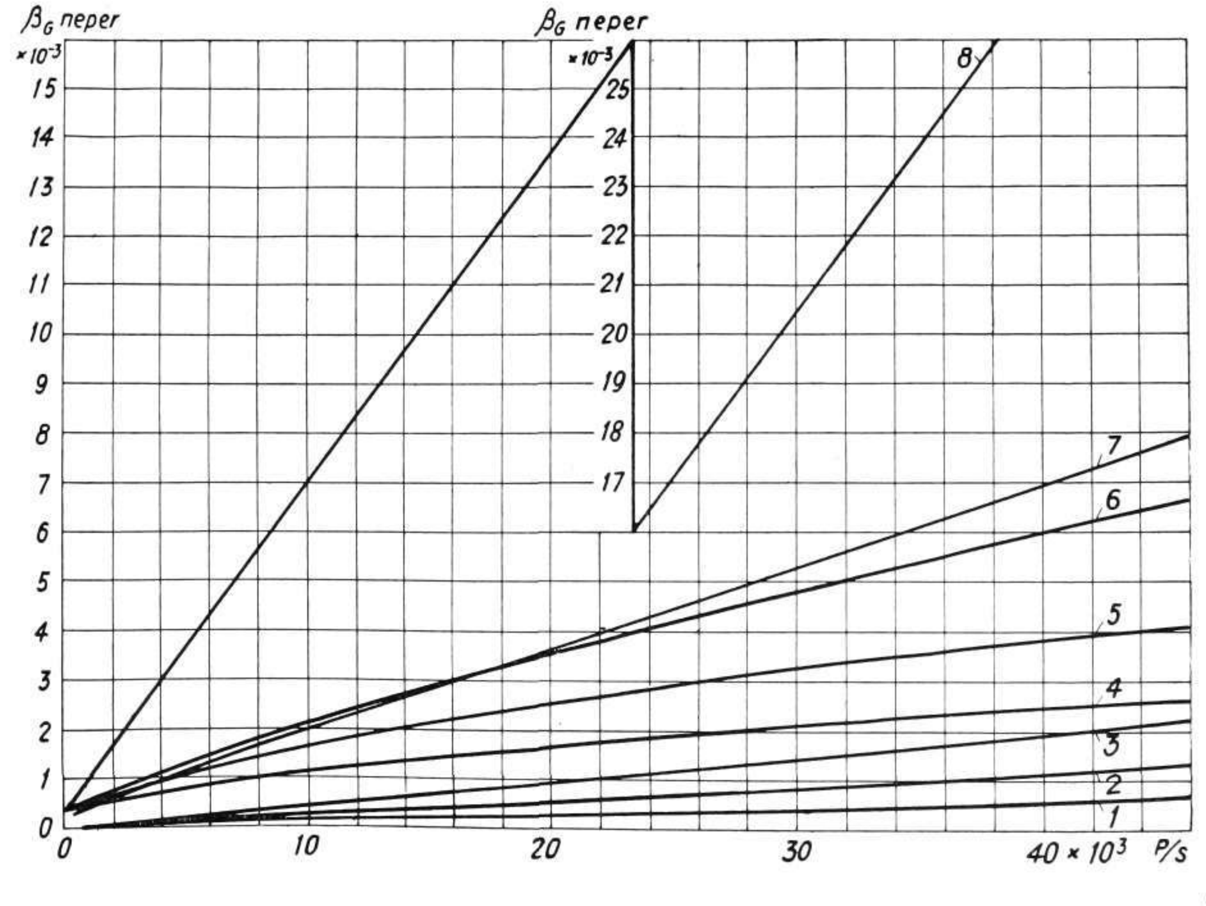
With white-frost the leakance is localized to the ice coat on the conductors and consequently the curves are correct irrespective of the number of poles. The figures for white-frost conditions are very variable, of course, but the curve indicated can serve as a calculation basis.

The different curves, Fig. 4, are valid for different insulator types and different weather conditions; when calculating the attenuation of a line, one has to select a curve which corresponds as far as possible with the actual conditions.

Fig. 4 X 7110

Attenuation caused by leakance

for telephone circuits, characteristic impedance 600 ohm, 20 pairs of insulators per km
1, 2, 3 dry weather
4, 5, 6, 7 wet weather
8 white-frost



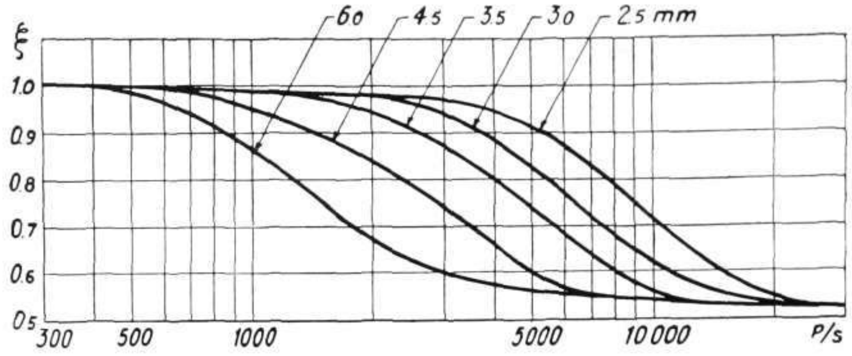


Fig. 5 X 5350
Correction factor for β_R

Curve 1 represents the leakage attenuation at dry weather for *CS*-insulators, curve 2 for *CW*-insulators and curve 3 for *DP*-insulators. The curves 4, 5 and 6 show the leakage attenuation under wet weather conditions for *CS*-, *CW*- and *DP*-insulators. All the curves are the results of the measurements by *Green*.

The insulator names are American standard; *CS*-insulators are of borosilicate glass and mounted directly on iron pins. The pins are formed in pairs by an iron screwed to the wooden crossarm; the *CW*-insulators are also of borosilicate but mounted on wooden pins covered with a metal foil. The metal foils belonging to a pair of pins are interconnected and mounted on crossarms of wood; the *DP*-insulators are of alkali glass and mounted on unclad wooden pins on wooden crossarms.

Curve 7 represents the leakage attenuation under wet weather conditions and curve 8 the leakage attenuation with white-frost. Both these curve are measured by *Kaden & Brückensteinkuhl*, but no information regarding insulator and crossarm types is given.

As far as is known no very satisfactory measurements have been made on European lines. For a single frequency, 28 000 c/s, a measurement has been carried out on a 4.5 mm line with a heavy white-frost; the results give values for β_G of 16×10^{-3} to 23×10^{-3} neper/km, which corresponds fairly well with curve 8, Fig. 4, which for the same frequency gives $\beta_G = 19 \times 10^{-3}$ neper/km.

There are, however, the interesting laboratory measurements carried out by *Boella*, who has measured a number of normal and experimental insulators under varying conditions. *Boella* has tried a metal cap on the insulators as proposed by *Wilson* and has also made trials with a protecting ring around the base of the insulator, Fig. 6.

When calculating the effective attenuation to be covered by a carrier system the figures for wet weather conditions are generally used; when the exact knowledge of the characteristics of the lines and insulators is missing a value of the leakage attenuation must be chosen in accordance with curve 6, Fig. 4. The ranges shown with full-faced types in the table below are then obtained.

The leakage attenuation obtained when *Boella's* figures for the leakance are used as a basis of calculation are shown in Fig. 7. For comparison's sake some of the curves in Fig. 4 are reproduced.

The reduction in leakance is considerable. It may be of interest to investigate which ranges could be obtained with single and three-channel carrier telephone systems now in use if *Boella's* low leakance values could be attained.

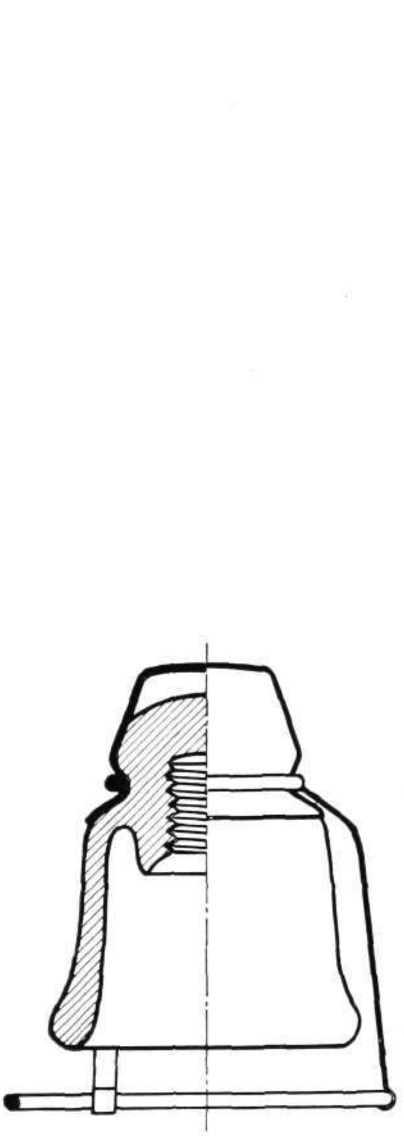


Fig. 6 X 3709
Insulator with cap and protection ring

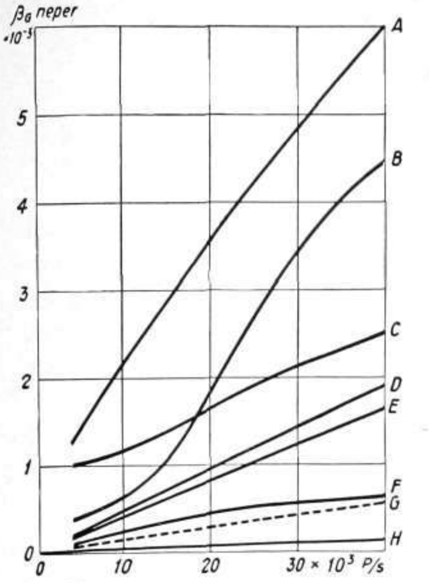


Fig. 7 X 3712

Leakage attenuation caused by leakance

for experimental insulator

- A DP-insulator, wet, wooden crossarm *(Green)*
- B porcelain insulator, wet, iron crossarm *(Boella)*
- C CS-insulator, wet, wooden crossarm *(Green)*
- D DP-insulator, dry, wooden crossarm *(Green)*
- E porcelain insulator with cap, wet, iron crossarm *(Boella)*
- F porcelain insulator with cap and protecting, ring, wet, iron crossarm *(Boella)*
- G CS-insulator, dry, wooden crossarm *(Green)*
- H porcelain insulator, dry, iron crossarm *Boella)*

lines with a wire distance of 30.5 cm	wire dimensions		range in km for			
			DP-insulators	CS-insulators	porcelain insulator to *Boella*	
	mm	lb/mile			with cap	with cap and ring
three-channel system, range 5 neper, highest frequency 30 000 c/s	2.84	200	**350**	440	480	515
	3.48	300	**400**	520	570	620
	4.50	500	**470**	625	700	770
single-channel system, range 3.75 neper, highest frequency 10 000 c/s	2.84	200	**470**	540	610	630
	3.48	300	**550**	645	745	770
	4.50	500	**660**	800	940	980

As will be seen from the table the range will increase considerably and furthermore the insulator with the cap shows a much smaller variation in leakage from wet to dry weather conditions than other insulators. Thanks to this fact the regulation of the communication channel is simplified and stabilized. Of course, one will ask why these insulators have not come to be used. Firstly it must be remembered that the figures of *Boella* are based on laboratory tests and consequently probably too favourable; secondly very few new long-distance lines are built nowadays and thirdly the manufacture of an insulator with a cap and ring would be rather expensive and has up to now met with considerable technical difficulties. However, the ceramic industry has made such progress during the last few years with metal-plated goods that possibly also insulators could be manufactured with satisfactory economical result, which would make it possible to reach in practice the results *Boella* has found in the laboratory.

References

Green, E. I.: »The Transmission Characteristics of Open-Wire Telephone Lines», Trans. Amer. Inst. Electr. Engr., Oct. 1930.

Green, E. I.: »Methods of Measuring the Insulation of Telephone Lines at High Frequencies», Trans. Amer. Inst. Electr. Engr., Oct. 1927.

Wilson, T.: »A Study of Telephone Line Insulators», Trans. Amer. Inst. Electr. Engr., Oct. 1930.

Kaden, H., & Brückensteinkuhl, K.: »Die Ableitungsverluste von Freileitungen bei Raureif», Elektrotechn. Z. No 47, 1934.

Boella, M.: »Prove su isolatori per linee ad onde guidate», Alta Frequenza No 2, 1932.

Pedersen, P. O.: »Wirbelstromverluste in und effektiver Widerstand von geraden, runden Metallzylindern», Jb. drahtl. Telegr. Teleph. Vol. 4, No 5, 1910.

Gebe Electric Light Fittings

E. JENSEN, SIEVERTS KABELVERK, SUNDBYBERG

The first fittings of Gebe type were put on the market by Sieverts Kabelverk in 1932 and there are still some of them giving good service in a large number of installations, being as a rule fitted in places where conditions are unfavourable. It is natural, however, that the experience gained during these years has led to improvements both in the Gebe fittings and the Gebe cable. The latter was described in its new form in Ericsson Review No 3, 1936, and below will be found particulars of the thoroughgoing revision recently undertaken in the Gebe fittings.

The Gebe system is a combination system with which it is possible to build up from a comparatively small number of parts a large number of fittings. The system comprises a series of bakelite distribution boxes and a series of cast-iron distribution boxes, a switch, a lamp-holder, a pair of bakelite suspension covers — upper and lower — and a pair of cast-iron suspension covers. These parts may be combined together as desired to form various fittings, see Fig. 1: fixed fitting, suspension or wall arm, all with or without switch. The fittings made up in this way can then be provided with globes, glass shades, metal shades or combinations of these. With a view to still further increasing the versatility of the fittings there has been developed a system of consoles also.

In the revision just completed of the Gebe fittings the original system and the original main dimensions have been retained, so that the old and the new are still suited to each other. The aim of the revision has been to attain better standardisation of the parts comprising the system, lower cost of manufacture along with further increase of reliability when the material is to be used in the worst of localities.

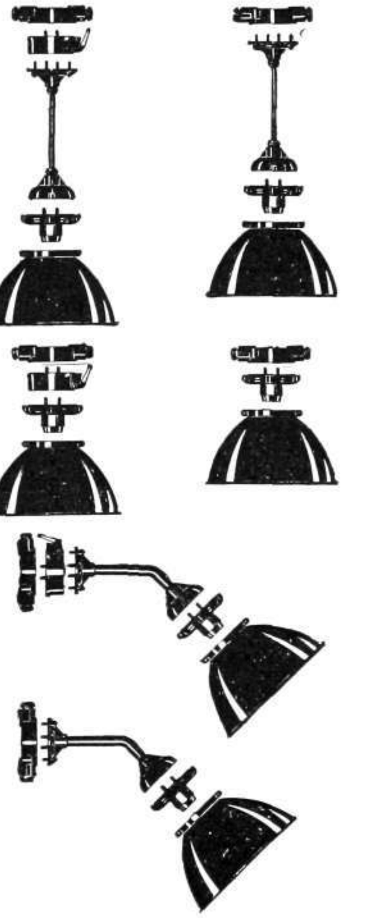


Fig. 1 X 3713
Typical combinations of Gebe fittings

Distribution Boxes

In the new system the parts of the fitting are fixed together by four screws. When bakelite is constantly exposed to great humidity it absorbs a certain amount of moisture after a period. If at the same time it is subjected to mechanical strain it displays a certain tendency to change shape. When a lamp-holder or a shield is screwed tight on a box, the packing between these parts will exercise a pressure in the opposite sense to the pressure exercised by the screws used. When only two diametrically opposed screws are used, the bakelite may in particularly bad cases be forced out of shape to such an extent that the joint is no longer tight. By making use of four screws and giving a suitable shape to certain of the parts the risk of alteration in shape and defective tightness is eliminated. On boiling distribution boxes, with cover fixed, in water at 100° C for 50 to 100 h — probably one of the severest tests to which bakelite can be submitted — it was found that the change of shape in the bakelite was not so great that the boxes did not remain tight with an inside pressure of over 1 at.

As the Gebe cables are now always supplied with earth wires, the connection of the sheaths can now be done by joining up the earth wires on a terminal in the box, which allows of appreciable simplification of the bakelite boxes. These are moulded now in two types only, one with four and one with five cable bushings, Fig. 2. All the apertures are closed on moulding. The boxes are, however, delivered with packing and cap screws for the bushings corresponding to the descriptions. For bushings with packings the hole is made

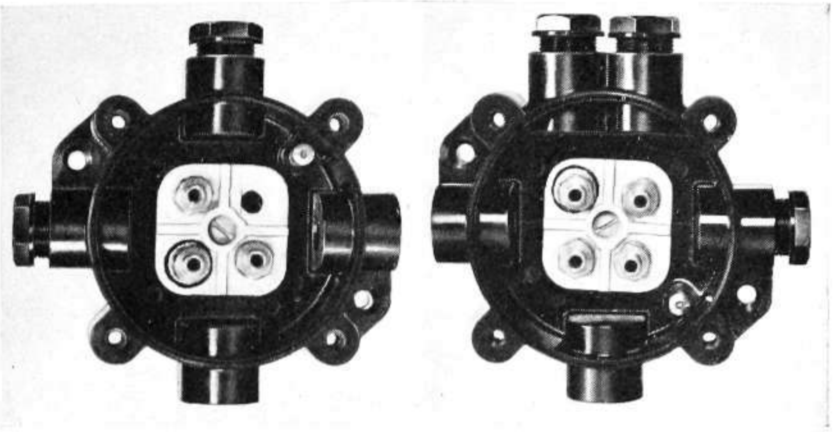


Fig. 2 X 5352
Gebe distribution boxes
left with four, right with five inlets

in the bottom. The other bushings have closed bottom and in addition have the opening covered outside by a thin bakelite blank, see Fig. 3. By means of this system it is possible without further additions to obtain all the connecting combinations imaginable. Fig. 4 shows the combinations kept in stock. The bushings not used can be utilised later if required: the bakelite blank is removed, the hole in the bottom is opened and packing and capping screw set in. In such case it is therefore possible to connect a new cable quite normally to a box already installed, without disturbing the box or existing connections. In the case of cast-iron boxes this system cannot be applied, on account of expense among other reasons. They are made in a sufficient number of types to cover the various specifications.

Two further small details should be mentioned. Boxes with double inlets have parallel bushings for the double inlet, which gives a smart cable lead. The two holes for fixing the box are diametrically opposite and have the same positions on all boxes, giving the special advantage that it allows of a simple console system to be made. The lead opening is cylindrical where the packing comes, see Fig. 3, and it is only outside this that the screwed part comes. All risk of the packing being caught in the screw thread is thus eliminated. In conjunction with this the inner end of the cap screw is not threaded, and it can thus press up the packing. The thread is normal armoured tube thread of 22.5 mm outside diameter.

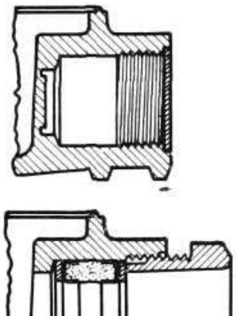


Fig. 3 X 3714
Section of inlet bushing
above, unutilised inlet, below, bushing with packing and cap screw

Lamp-Holder

The former lamp-holder was a safety holder insofar as it had a guard ring of bakelite which pressed against the end of the lamp and covered its metal socket. The screw cap carried current. This design has numerous advantages and one in particular which unquestionably is of value in practical use: like older lamp-holders of good makes, it gives a thoroughly dependable contact. For various reasons, however, this design was considered to have outlived its purpose. An entirely new one has been made, which in its main features resembles other safety holders. It has, for instance, a bottom contact against which the bottom of the lamp socket rests and a double lateral contact against which the exterior of the lamp's metal thread makes contact, see Fig. 5. The threaded cap of the lamp-holder not carrying current is firmly fixed in the protector. This last is fixed by two screws to the bakelite bottom of the holder. Four threaded holes have been pressed out of the bakelite base, to which fitting can be screwed parts of different kinds.

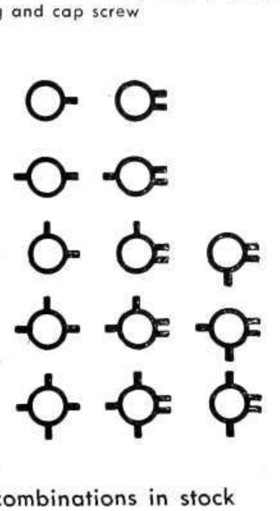


Fig. 4 X 3715
Inlet combinations in stock

A point of great importance affecting the tightness of the fitting and thereby its reliability is the bushing which must exist between the outer contact parts of the lamp-holder and the contact pins in the box. Close investigation of models based on various designs has demonstrated that decidedly the most dependable, while at the same time simplest and least expensive, is that employed in earlier holders with through-going brass bolts moulded in the bakelite when making the lamp-holder base.

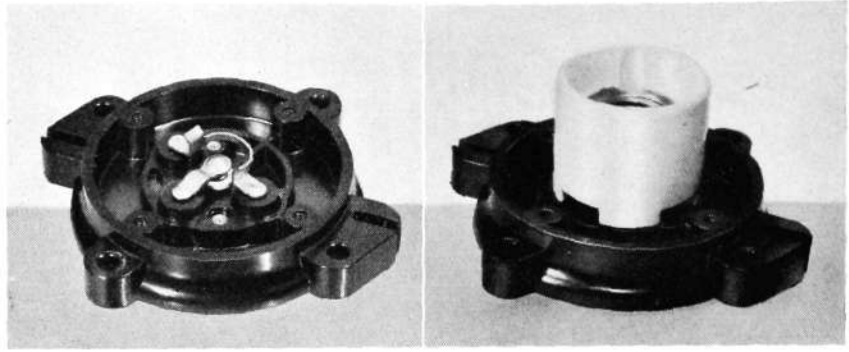


Fig. 5 X 5353
Gebe lamp-holder
left, socket with bottom and lateral contacts right, socket with guard ring

Suspension Cover

The suspension cover, Fig. 6, has been given an attractive appearance. Each contact pin or hole has been firmly set in a steatite socket and the two sockets of a cover are fixed to a sheet-iron bridge.

In Ericsson Review No 3, 1936, reference was made to the investigations on which were based the discarding of the support wires in the suspension cable. As the holding of the cable by means of packing has proved very reliable and it is besides simple and inexpensive, it has been retained. It might perhaps be mentioned that even ordinary rubber tube cable, Type RDV, which never did have support wires, has been used in conjunction with Gebe suspension cable, Type RDCU, and has always been held by packing alone.

All ears on lamp-holders, covers and suspension covers are of the same height, with the result that only two lengths of screws are required for screwing together the fittings, namely a short one for fitting without switch and a long one for fitting with switch. In order that the pins employed for connecting up the fitting parts shall have good spring, they have before the groove is sawn been bored with holes of diminishing diameter towards the bottom. The four tongues on the completed pin thus grow in thickness towards the base.

Consoles

When Gebe fittings have been fixed on a wall, a wall-arm of a console of some other type has generally been used. On revising the Gebe fitting it has been possible to work out a simple console system for fixing the fitting to walls or in corners without the use of wall-arms.

The new system comprises two consoles of different lengths for fixing fittings with vertical axis and one console for fixing the fitting at an angle of 45°, Fig. 7. The two first are long enough for the fitting's centre to come 160

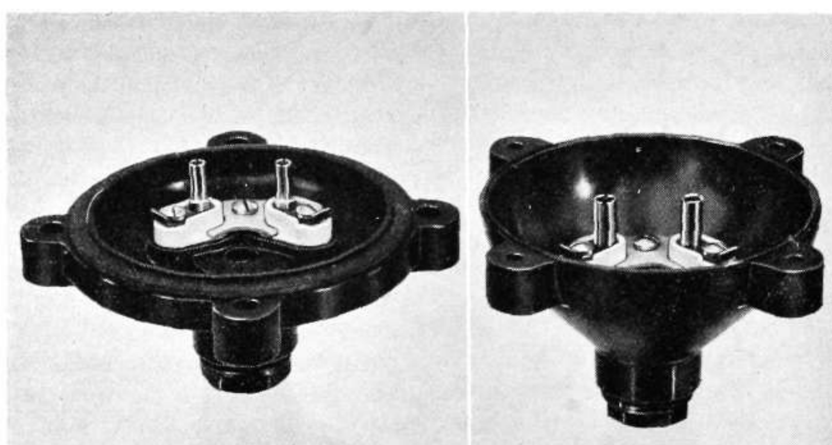


Fig. 6 X 5354
Gebe suspension cover
left, upper cover with contact pins; right, lower cover with contact holes

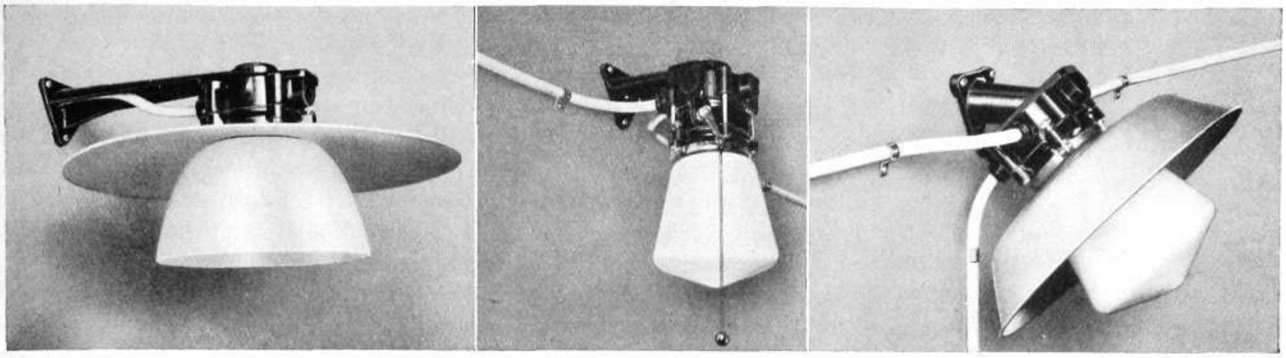


Fig. 7 X 7111
Gebe consoles
left, long console, centre, short console, both for vertical fittings; right, short console for fitting at angle of 45°

and 300 mm respectively from the wall. If the console is to be fitted at a corner a corner-piece is first fixed, Fig. 8 — one for an outer corner and another for an inner corner — and the console is then attached to that. The feet of the consoles are the same shape so that they require no adaptation for the corner-pieces. The consoles have a plate to which the box of the fitting is attached in the ordinary way by two screws. This plate is made loose and with two screws can be set in two positions, for the occasions where it is required that the box shall have in one case one position in relation to the cable and in another case a position at 90° to same.

The shape of the console has been determined with a view to allowing the cable being led to the box in a natural and neat manner. The new consoles allow of connection of one or two cables from below, from above, from the side or from behind through a wall.

It has already been stated in regard to boxes that certain investigations have shown that the principles applied in the design of Gebe fittings were correct. Sieverts Kabelverk have aimed at coming as close as is at present possible to perfection. Alongside the work of design has proceeded very comprehensive research to discover as far as possible all weaknesses in former designs. Each new detail of design has been executed in model and tried. As the new parts were completed they were likewise tested and adjusted until the desired result was achieved. Finally the completed material has undergone duration tests in certain installations giving extremely difficult service conditions, which it had formerly been impossible to get installation material of any kind to withstand. As bakelite for years has been the scapegoat of experts great and small in installation material, Sieverts Kabelverk when redesigning have been especially concerned to eliminate the weaknesses which might have attached to the earlier material. No small part of the investigation referred to was therefore devoted to the shape of the bakelite and to the moulding of the bakelite itself. The results obtained on laboratory tests and in installations actually made should demonstrate beyond all dispute that the new Gebe fitting as regards reliability and suitability to its purpose is right in the forefront of what can be produced at the present day.

Progress in installation practice which has occurred since Sieverts Kabelverk put its new system on the market can without exaggeration be characterised

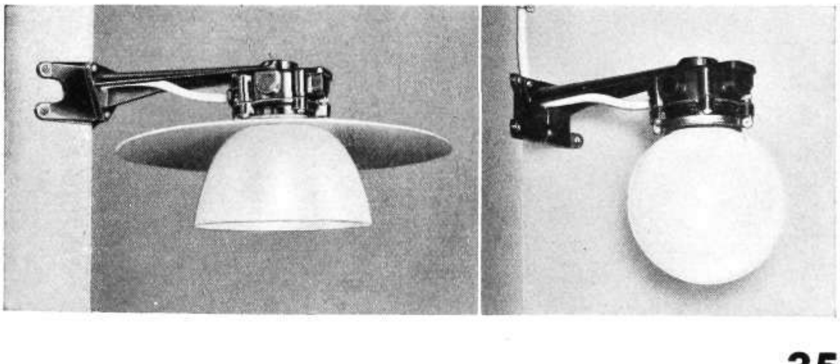
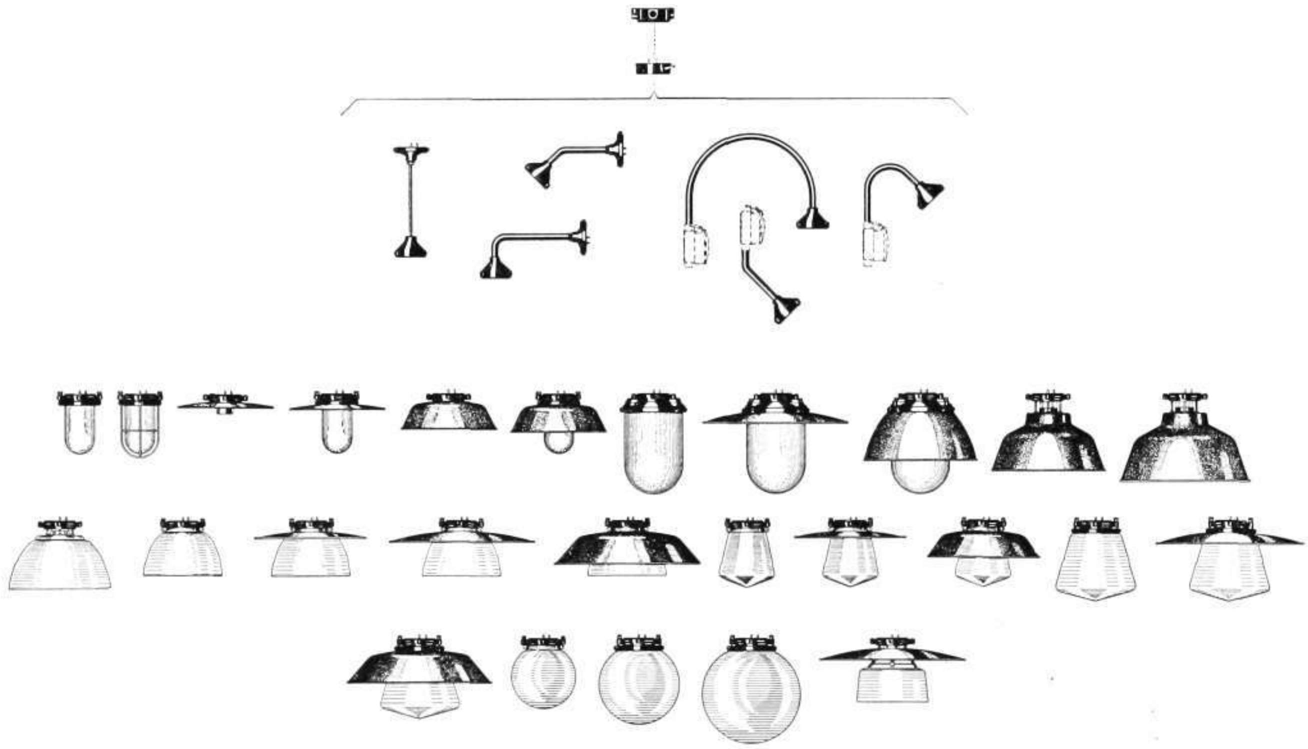


Fig. 8 X 5355
Gebe consoles
left, attached to outer corner, right to inner corner

as a revolution of its kind. From the outset it was considered that improvement in safety against fire, in reliability and durability were obtainable for the inflammable and damp premises of farms when installations were of the new material. The superiority of the system over older material soon attracted the attention of industrialists, however. It was found that it offered high reliability and that it was simple and comparatively inexpensive to fit. Gradually it was realised that in the long run it did not pay to employ older material but that it was cheaper and better to employ the Gebe system throughout in all premises, no matter whether they were damp or inflammable or more normal in character. As the system has been developed side by side with the increased demand for good lighting it has consequently with the years become an extraordinarily widespread installation system which is used in all kinds of premises both for industrial and farm buildings. In addition it has found considerable employment in other spheres, such as in hospitals, restaurants, dwelling houses, etc.

Fig. 9 X 7112
Combination possibilities of Gebe fittings



Watertight Telephone Instrument

S. WERNER, TELEFONAKTIEBOLAGET L. M. ERICSSON, STOCKHOLM

Telefonaktiebolaget L.M. Ericsson has designed a new telephone instrument, intended for mounting in exposed positions, such as damp localities, workshops, shipyards and railway yards; it is made both as LB-instrument and for connection to manual and automatic exchanges. In addition, with special equipment it is adapted for use as mine telephone and as police telephone.

The instrument, Type DAT 1001, Fig. 1, is of watertight construction and enclosed in a black-enamelled cast-iron box with door for opening by a simple handle when the instrument is to be used. Where required the handle is provided with lock. Dimensions of the instrument are: height 350, width 215, depth 180 mm, and it weighs about 20 kg.

The instrument box is provided with three strong fixing ears. The cables are led to the instrument from below through cable bushings. To connect the cables the lower panel inside the instrument is opened, exposing the terminal block, see Fig. 2. Connection can thus be made without taking the instrument apart.

The handset is held by a pair of thick chrome-plated metal pins, the lower one fixed and the upper moveable. The latter, pressed upwards by a strong spring, holds the handset rigidly in the proper position. It also acts on the switchhook when the handset is lifted. The handset is furnished with rubber cable which is connected through a bushing with packing to a terminal block inside the instrument. This block is accessible when the upper panel of the instrument is opened, see Fig. 2.

The generator crank is strongly made and easy to operate. It is coupled direct to the generator which is screwed on to the middle cast-iron panel. The generator may be taken out complete for inspection on unscrewing the panel. The crankshaft connection through the panel is made by packing.

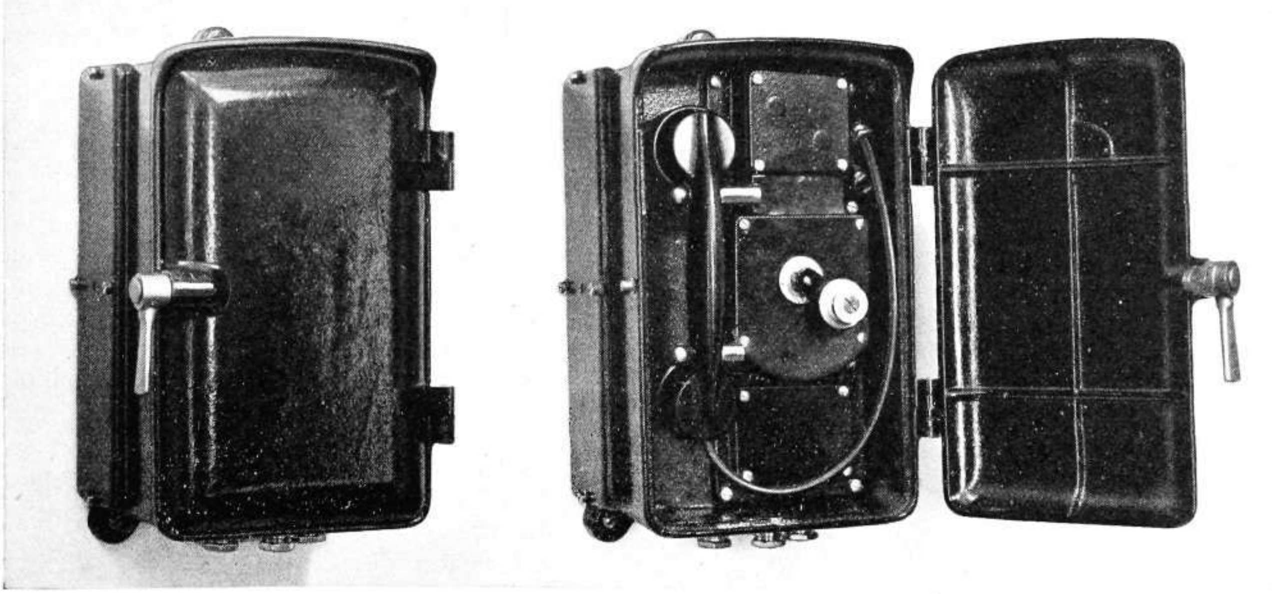


Fig. 1 X 7108
Watertight telephone instrument, Type DAT 1001

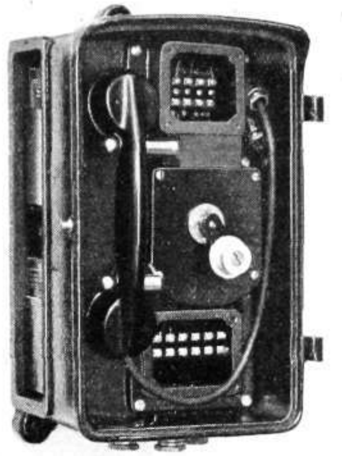


Fig. 2 X 3704
Watertight telephone instrument
with panels removed; above handset terminal, below cable terminal, at side battery compartment

The batteries are located in a compartment at the lefthand side of the instrument. There is room for two dry cells each of 1.5 V and measuring $125 \times 55 \times 55$ mm, connected by two watertight bushings with the inside of the instrument. For inserting or replacing batteries the cast-iron panel, see Fig. 2, is unscrewed. This panel is provided with holes for ventilating the battery space.

The instrument is not fitted with bell for incoming call, since it is advisable that the most suitable signal device be selected according to local conditions, and consequently under certain circumstances it may be necessary to locate the signalling device elsewhere than on the instrument. On the lower part of the instrument there is a bushing for introducing the cable from the bell, the wires being connected to the same terminal block as the wires from the instrument. A suitable bell, designed for outdoor mounting, is described elsewhere in this number.

The transmission qualities of the instrument are considerably better than earlier instruments of similar kind, mainly on account of the good properties of the bakelite handset in combination with a suitable induction coil. Likewise the strength of the outgoing signal is especially high because of the adaption of a small but particularly effective generator.

Fig. 3 X 3705
Instrument set
from top downwards induction coil and switch hook, generator, terminal block

Fig. 4 X 3706
Diagram of telephone instrument, Type DAT 1001

Construction

The instrument, which consists of an inset, case with door and battery compartment and batteries, is constructed specially with a view to adaption for various purposes. The inset has therefore been made as a unit which can be fitted with different parts for different types of apparatus, thus making it possible to satisfy unusually high requirements for a special instrument of this kind.

The inset, Fig. 3, comprises all parts for a complete instrument, combined on a cast-iron frame which is furnished, mounted, connected and tested for inserting in the case. Between the inset and the case there is a packing preventing the penetration of moisture. The inset frame for a normal LB-instrument carries handset, ringer, induction coil, switch-hook and two terminals of bakelite, the lower for connecting to line and signal bell and the upper for connecting the handset, and extra receiver if required. All panels on the inset, which can be opened from outside, are tightened with packing. The handset is normal bakelite type. It is provided with four-wire cord made as a rubber cable with circular section. The generator is of a new type giving great output but of smaller size and weight than generators hitherto used; it was described in Ericsson Review No 2, 1935. The induction coil is also of normal type; it has closed iron core of sheet alloy and is anti-sidetone connected. The diagram for a normal LB-instrument is shown by Fig. 4.

The watertight telephone instrument can be supplied in several different designs. For instance, the normal LB-instrument may be provided with extra receiver which is connected at the inlet below the bushing for the handset cord, see Fig. 1. The instrument can also be supplied with dial in place of generator, and, finally, it may be used as a combined LB and automatic instrument if the normal LB-instrument is supplemented by a dial and two press-buttons mounted on the upper panel.

Watertight Bell for AC

S. WERNER, TELEFONAKTIEBOLAGET L. M. ERICSSON, STOCKHOLM

There has now been added to the series of bells for various purposes developed lately by Ericsson a new polarized AC bell of watertight construction. The bell, which is mainly intended as signal device for telephone instruments, is particularly suited for mounting outdoors and in damp or otherwise exposed places.

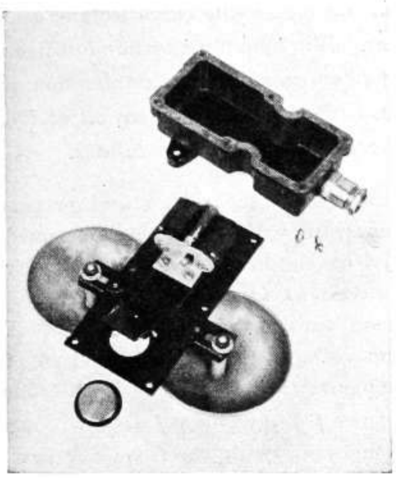


Fig. 1 X 3632
Bell mechanism

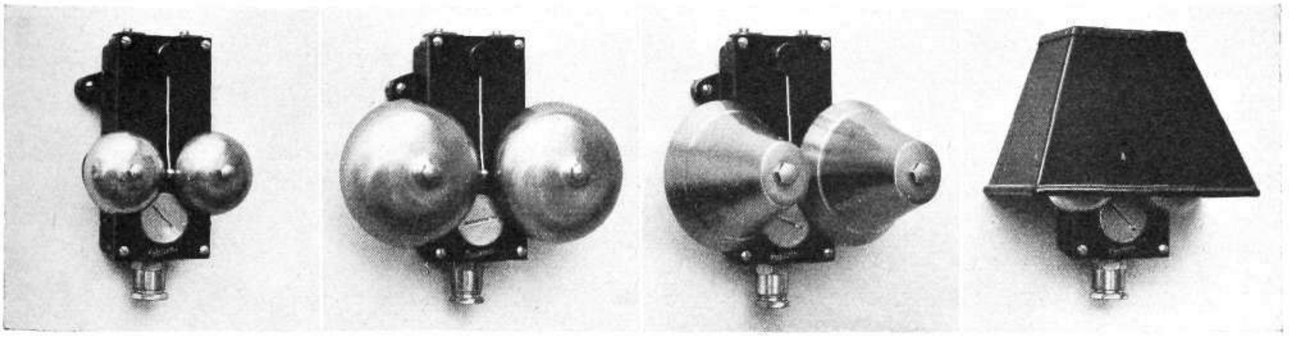
Fig. 2 X 7099
Watertight bell
left to right, Types KLA 62, KLA 63, KLA 64 and KLA 62 with protective roof

The bell is made watertight and despite its strong construction is small and neat. The mechanism, Fig. 1, is enclosed in a cast-iron case, with cable bushing below for leading in the wires.

The bell mechanism, of normal type, is mounted on a front plate which with packing between is screwed in the cast-iron case. The trembler of the mechanism has watertight bushing. The projecting part of the trembler which carries the clapper is protected by a cowl. Connection of the wires is to a bakelite terminal accessible from outside through the round panel on the front plate. The bell is simple to mount; fixing is by two screws only.

The bell is designed for 16—25 c/s AC, but is made also for connection to 50 c/s AC. It is normally made with winding for 300, 1 000 or 2 000 ohm resistance.

The bell is delivered in three patterns with gongs of different sizes, Fig. 2. The smallest, Type KLA 62, has two gongs of different tones each 64 mm diameter; the two larger, Type KLA 63 and KLA 64, have 108 mm circular and sheep gongs respectively; the last-named gives a distinctive signal easy to distinguish when several bells are mounted in proximity to each other. Bells, Type KLA 62 and KLA 63, may for outdoor mounting be provided with roofs as protection against snow and rain.



Frequency Transformations, Applied on the Heaviside Expansion Theorem

T. LAURENT, TELEFONAKTIEBOLAGET L. M. ERICSSON, STOCKHOLM

The frequency transformations, shortly described in the Ericsson Review No 4 1935, and more closely dealt with in the Ericsson Technics No 5, 1934, No 2, 1935 and No 1, 1936 as well as in the Elektrische Nachrichten-Technik No 11, 1936 have been studied further. This time the question has been to find out their importance for transient phenomena by the application of the Heaviside expansion theorem. The result has been an extension of this theorem giving a considerable simplification of practical calculations.

It has been shown in the papers mentioned how the design and properties of complicated, passive linear impedance networks may be determined by means of frequency transformations of simple and easily calculable networks. The properties are then expressed as frequency functions; for instance the complex relationship between an applied sinusoïdal EMF E of angular frequency ω and the resultant voltage drop V in any part of the network may be expressed as a frequency function. If we call this property of a simple impedance network $f[j\omega]$, where $j = \sqrt{-1}$, and make a frequency transformation of the network with the frequency function $w(j\omega)$ the said property will be $f[jw(j\omega)]$.

It may now be seen how this change in the property is reflected in the building-up of the voltage drop V due to an instantaneous voltage change E at the time $t = 0$. Then $j\omega$ is replaced by the operator p and $jw(j\omega)$ by $P(p)$. The symbolic solutions of the original and frequency transformed networks are then

$$f[p] \text{ and } f[P(p)]$$

which may be written in the form

$$\frac{Y[p]}{Z[p]} \text{ and } \frac{Y[P(p)]}{Z[P(p)]}$$

in such a way that the equation $Z(p) = 0$ contains the largest possible number of roots. Supposing that no root is zero and two roots not identical the time functions for $t \geqq 0$ may be determined by means of the *Heavisides* expansion theorem as follows

$$f[p]_t = \frac{Y[0]}{Z[0]} + \sum_{p_1 p_2 p_3 \cdots} \frac{Y[p]\, e^{pt}}{p \dfrac{dZ[p]}{dp}}$$

where $p_1 p_2 p_3 \cdots$ are the roots of $Z[p] = 0$

$$f[P(p)]_t = \frac{Y[p(0)]}{Z[P(0)]} + \sum_{p'_1 p'_2 p'_3 \cdots} \frac{Y[P(p)]\, e^{pt}}{p \dfrac{dZ[P(p)]}{dp}}$$

where $p'_1 p'_2 p'_3 \cdots$ are the roots of $Z[P(p)] = 0$.

If the inverse function to $P(p)$ is called $T(p)$ the latter expression may be transformed to

$$f[P(p)]_t = \frac{Y[P(o)]}{Z[P(o)]} + \sum_{p_1 p_2 p_3 \cdots} \left[\frac{Y[p]\,e^{pt}}{\frac{dZ[p]}{dp}}\right]_p \left[\frac{p}{T(p)} \cdot \frac{dT(p)}{dp}\, e^{[T(p)-p]t}\right]$$

where $p_1 p_2 p_3 \cdots$ are the roots of $Z[p] = o$.

The constant term is determined in the ordinary way be means of frequency transformation. The terms after the sign of summation consist of two factors, the first of which determines the building-up properties in the original network, while the second factor which, being a function of p and t, depends only on the frequency function in question, determines the change in the building-up properties when the frequency transformation is applied. The latter factor, which can be called the ***transformation factor*** $U(p)$, is a function of p and t and consequently it may be determined once and for all for each frequency function.

For the simple frequency functions the expansion theorem may be written as follows

$$f[P(p)]_t = \frac{Y[x]}{Z[x]} + \sum_{p_1 p_2 p_3 \cdots} \left[\frac{Y[p]\,e^{pt}}{\frac{dZ[p]}{dp}}\right]_p \cdot U(p)$$

frequency function	x	$U(p)$
b	o	1
d	∞	$-e^{-p\left[1-\left(\frac{\omega_m}{p}\right)^2\right]t}$
m	∞	$\pm\frac{1}{\sqrt{1-\left(2\frac{\omega_m}{p}\right)^2}}\,e^{-\frac{p}{2}\left[1\mp\sqrt{1-\left(2\frac{\omega_m}{p}\right)^2}\right]t}$
n	o	$\pm\frac{1}{\sqrt{1-\left(2\frac{p}{\omega_m}\right)^2}}\,e^{-\frac{p}{2}\left\{1-\left(\frac{\omega_m}{p}\right)^2\left[1\mp\sqrt{1-\left(2\frac{p}{\omega_m}\right)^2}\right]\right\}t}$
bm	ω_1	$\frac{1}{1-\left(\frac{\omega_1}{p}\right)^2}\,e^{-p\left[1-\sqrt{1-\left(\frac{\omega_1}{p}\right)^2}\right]t}$
dm	∞	$\frac{1}{\left(\frac{\omega_1}{p}\right)^2-1}\,e^{-p\left[1-\frac{\frac{\omega_1}{p}}{\sqrt{\left(\frac{p}{\omega_1}\right)^2-1}}\right]t}$
bn	o	$\frac{1}{1-\left(\frac{p}{\omega_1}\right)^2}\,e^{-p\left[1-\frac{1}{\sqrt{1-\left(\frac{p}{\omega_1}\right)^2}}\right]t}$
dn	ω_1	$\frac{1}{\left(\frac{p}{\omega_1}\right)^2-1}\,e^{-p\left[1-\frac{\omega_1}{p}\sqrt{\left(\frac{\omega 1}{p}\right)^2-1}\right]t}$

As may be seen double signs appear in $U(p)$ at m and n transformations, which means that for each term in the summation for the original network there are two factors $U(p)$, one for each sign. Consequently the number of terms in the summation is doubled.

At repeated frequency transformations, for instance with the operator functions $P_1(p)$, $P_2(p)$ and $P_3(p)$ the resultant operator function is obviously $P(p) = P_1\{P_2[P_3(p)]\}$ and the resulting inverse function $T(p) = T_3\{T_2[T_1(p)]\}$. If the transformation factors for $P(p)$, $P_1(p)$, $P_2(p)$ and $P_3(p)$ are $U(p)$, $U_1(p)$, $U_2(p)$ and $U_3(p)$ resp. the following relation is obtained

$$U(p) = U_1(p) \cdot U_2[T_1(p)] \cdot U_3\{T_2[T_1(p)]\}$$

With reflexionless cascade connection of impedance networks the following symbolic solution may be of interest

$$f_P = \frac{Y_1[P_1(p)]}{Z_1[P_1(p)]} \cdot \frac{Y_2[P_2(p)]}{Z_2[P_2(p)]} \cdot \frac{Y_3[P_3(p)]}{Z_3[P_3(p)]}$$

With the same designations as above the time function will be

$$f_t = \frac{Y_1[P_1(0)]\; Y_2[P_2(0)]\; Y_3[P_3(0)]}{Z_1[P_1(0)]\; Z_2[P_2(0)]\; Z_3[P_3(0)]}$$

$$+ \sum_{p'_1 p'_2 p'_3 \cdots} \frac{Y_2\{P_2[T_1(p)]\}\; Y_3\{P_3[T_1(p)]\}}{Z_2\{P_2[T_1(p)]\}\; Z_3\{P_3[T_1(p)]\}} \cdot \left[\frac{Y_1[p]\,e^{pt}}{p\,\frac{dZ_1[p]}{dp}}\right] U_1(p) \quad \begin{matrix} p'_1 p'_2 p'_3 \cdots \\ \text{for } Z_1(p) = 0 \end{matrix}$$

$$+ \sum_{p''_1 p''_2 p''_3 \cdots} \frac{Y_1\{P_1[T_2(p)]\}\; Y_3\{P_3[T_2(p)]\}}{Z_1\{P_1[T_2(p)]\}\; Z_3\{P_3[T_2(p)]\}} \cdot \left[\frac{Y_2[p]\,e^{pt}}{p\,\frac{dZ_2[p]}{dp}}\right] U_2(p) \quad \begin{matrix} p''_1 p''_2 p''_3 \cdots \\ \text{for } Z_2(p) = 0 \end{matrix}$$

$$+ \sum_{p'''_1 p'''_2 p'''_3 \cdots} \frac{Y_1\{P_1[T_3(p)]\}\; Y_2\{P_2[T_3(p)]\}}{Z_1\{P_1[T_3(p)]\}\; Z_2\{P_2[T_3(p)]\}} \cdot \left[\frac{Y_3[p]\,e^{pt}}{p\,\frac{dZ_3[p]}{dp}}\right] U_3(p) \quad \begin{matrix} p'''_1 p'''_2 p'''_3 \cdots \\ \text{for } Z_3(p) = 0 \end{matrix}$$

In addition to the transformation factors obviously correction factors are also obtained by means of inverse frequency transformation of the symbolic solutions.

The practical advantages of this extension of the expansion theorem is that only the roots of the equation $Z(p) = 0$ have to be determined and used, *i. e.*, the roots of the comparatively simple original network. Therefore $Z(p) = 0$ will not be of a high power and will be easy to solve. The roots will not be complicated, which means that they may easily be inserted in the operator expressions and the risk of obtaining two equal roots is reduced. The calculations may also be simplified by means of the determination once and for all of the transformation factors employed.

Finally it may be mentioned that there is no need to change the name »frequency transformation», even if the transformation be used on operators. The operator differs from the angular frequency only by the constant factor j. Thus an operator transformation must mean a frequency transformation.

In a future issue of the Ericsson Technics the new extension of the expansion theorem will be dealt with in detail together with examples.

Theory of Rectifier Modulators

S. KRUSE, TELEFONAKTIEBOLAGET L. M. ERICSSON, STOCKHOLM

In the description of the new single-channel carrier telephone system for open-wire circuits, published in the Ericsson Review No 2, 1936, a brief account of the rectifier modulators employed in this system was given. The rectifiers were assumed to be ideal, i. e., to have a constant conductance for one current direction and to block completely for the opposite direction. A short survey of the theory for modulators composed by rectifiers with any current-voltage characteristic will be given below.

The modulator, Fig. 1, is assumed to consist of four identical rectifiers with the current-voltage characteristic $i = f(v)$. At the terminals $1'2'$ is connected a sinusoïdal EMF $e' = E' \sin \omega' t$. The current and the voltage at these terminals are i' and v' and at the output terminals $1''2''$ they are i'' and v''. The carrier voltage is v_c and its angular frequency ω_c. If v' and v'' are small the following equations for i' and i'' are obtained

$$\left.\begin{aligned} i' &= hv' - mv'' \\ i'' &= -mv' + hv'' \end{aligned}\right\}$$

where

$$h = \frac{f'(v_c) + f'(-v_c)}{2}$$

$$m = \frac{f'(v_c) - f'(-v_c)}{2}$$

$$f'(v_c) = \frac{d\,f(v_c)}{d v_c}$$

It is found advantageous to choose for the carrier voltage v_c a time function that contains only odd harmonics. If v_c is such a function h and m may be written as follows according to the *Fourier* series

$$\left.\begin{aligned} h &= a_0 - 2a_2 \cos 2\omega_c t + 2a_4 \cos 4\omega_c t - \dots \\ m &= 2a_1 \sin \omega_c t - 2a_3 \sin 3\omega_c t + 2a_5 \sin 5\omega_c t \dots \end{aligned}\right\}$$

If investigating which modulation products occur at the terminals $1'2'$ and $1''2''$ it will be found that i' and v' contain only components with the angular frequencies ω', $2\omega_c \pm \omega'$, $4\omega_c \pm \omega'$ etc., while i'' and v'' contain only the angular frequencies $\omega_c \pm \omega'$, $3\omega_c \pm \omega'$, $5\omega_c \pm \omega'$ etc.

By inserting the expressions obtained for h and m in the first two equations, vector equations for the different sub-frequencies of i' and i'' are obtained. In order to find more suitable expressions the general angular frequency may be written as $\omega' \pm p\omega_c$. The corresponding current and voltage vectors are written as $\overline{I}'_{\pm p}$, $\overline{V}'_{\pm p}$, when p is an even number, *i. e.*, for the angular frequencies ω' $\omega' \pm 2\omega_c$, $\omega' \pm 4\omega_c$ etc. and $\overline{I}''_{\pm p}$ $\overline{V}''_{\pm p}$, where p is an odd number, *i. e.* for the angular frequencies $\omega' \pm \omega_c$, $\omega' \pm 3\omega_c$ etc One will find a group of vector equations, the matrix of which may be written as follows:

frequency		$\overline{V}_0'$	$\overline{V}_1''$	$\overline{V}''_{-1}$	$\overline{V}_2'$	$\overline{V}'_{-2}$ etc.
ω'	$\overline{I}_0'$	a_0	$-ja_1$	ja_1	$-a_2$	$-a_2 \dots$
$\omega' + \omega_c$	$-\overline{I}_1''$	$-ja_1$	$-a_0$	a_2	ja_1	$ja_3 \dots$
$\omega' - \omega_c$	$-\overline{I}''_{-1}$	ja_1	a_2	$-a_0$	$-ja_3$	$-ja_1 \dots$
$\omega' + 2\omega_c$	$\overline{I}_2'$	$-a_2$	ja_1	$-ja_3$	a_0	$a_4 \dots$
$\omega' - 2\omega_c$	$\overline{I}'_{-2}$	$-a_2$	ja_3	$-ja_1$	a_4	$a_0 \dots$
etc.	etc.			etc.		

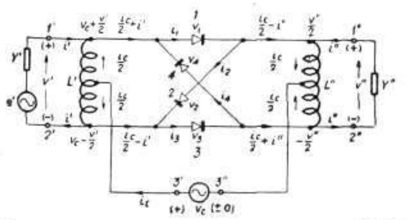


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Fig. 1
Principle diagram of rectifier modulator

Here $j = \sqrt{-1}$ and the coefficients a_p are half the coefficients of h and m in the *Fourier* series (the whole coefficient for $p = 0$). If all the composants of i'' are introduced in the equations with negative signs the matrix will become symmetrical.

Now the problem arises to find suitable termination impedances for the different frequencies in order to obtain a high efficiency and good operation of the modulator. In this connection it is of interest to look at the vector equations in a special way. As the frequencies are not to be found in the equation the different vectors may be regarded as corresponding to currents and voltages of one and the same frequency. The vector equations then represent a linear multi-pole network with the current $(-1)^p \overline{I}_p$ and the voltage $\overline{V}_p$ at the p:th pair of terminals (indices may be left out as even values of p correspond to $'$ and odd values to $''$). Consequently the modulator problem is brought back to the investigation of a linear multi-pole network, which one can treat mathematically by means of ordinary transmission theory.

The theory indicated above together with examples will be dealt with in detail in a future issue of the Ericsson Technics.

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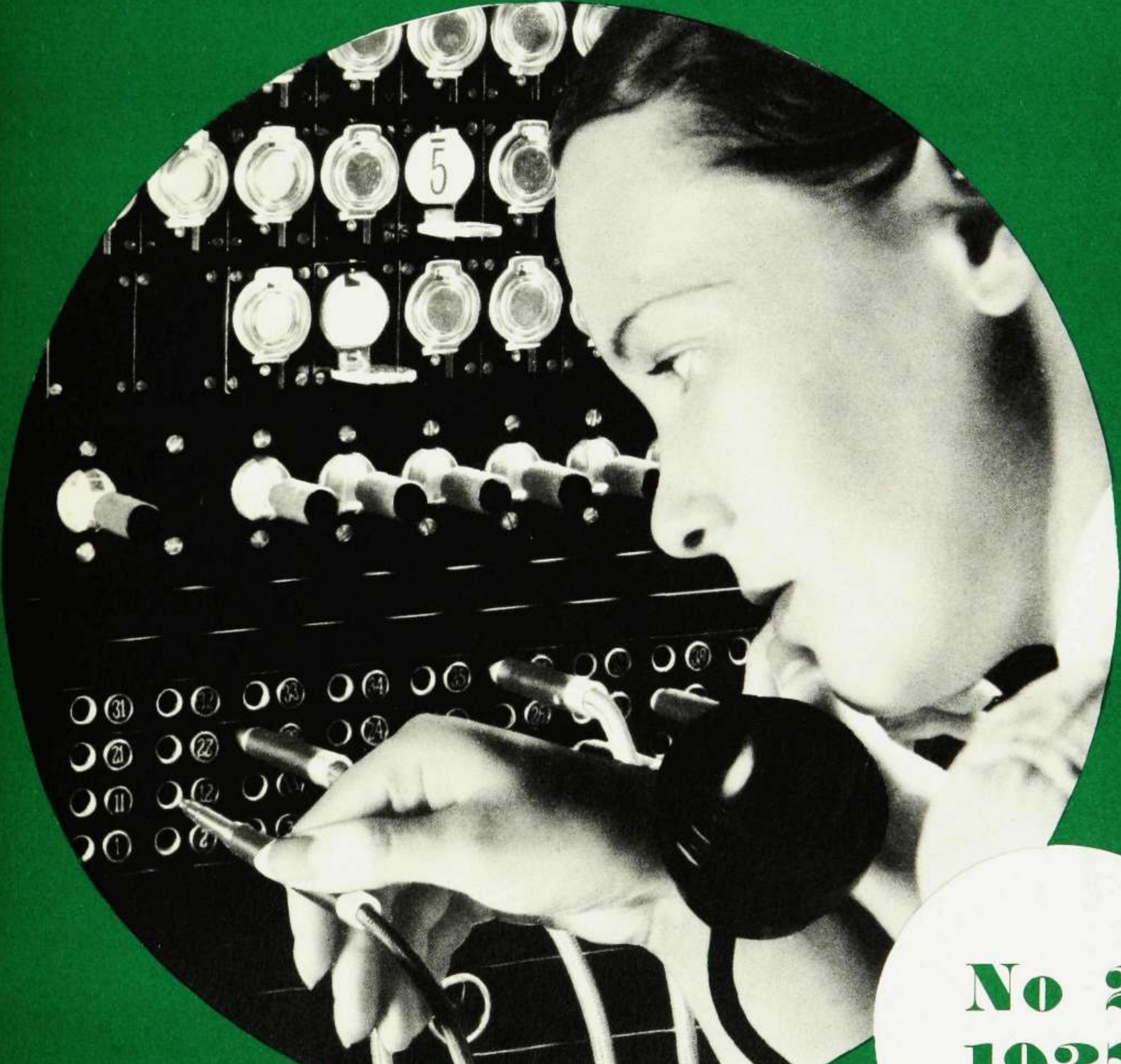

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Time Control for Synchronous Clock Operation and Load Distribution

H. FRANSÉN, DIRECTOR OF OPERATION, SWEDISH ROYAL BOARD OF WATERFALLS, STOCKHOLM

In Ericsson Review No 3, 1936, was given a description of the Ericsson time-control system. The present article deals with time control from the standpoint of operation, referring more closely to the advantages offered by the introduction of time control in more extensive networks with a large number of power stations. In conjunction with this a report is given on the application of time control in the Central Network of the Swedish Royal Board of Waterfalls.

Time control is a fairly recent conception in power-station operation. It constitutes a complement to pure frequency control as formerly applied in that not only is watch kept that the frequency of the electric current at each instant is maintained sufficiently near the nominal figure but also the mean frequency is controlled during a great interval of time to agree exactly with the nominal figure. The application of time control means in other words that the number of cycles delivered in a certain unit of time, say twenty-four hours, is always kept constant.

The first inducement for the introduction of time control was that it should be possible to connect synchronous clocks to the AC network. In its simplest form this original form of time control consisted of regulating the turbine throttle in such a way that the difference between a synchronous clock connected to the generator bus bars and a standard clock, *e. g.* an accurate pendulum clock, was maintained within sufficiently narrow limits. As a result similar accurate running is obtained with all synchronous clocks connected in the network, as these give exactly the same time as the clock mounted at the power station. Very soon, however, there were constructed special time control clocks, indicating directly the variation in time, *i. e.*, the difference between synchronous time and astronomic time.

Time control in itself involves no special complication in respect of operation of the power station. Even when time control was rather primitive the frequency during normal operation could be kept within $\pm$ 1 % of the nominal figure and for an extended period the difference would seldom amount to more than $^1/_2$ %. Even when such a large difference occurs during a whole hour it does not result in greater variation in the synchronous clocks than about 20 s, and it can therefore be seen that no excessive adjustment is required to limit the error in the synchronous clocks to considerably smaller figures, provided of course that sufficient machine capacity is available for it not to be necessary to run the plant with too low a frequency for any length of time.

The expense of time control at a power station is restricted to the acquisition and upkeep of time control clocks and must be admitted to be very low in comparison with the benefit derived by subscribers. On the other hand, it should be observed that the power supplier practically speaking has no direct return for the time control. A special charge could hardly be made for connection of synchronous clocks and any energy it takes must for the most part be supplied free since the consumption of current is so small that ordinary AC meters do not register it when only one or two synchronous clocks are connected to the network. If despite the above, electricity-supply companies have in many places introduced time control, it has mostly been done to give subscribers opportunity to take advantage of all spheres of utility for electric current, and the expense and trouble have been counterbalanced by the publicity value involved in the possibility of connecting synchronous clocks. That most certainly has been the cases in many instances of change-over from DC to AC, »electric time» providing an excellent selling point with which to counteract any mistrust on the part of the public against the new kind of current. The expense of time control, moreover, is insignificant in comparison with the other amounts expended by the electricity company on improving the quality of the current, *e. g.*, for tension regulating and reliability of operation. The introduction of time control at a power plant may, therefore, be put down to something like the same cause as when other necessaries of life are supplied in attractive colours or packages.

Seeing that time control thus only causes power stations modest expense and an insignificant increase in supervision work, it might be surprising that, in the 15 years or more since the American *Warren* designed the first time control clock, it has not been as generally applied in Europe as in the United States. In the main the reason may be found in two circumstances: it might be feared that general employment of synchronous clocks may impose demands on uninterrupted current supply such as is not economically practicable in scattered areas; further, time control is very complicated in interconnected power networks, which mode of operation has been developed to a great extent in the last years.

As the synchronous clocks come to a stop if an interruption of current occurs in the network, such an interruption which otherwise would be scarcely noticed gives rise to general complaint when synchronous clocks are connected. Up to now it has been fairly common for electricity companies which for economic reasons could not maintain a complete reserve of spare circuits to cut off the current now and again for maintenance work on the network, the interruption being done at night when subscribers were not inconvenienced in view of the uses of electricity up to now available. Such companies consider that the introduction of synchronous clocks entails the risk of increase in complaints, since the public would be in a position to notice all interruptions of current consequently these undertakings are disinclined to adopt time control.

However, the demand for reliability of operation is sharpened quite irrespective of the use of time control. Electric energy is constantly finding new applications both for private and industrial needs and in many cases the necessity for practically continuous supply of current is imposed. An important example of this kind is electric railway traction, a minor one though yet of considerable importance is constituted by mains-connected wireless receivers. An increasing number of industrial processes are subjected to financial loss by current interruption, not only because of lost working time but to a far greater degree by loss of materials or deterioration in quality of the finished product. Even with rural distribution, where up to a few years ago, the notification of an interruption of some hours on a Sunday morning gave rise to no protest, it becomes increasingly difficult to carry on necessary maintenance work where reserve supply cannot be arranged. Power plants are thus obliged to work for continual improvement of operating reliability and aim at the greatest continuity of current supply possible, and the risk of interruption is therefore of decreasing importance when it is a question of synchronous-clock operation.

Time Control in Interconnected Power Networks

Unquestionably time control becomes considerably more difficult when the supply of power is not of the simple nature that the distribution network is fed from a single power source; and such nowadays may be counted as an exception. The large power suppliers produce the energy in a number of interconnected power stations and are often more or less cooperating with other supply undertakings. The electricity distributing companies, even when they buy power from a large power-supply plant, have very often their own power plants, either for regular operation or for reserve operation and supply of peak power. An undertaking therefore has rarely time control at its command in all circumstances, and in any case there is the risk that a section of the network which normally is fed from a time controlled plant, may be temporarily disconnected from this and fed by a power station which normally has nothing to do with time control and is consequently not equipped with control apparatus. Such sectioning may take place without interruption of current in the part of the network concerned and without stopping the synchronous clocks. This involves the risk that if the interruption continues for an appreciable time the clocks will be more or less wrong and the error will remain when the network is again connected to the power plant which usually feeds it. If time control is to be introduced in a network with such complicated power supply it is necessary to organise the operation in such a way that the time control is maintained even with sectioned working and that the phasing after an interruption is not done until the time deviation on synchronous clocks has been made the same for all portions of the network. This does not entail any appreciable costs, since time control at those power stations which do not normally have time regulating may be arranged by quite simple means. The conditions referred to, however, do require a certain amount of forethought on the part of the operation management and careful instructions respecting frequency and time regulating at all power stations connected to the network.

It is understandable that the trouble attached to such an organisation has in many places deterred the power company owners from introducing time control, but if the question is gone into more closely it will be found that the power plant with time control is in possession of a very useful accessory for rational distribution of load, and the cost and trouble involved in its application is well repaid by the advantages gained.

With interconnection between several power suppliers the principles on which load distribution are to be determined may be quite complicated. With the combination of water-power and steam-power typical of large power undertakings the chief factor in load distribution is the attainment of the least cost possible for the requisite steam-power supplement. With this in view consideration must be given not only to losses in machinery but also to losses in intake and outlet at the hydroelectric plants as well as in transformers and in transmission lines from the power plants to the consuming centres. In addition the losses due to daily and weekly regulation at the hydroelectric plants have to be compared with the costs of fuel and other operating costs for the steam power when more or less continuously fed in. In other words, it is a matter not only of determining the most favourable distribution of the load at any given moment but to decide on the economic distribution of the daily and weekly regulation at the different hydroelectric and steam plants.

The problem is still further complicated because it is not known beforehand how great the load will be and how it will vary. It is therefore not possible to achieve fully the most economic distribution, since that would require exact knowledge not only of the state of the load at the moment but also of the power required and the water available for a certain period in advance, *e. g.*, for the remainder of the day or of the week. One has therefore to be satisfied by making an estimate in advance of the probable load and its variations and on the basis of these an approximate plan of distribution of load, which must be adjusted to circumstances as the day or the week proceeds.

In order to arrive at the requisite stability in the load distribution it is generally found advisable, so long as certain operating conditions prevail, to have

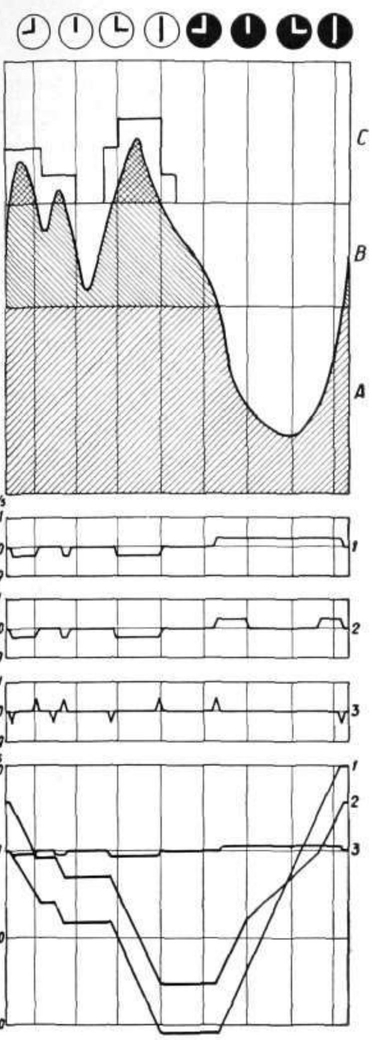

Fig. 1
Load distribution between three power plants and time deviation in the synchronous clocks connected

A main power plant	1 frequency signalling
B storage power plant	2 frequency signalling with time adjustment
C peak power plant	3 time signalling

time regulation at a single power station suited for this purpose, while the remaining power plants are instructed to work to a certain plan, calling for a certain stated output or a certain regulation of the water supply. When the operating conditions in question cease to exist the frequency regulation is transferred to another power plant, while the former changes over to feeding, in accordance with the prescribed plan. Should the load conditions change once more it may be advisable either to apply frequency regulation again to the first station or transfer it to a third power plant.

The transfer of frequency regulation may be arranged by telephone communication between the two power stations or by report from the one station to the central operating office which can transmit its orders to the other station. In practice, however, it has been found that such a system of ordering is altogether too slow in view of the rapidity and short intervals between changes in the load conditions which may arise. It has been found that changeover of frequency regulating can best be fixed for suitable moments by means of *frequency signalling*. This means that one station, so long as a certain running situation fixed in the joint working plan continues, regulates at a determined signal frequency, *i. e.*, in practice within a certain frequency interval, but on a certain variation in load conditions it allows the frequency to go below or above the said interval, which constitutes a signal for another station to take over frequency regulation. While the new conditions prevail this second station regulates on its own frequency, higher or lower as the case may be. In this way it is possible for all the stations interconnected to observe which power plant is regulating the frequency and in accordance with this adhere to the general operating conditions.

An illustration of the application of this system is shown in the diagram, Fig. 1, giving load distribution for a typical case. It represents interconnection between two hydroelectric plants *A* and *B* and a steam power plant *C*. High water prevails at station *A*, at station *B*, assumed to be a storage plant, the flow of water is limited though the total water supply shows a certain surplus, and the steam power is thus only required to cover peak loads. In this case the plants may, *e. g.*, be given the following signal frequencies: 50.3 c/s for *A*, 50.0 c/s for *B* and 49.7 c/s for *C*. This means that station *A* must run with full throttle as long as the frequency consists of 49.7 or 50.0 c/s or thereabouts, that station *B* shall run with full throttle at 49.7 c/s and with closed throttle at 50.3 c/s, and finally that station *C* shall run with closed throttle, so long as the frequency stands at 50.0 or 50.3 c/s. In this way it is ensured by means of frequency signalling that the supplement from steam power is the smallest possible, and that the storage at power station *B* is refilled as rapidly as possible, which means that readiness for unforeseen changes in the power balance is the greatest possible.

When load distribution is arranged in the manner above described it has, however, the result that the mean frequency for the whole day deviates from the nominal figure by an amount governed by the duration of the periods in which the different signal frequencies are applied, see the lower diagram Fig. 1. In the course of the day there either arise varying deviations in time, fast or slow, or a persistent error, slow in the case here given. This result of frequency signalling has been found to entail certain inconvenience, especially for those industries whose daily production is in direct ratio to the total number of cycles delivered over the whole day. To avoid this inconvenience and bring the mean frequency into agreement with the nominal figure, it is possible in those parts of the day when the load distribution is definitely fixed and frequency regulation can unconditionally be put on a certain power station, to instruct that particular station to carry out *time adjustment*, consisting of the power station during the prescribed period of time regulating the frequency in such a way that the deviation in time previously arising is eliminated.

Frequency signalling can naturally be used also for fixing the moment for other changes of the load distribution than the two described. For example, it may be employed for connecting and disconnecting controlable loads, such as electric steam boilers. However, as the system expands the need for signal frequencies increases and consequently the band in which frequency needs to be regulated eventually becomes inconveniently broad. The signal frequencies cannot be allocated too close together, in the first place because variations of load even with careful adjustment impose frequency variations of a minimum size, and also because a certain limit is set by the accuracy of the frequency meters. Considerably greater possibility is given, however, by adopting frequency control with *time signalling*, so arranged that the deviation in time shown on each occasion by the time control apparatus represents the signal figure for a load distribution. This has the advantage that the station regulating frequency at the moment, whichever it may be, can regulate the frequency to the nominal figure and that the deviations in frequency are confined to low figures and to the times for change-over from one signal figure to another, which naturally cannot be achieved without the frequency being considerably raised or lowered for a certain period. The system, therefore, demands fixed rules also for the frequency adjustment during the transition periods and, in order that these shall be short enough, that the time control indicates deviations of time with an accuracy of at least ± 1 s. The interval between two signal figures may then be set at 2 s, whereupon the transition can proceed for some minutes with a reasonable deviation of frequency. How this system would act in the example dealt with above is shown by Fig. 1. There the power plants are taken as being allotted the signal figures + 2 s for station *A*, ± 0 s for *B* and — 2 s for *C*. Moreover station *A*, when the time deviation is 0 s shall apply frequency adjustment at 50.3 c/s, *i. e.*, on rise of frequency reduce throttle and regulate on 50.3 c/s until possibly a time deviation of + 2 s occurs, after which the station changes over to regulation at normal frequency. Station *B* has frequency adjustment at 49.7 c/s when the time deviation constitutes + 2 s, and at 50.3 c/s when the time deviation is — 2 s. Finally the station *C* has frequency adjustment at 49.7 c/s when the time deviation is ± 0 s.

Fig. 2 X 3734
Power system of the Royal Board of Waterfalls

- □ power station
- ○ secondary station
- — trunk line 220 kV
- — trunk line 132 kV
- — primary line 77—55 kV

A condition for being able to apply the signal system described above in the manner intended is that the time control apparatus in all the power plants indicate the same time deviation for an error within the limit of 1 s, which requires that the pendulum clocks working with the time control apparatus run with this degree of accuracy. The best result would naturally be obtained if the pendulum clocks were automatically synchronised over special circuits, but with the great distances between power stations generally found this would impose far too great expense. It has been found, however, that even without such synchronisation devices satisfactory agreement in the running of the clocks can be attained, provided the individual pendulum clocks used are sufficiently accurate.

Time-Control System in the Swedish Central Network

In the Central Network of the Swedish Royal Board of Waterfalls, see Fig. 2, the system described above for frequency regulation and load distribution by time control has been applied since the autumn of 1934, with satisfactory results from all points of view. It is shortly to be introduced also in the North Network which is soon to be interconnected with the Central Network.

Time-control apparatus of Ericsson make are installed in the Trollhättan, Västerås, Älvkarleby, Motala and Malfors power plants, and in the central control office at Stockholm. As up to now there have only been required a few signal figures, usually only three, 5 s interval between the signal figures on time deviation has been considered sufficient for the present, *i. e.*, the most usual signal figures have been -5, ± 0 and $+5$ s. It has been found possible to limit the error in the clocks at the different places to some few seconds a day. Each day the time given by the pendulum clock in Stockholm is adjusted to agree with the broadcast time signal, the clocks at the other places then being corrected to agree with that in Stockholm. By this procedure the constant indication of practically the same time deviation by all the time control clocks has been achieved.

The system with time control clocks directly indicating deviation in time has shown itself to have quite a number of advantages over those already described. Both for the operations supervisor in Stockholm and for the engineers at the power stations the position of the deviation pointer constitutes at any given moment a reliable and clear indication of the power balance prevailing. The time control clocks have therefore been given at each place a prominent position in the control equipment, Fig. 3. At the instigation of the Royal Board of Waterfalls, Ericsson has also made the clocks with signal contacts, so that when a signal figure has been passed the staff in the power station concerned have their attention attracted to it by an audible signal. The sensitive and rapid reaction of the system to alterations in the balance of power allows of a more even adjustment of the load distribution to the actual situation, *e. g.*, by complete substitution of purchased power from outside plants for the more costly steam power, as orders can be continuously regulated on the basis of the time deviation, a more complete utilisation of surplus power for electric steam boilers etc. Finally it should be mentioned that cooperation with two private power systems, which themselves apply time control for synchronous-clock operation, is not adversely affected but on the contrary has on several occasions been facilitated by time control.

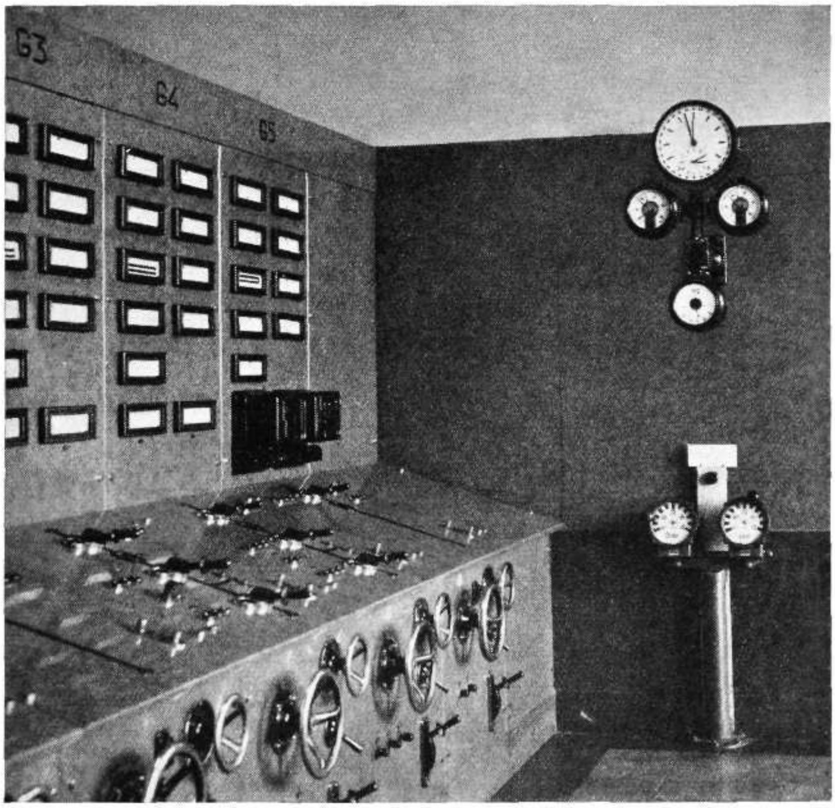

Fig. 3 X 5381
Time-control clock at Västerås power station

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Interlocking Plant at the Madrid Underground Railway

M. NUEZ DEBESA, CHIEF ENGINEER, UNDERGROUND RAILWAY, MADRID

In August 1936 the third line of the underground electric railway was opened in Madrid. Only lines I and II have coach depots, however, and it has consequently been necessary to arrange a junction line between line II and line III to transfer rolling stock from the new line to the depots.
To allow of transfer of trains from line III to the junction line and vice versa with complete safety despite the particularly dense traffic — one train passes every other minute — an interlocking plant has been installed at station Sol III, connected to another at Sol II station. The interlocking plant at Sol III has been made by Compania Española Ericsson, which delivered and erected the material.

The control apparatus, mounted in the station master's office, comprises an illuminated track diagram on which are reproduced the signal indications, the position of the points, the state of the automatic block sections, etc. In addition there is on the diagram a series of two-way switches for setting the different train roads and for manual operation of points and signals. All relays are combined in a cabinet where they are protected and easily accessible for inspection and supervision. There are in the underground tunnel only the point machines and cabinets containing the junction boxes, track-circuit transformers, lighting transformers and fuses.

The system employed for the operating devices is such that the relations between the different devices are entirely electric. The point and operating switches are interdependent so that they can only be used for combining possible roads. All points and signals belonging to roads are afterwards operated by a single switch, which prevents opposing train roads being set. The signals are operated last and are normally at »stop», to be put over to »clear» only when the road has been laid out, locked and checked on the track diagram. When the signals have shown »clear» for a determined road and a train has been driven on to it the signals are returned to »stop» as the train proceeds through the different sections. When the last section of the road has

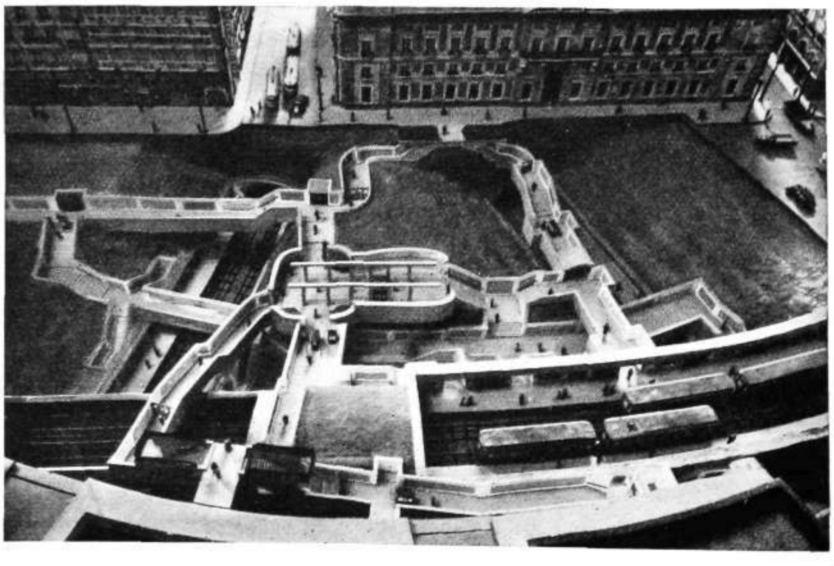


Fig. 1 X 5359
Plan of Sol station
left line I, foreground line II, right line III

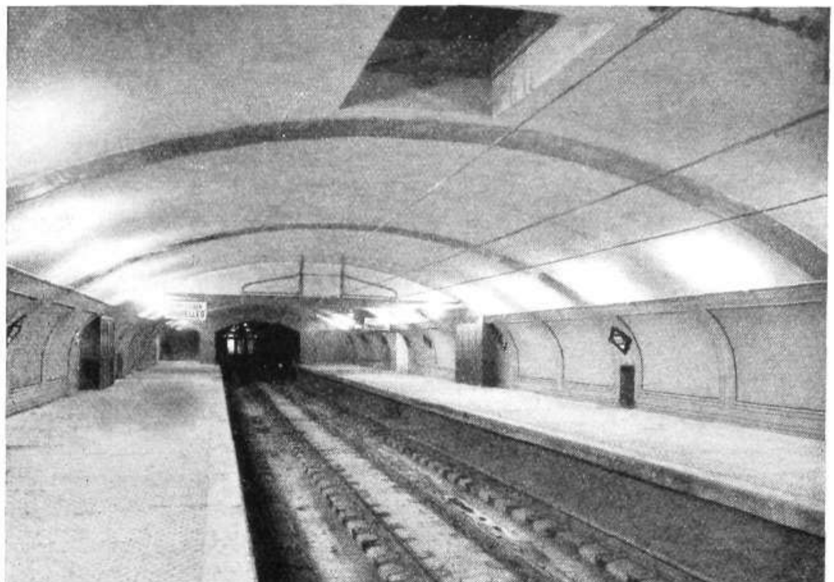


Fig. 2 X 5360
Sol III station
left, on wall, control apparatus

been passed the road is released and the corresponding points and signals return to normal positions.

If all the elements contributing to form a train road are in their right positions, *i.e.*, if opposing track relays are opened, the corresponding blocking relays closed, the cooperating operating devices in the Sol II plant blocked and corresponding relays closed, the relay of the desired road will be energised, when the corresponding switch is actuated, through the switch and then through its own contact as well as through the back contacts on the relays which operate the signals and make the road clear. The track relay closes when all the elements which make up the road are in the right position and these positions have been checked. The relay remains attracted until all the signals in the road have been set at »clear», that is when the road has been laid out, locked and checked.

The point machines are operated by double relays, which are mechanically locked in relation to each other and each of which corresponds to a position of the points. The relays are attracted through contacts on the locking relays belonging to the road to be laid out; the attraction of the relays occurs in addition through contacts on the track relays for the track section to which the points belong, this being to prevent changing of the points for another road when a vehicle is passing.

When these safety conditions have been fulfilled the road relay is attracted, whereupon the point machines set the points at the correct position. After that the checking of the position of the point tongues is done by attraction of a control relay corresponding to the point position and which breaks the current to the point machine. The control relays are DC relays provided with

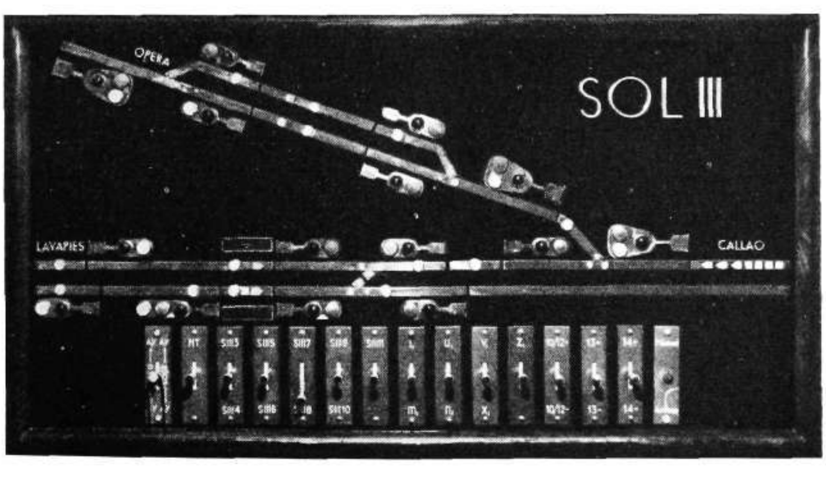


Fig. 3 X 5361
Control apparatus with illuminated track diagram

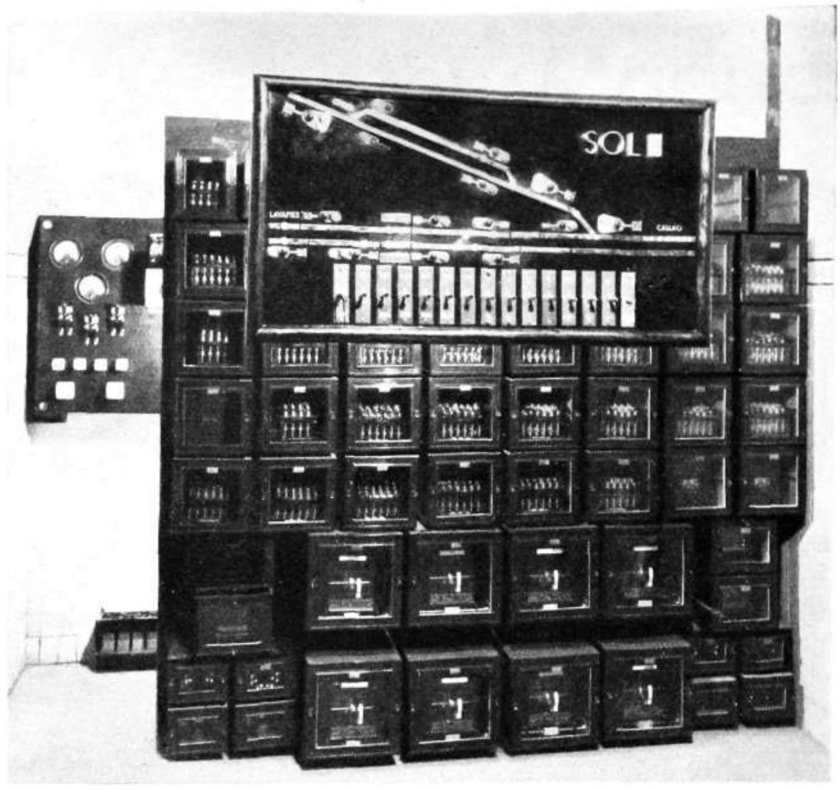


Fig. 4 X 5362
Relay frame with control apparatus and illuminated track diagram
background, power plant

rectifiers so that they attract only for a determined current direction. The locking relays of the road normally receive current over a break contact on the road relay and over contacts of their own. When the circuit is broken through attraction of the road relay, current is fed over the back contacts on the point-control relays included in the road. When the point has taken up the position it should have for the road in question, the corresponding control relay attracts, whereupon the relay contacts break the current to the locking relay, which opens. As a result opposing train roads cannot be laid out and moreover no other movement of trains can take place on the track sections in which the points are, since the contacts of the locking relay break the circuits to the relays belonging to opposing roads and the operating relays for the points in question.

When all operations for laying the road have been carried out and the road is locked, the signals are set at »clear» which is done over contacts on the point-control relays, over contacts on the track relays included in the road, and further over front contacts on the road relay as well as over back contacts on the locking relay. When the signal relay has attracted, it obtains holding current over its own contact.
The signal-operating relay is repelled when any of the above conditions is no longer fulfilled or when a train comes into the corresponding block section or even by emergency release of a road already laid out. When a train comes into a section, the track relay falls and the corresponding signal is set at »stop». When the train has passed through all sections of the road and caused all signals to be set at »stop» the road locking relay is closed and remains closed. On this the current flows through the point-operating relay and the point machine returns the point to normal position. With this everything has returned to normal position and the different devices have the same positions as before the road was laid out.

By means of the interlocking plant now installed the execution of the different operations has been very much simplified, and the train dispatcher's work has been made much easier, since anybody can handle the plant in accordance with the information given on the illuminated track diagram. Moreover, no special operations are necessary to restore the points and signals to normal position, which constitutes a great advantage in comparison with the very cumbersome mechanical plants. In the time the interlocking plant has been in operation it has worked to complete satisfaction.

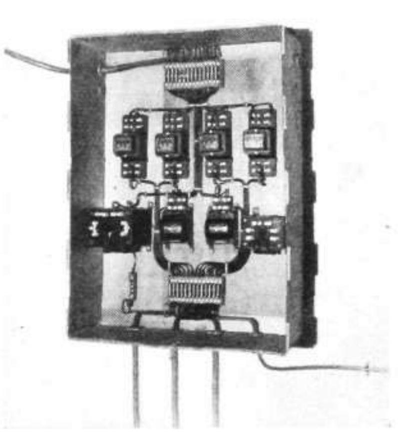


Fig. 5 X 3718
Transformer cabinet

Automatic Traffic over Trunk Lines

E. LINDSTRÖM, TELEFONAKTIEBOLAGET L.M. ERICSSON, STOCKHOLM

The introduction of automatic switching from one trunk exchange via one or more other trunk exchanges to subscribers at distant places has made it possible for such connections to be established by a single operator, whereas manual switching requires the attention of several operators. This causes reduction in operating expenses and a considerable saving in switching time, while better use of the lines is obtained by concentration of the trunk lines in bigger bundles between those exchanges which are arranged for automatic transit switching. It is then most suitabie to use AC for the impulsing via the trunk lines.

In the following article the Ericson AC repeaters for 50 c/s are described as also their adaptation to the trunk equipment.

Formerly the establishment of calls between local telephone networks at different places was effected via manual trunk exchanges. To begin with, one operator was needed at each of the two places between which a call had to be established. When establishing a connection, the local subscribers were first switched to their respective trunk exchanges; this was usually done via an incoming position, and then the connection was completed by the two trunk operators through switching on to the trunk line. Thus the attention of four operators was taken up for such a connection, though only one operator was really needed to supervise the call.

If there were no direct line between the two places, the connection would have to pass through intermediate trunk exchanges, and at each of these exchanges at least one operator was required to assist in establishing the connection. The more intermediate exchanges to be passed through, the more operators would have to assist in completing the connection, and, as manual service always involves a certain delay in the switching, the establishment of a connection by this method caused loss of time, besides being expensive. The natural result was that direct lines were arranged as far as possible between the different places in order to avoid connections via intermediate exchanges. The lines were consequently divided into several small bundles, the utilization of which was unsatisfactory unless traffic were carefully planned by preparing the calls and switching the subscribers in anticipation to the respective trunk exchanges, so that the operators could immediately switch through the new connection when the wanted trunk line became disengaged. This method, however, caused long waiting times. The reduction in switching time thus gained by rearrangement of the lines to avoid transit exchanges in its turn caused difficulty in ensuring good utilization of the lines when these were divided into small bundles.

It is possible by the introduction of automatic selectors at the intermediate and the incoming trunk exchanges for one operator alone to establish a connection quickly via several intermediate exchanges by means of a dial or a key-set. The switching time taken up by hunting for a disengaged trunk line in the wanted direction is so short as to be practically negligible, and there is no necessity to divide the trunk lines into smaller bundles with the resultant unsatisfactory utilization of the lines and longer waiting time.

In recent years the automatic method of establishing a connection via trunk lines has been widely adopted in different countries, and at present it is possible for the operator at an outgoing exchange to establish a connection to any subscriber within the automatic trunk district without the assistance of operators at intermediate and incoming exchanges; this can be done no matter whether the lines are equipped with telephone repeaters or not.

For remote operation of automatic selectors, DC is most frequently used; but this is not always suitable for the switching via trunk lines, as DC circuits are always sensitive to disturbance from power networks. Furthermore with loaded lines the coils could be adversely affected by excessive currents, and transformers and phantom circuits could not be used to the same extent with DC. All signalling via the trunk lines is therefore usually done with AC.

As to the signalling current, the system used at present may be divided into two groups, *viz.*, systems with voice-frequency signalling current, *i.e.*, signalling current with a frequency above 300 c/s; and systems with low-frequency signalling current, *i.e.*, signalling current with a frequency less than 100 c/s. For economic reasons its range of employment is limited to lines equipped with two or more telephone repeaters, generators and receivers for such signalling current being too expensive to allow of profitable use of the system with shorter or cheaper lines.

For impulsing with low-frequency current the telephone repeaters have to be equipped with special impulse repeaters in place of the usual repeaters for 16 c/s ringing current. The signalling current for the low-frequency system may be taken from the existing AC mains and the frequency is usually 50 c/s.

Use of AC Repeaters

Automatic switching of calls via trunk lines is used in its most simple way, Fig. 1, at the small trunk exchanges which may with advantage be left without supervision during periods of low traffic. It is presumed that the local exchange at the place is automatic, and that the switching of calls from the trunk exchange is made via an automatic equipment. The establishing of connections and the supervision of these is then left to some bigger trunk exchange in the district, at which there is manual service day and night. This transference of the service from one exchange to another is possible only if the lines between the two exchanges are equipped with repeaters for automatic switching, which moreover are not in use during normal conditions. When the operators at the smaller exchange leave their positions for the day, some of the lines are switched over to the larger exchange, which then has to handle the switching of automatic traffic. By means of dial or key-set the operator at the larger exchange then establishes the trunk connections to subscribers belonging to the switched-off trunk exchange. These must, however, be able to call a trunk exchange in the night time as well, and therefore some of the transferable lines are arranged for ordering traffic in the reverse direction, so that the operator at the bigger exchange can also receive the ordering traffic for the switched-off exchange. With direct switching the signalling between operator and subscriber is carried out to the same extent as when a subscriber is called from his own trunk exchange. The switching over of the lines from manual to automatic traffic and vice versa is done individually for each line for the incoming traffic as any calls going on finish. The ordering lines on the other hand can be switched over at once.

The introduction of automatic traffic in a district is usually made in stages. The first stage is usually limited to places between which there is especially

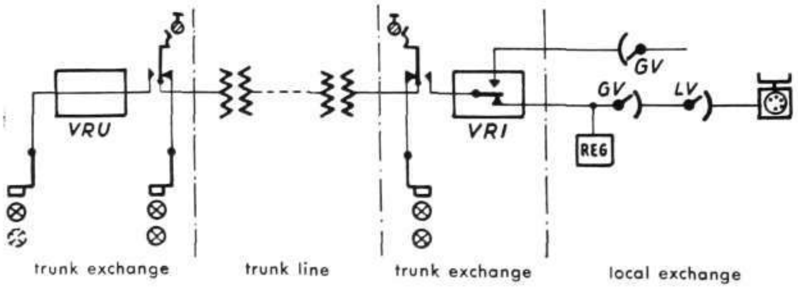


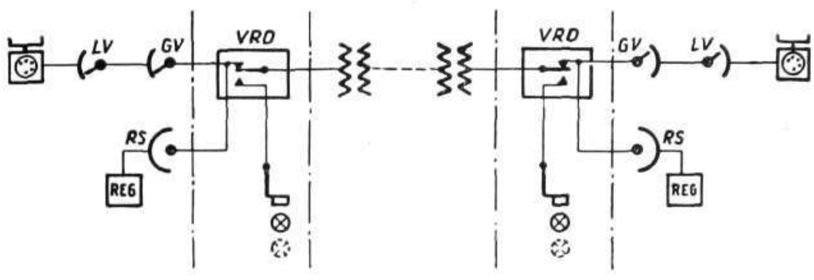
Fig. 1 X 5369
Diagram for one-way automatic trunk traffic

GV group selector
LV final selector
REG register
VRI incoming repeater
VRU outgoing repeater

Fig. 2 X 5370

Diagram for two-way automatic trunk traffic

GV group selector
LV final selector
REG register
RS register finder
VRD two-way repeater



heavy traffic, see Fig. 2. All lines between the two exchanges at these places are equipped with repeaters for two-way traffic, and connections from one of the trunk exchanges to local subscribers of the other are established and supervised by the operator at the first exchange only. Connections from other non-automatic trunk exchanges, which previously were switched through at one of the two exchanges to reach the subscribers of the other one, are now effected from the first exchange via the automatic lines. These are therefore used not only for traffic between the local networks of the two trunk exchanges but also for transit connections, and in that way the other exchange is released from the incoming traffic to the greatest possible extent.

The transit connections are carried out manually in the same way as before, and because of this the automatic lines must also be available for transit traffic. These lines are therefore equipped with special transit jacks at the trunk positions; on the plug being inserted in such a jack, a special calling signal is sent out giving the calling lamp of the line at the other exchange, instead of switching on the automatic receiving equipment. The call is then answered by the operator and the switching through to the next trunk exchange can be effected. The subscribers' ordering of trunk calls is received at the original trunk exchange. The repeaters of the lines can be built for one-way or two-way traffic.

When most of the trunk exchanges in a district have been converted to the automatic system, it is usually not advisable to continue with manual service for the transit traffic. The outgoing trunk lines are then connected to the multiples of the selectors for the incoming lines, so that the operator at the outgoing exchange may be able to direct the switching via a new trunk line. Thus not only the supervision and charging for a call but also the establishing of the connection can be done by the operator at the outgoing exchange. In a modern trunk network where the transit connections are also switched automatically, these are established very quickly and without the assistance of other operators, and because of this the number of transit exchanges may be increased with a view to more concentrated line grouping, see Fig. 3. The transit directions, Fig. 4, are reached by the dialling of direction numbers distributed in such a way that it is possible to reach a certain exchange within the same district by dialling the same direction number from any of the other exchanges.

The method of switching is very simple for the operator. The instructions to be followed previously, giving the intermediate exchanges to be passed to reach a certain subscriber, are replaced by direction digits which are to be dialled for automatic switching to the exchange of the wanted subscriber. The operator at the outgoing exchange thus switches on to a line of the direction indicated in the instruction for a transit exchange and then dials the direction digits, also indicated in the instruction, for the wanted exchange, or if another transit exchange has to be passed the direction digits for this latter. This is repeated until the final exchange is reached, and then the wanted subscriber's number is dialled. It has been demonstrated that the switching time is considerably reduced by transit switching on this method, owing partly to the fast operating of the selectors and partly to the short waiting time for new dialling tone between the different direction numbers or between direction number and the final subscriber number. When transit switching is done over

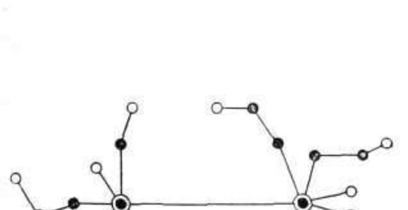


Fig. 3 X 3723

Arrangements of the lines in a modern trunk system

- big transit exchanges
- small transit exchange
- final exchange

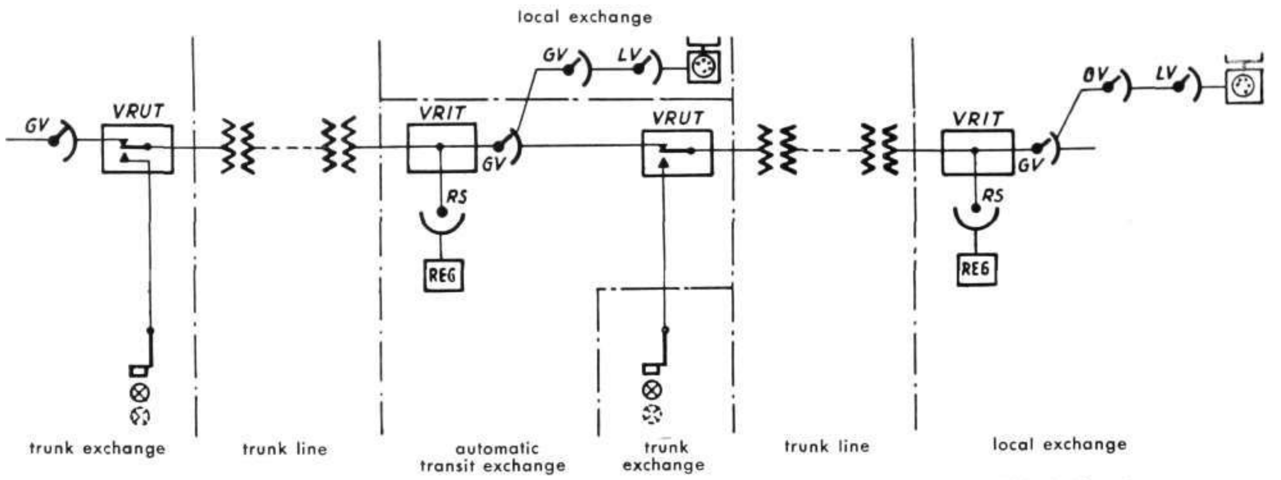


Fig. 4 X 7114

Diagram for automatic transit traffic

GV group selector
LV final selector
REG register
RS register finder
VRIT incoming transit repeater
VRUT outgoing transit repeater

several exchanges at once, it may sometimes be difficult for the operator to determine from which exchange she hears dialling tone at a given moment and thus which number she has to dial next. In districts where there is much transit switching of the connections, simple talking machines should be mounted to announce the name of the exchange instead of sending out dialling tone when the equipment is ready to receive the impulses. These machines are now so simple that the provision of them, at least in the bigger transit exchanges, does not entail any appreciable increase in the cost of the whole equipment. No extra devices for the connection of the talking machines to the repeaters are required, beyond those needed for the connection of the dialling tone. A more general use of such devices may no doubt be expected in the future.

Some of the trunk exchanges in each district of any size are equipped with cord-circuit repeaters which are switched in to the transit connections if necessary. The amplification is then adjusted by means of manual or automatic operation. At exchanges with automatic transit traffic the switching on and the operation of the cord-circuit repeaters is also effected automatically, Fig. 5. This is done without the intervention of the operator, and the switching on of the repeater is done only in case the incoming and outgoing lines need amplification on being switched together. Adjustment of the repeater to the most suitable gain is also done automatically by special indications from the relay equipments of the respective lines. The switching on of the repeater ought to be done as soon as the outgoing line is determined. Moreover, this switching on and the adjustment ought to be done quickly enough for the dialling tone coming from the following exchange, and indicating that the switching can continue, to pass through the repeater. Otherwise the operator might, if the lines are long, have some difficulty in hearing the tone. The progress of the switching of the connection must not, however, be dependent on the switching on of the repeater. A momentary shortage of repeaters may occur, but on such occasions it must be possible to continue with connections needing amplification, and as soon as a repeater is disengaged it can be switched on to the connection irrespective of what stage has been reached.

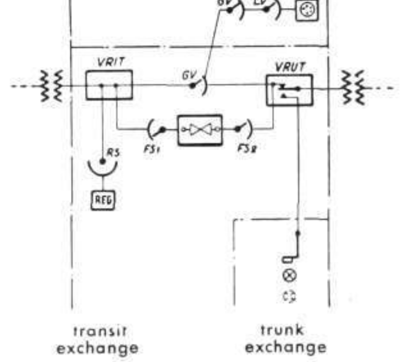


Fig. 5 X 3724

Connection of cord-circuit repeater for automatic transit traffic

FS repeater finder
GV group selector
LV final selector
REG register
RS register finder
VRIT incoming transit repeater
VRUT outgoing transit repeater

Signalling System

The only signals sent via trunk lines served entirely manually are ringing signals of independent duration and sequence. With automatic lines, however, the signals via the lines ought to be regulated to a certain system, due to the operator at the outgoing exchange also taking on the function of the operator at the incoming exchange. The signals from the equipment at the local exchange, which indicate the conditions on the called subscriber line, have to be transferred to the operator at the outgoing exchange to the greatest extent possible. These systematic signals have in fact to be transformed into local indications at the outgoing exchange, to show the operator in a clear and simple way the stage in which the connection is. These local signals vary, however, according to the type of trunk positions connected, but usually sufficient signals can be transferred from the distant exchange to keep the same principle of signalling as for the purely local switching. The local indications at a trunk exchange usually consist of lamp signals. For economic reasons, however, all the indications coming from the local exchange cannot be transferred. A too complicated signalling system requires too intricate and expensive repeaters at the trunk lines. Signals transferred in the other direction due to the operator manipulating the dial or the ringing key have to be reversed to impulses, ringing or release signals suitable for the automatic system in use at the local exchange. For economic and practical reasons the signalling thus ought to be made as simple as possible, but without making operation too difficult, see Fig. 6. In the table are given normal values for the duration of the signals, and a fairly large deviation from same may be tolerated. The operator receives a lamp signal as shown in the list at the following stages of the switching:

a. the signal lamp of the cord is lit when the switching devices are set to position. The final selector at the distant exchange is then switched on to the line to be called. This is the case also when the connection is intended for a subscriber with more than one line (PBX subscriber). This signal is independent of whether the subscriber is disengaged or busy and is only meant to inform the operator that the switching has reached a stage requiring the condition of the called line to be ascertained. If the subscriber is engaged by another trunk call the operatar hears busy tone. Should the subscriber be locally engaged the trunk connection automatically comes in on the local conversation. The operator can thus hear that the subscriber is busy and she can offer the trunk call and, after a notification, release the existing local connection by pushing the ringing key. If the subscriber is disengaged the operator has only to send out the ringing signal. This is, however, not permitted until the signal lamp of the cord has lit up, indicating that the switches are set to position, and the operator has made sure that no local conversation is going on. The signal for completed switching is comparatively long — 100 ms — so that the lighting up of the cord lamp will not be prevented by an impulse train, sent out in error by the operator when the subscriber number is called, being switched on to the line at the exact moment of the signal for completed switching. The last-mentioned signal will in such case operate the relay equipment at the outgoing exchange in the interval between the first and second impulses of the said impulse train;

b. the signal lamp of the cord goes out when the subscriber answers. The answering signal is not made to take into consideration eventual signals in the opposite direction, because, after each signal sent out from the outgoing exchange when the subscriber has answered, a control signal is given automatically and this corresponds to the answering signal from the subscriber;

outgoing exchange	line	incoming exchange
operator inserts the plug	50 ms →	repeater is engaged and a disengaged register is found
operator dials the number of the subscriber	← dialling tone 45 55 45 55 ms →	switches are directed to the wanted line
supervision lamp is lit and repeater is switched over for ringing	← 100 ms	
operator presses the ringing key	45 55 45 55 ms →	if subscriber is locally engaged, the call going on is released; if subscriber is disengaged ringing signal is transmitted
supervisory lamp goes out	← 80 ms	subscriber answers
	conversation	
supervisory lamp is lit	← 45 95 45 95 ms	subscriber replaces handset
operator takes down the cord	450 ms →	automatic equipment is released

Fig. 6
Diagram showing the progress of signalling for automatic trunk traffic

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c. the signal lamp is lit again when the subscriber replaces the receiver. The impulse train keeping the cleairng signal lamp lit works with shorter intervals than the impulse train in the opposite direction by means of which the ringing and releasing is effected. When again calling a subscriber who has just finished a call, the impulse train from the outgoing exchange has to cut off the impulse train from the incoming exchange, and for that reason the interval between the impulses of the latter impulse train has been made about as long as the impulse and the interval together of the former train.

Signalling on this system has proved quite satisfactory in traffic.

Impulse Receivers

The most important parts of an AC repeater are usually the transmitting and receiving equipments. The transmitting equipment for signalling with 50 c/s AC is very simple. Apart from the arrangements on the speech wires for preventing disturbances going over to the local part, it merely consists of locally operated relays, the adaptation of which to existing demands will present no difficulties. The impulse receiver, on the other hand, must meet the demand for high quality, and for that reason it has been the subject of extensive investigation. As a result, two main types as regards impulse relay have been designed. One is a type with two cores having a phase angle between the fields in the cores, and the other is a DC relay with metal rectifiers in bridge connection.

In the Ericsson repeaters generally a receiving relay of normal construction connected with metal rectifiers is used, Fig. 7. On particularly long lines, however, a polarized relay may be used in order to avoid too high a transmitting tension. The receiving relay *R2* with the rectifier bridge *L* is permanently connected across the line and is always ready for receiving the signals when no transmitting is going on from the repeater itself. Thus signals can be received between two impulses of the same impulse train, which is of great importance in cases where the signalling current is switched on from both ends of the line, and the certainty of a signal in one direction always reaching the other end depends on this being long enough to work against the disturbing signal. The receiving relay thus has to be ready for receiving as soon as the transmitting current from its own repeater is cut off. Receiving relays connected to rectifiers have a tendency to become somewhat slow-acting when falling off. In order to reduce this retardation to the required extent, an additional resistance is inserted in the circuit of the receiving relay, as soon as the secondary correcting relay *R4* has operated. The resistance is calculated

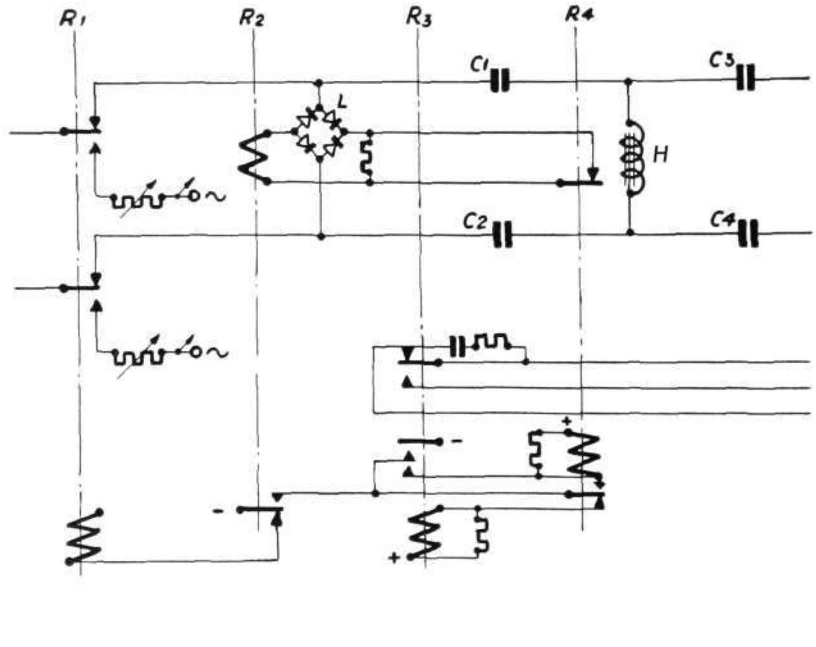


Fig. 7 X 5371

Diagram of impulse repeaters with correcting relays

C_1–C_4 filter condensers
H filter choke coil
L rectifier bridge
R_1 transmitting relay
R_2 receiving relay
R_3, R_4 correcting relays

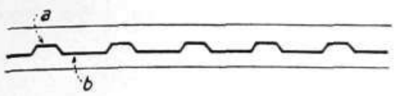


Fig. 8 X 3725

Impulsing curve

registered from the last correcting relay in transit traffic through 3 × 55 km of line according to Fig. 9

a make b break

to keep the receiving relay in operation as long as the AC is switched on to the line. When the AC is cut off, the relay falls quickly enough for an increase of the impulse speed to 12 imp/s with the same reliability. By introducing the correcting relays *R3* and *R4* there is less need for the impulse receiving relay to follow the impulses accurately and the AC impulse may also be made a little shorter.

The duration of the AC impulse is usually 45 ms, and by means of the correcting relays this figure is kept invariable also on transit traffic via a number of lines. These correcting relays have for this reason been designed specially for avoiding the short interval otherwise usual between the first and the second impulses, see Fig. 8. It is thus very important with transit traffic that the correcting relays deliver impulses of which the make corresponds as near as possible to the impulses of the dial at the outgoing repeater.

The receiving relay *R2* is separated from the DC circuits of the local side by means of a filter consisting of the condensers *C1*—*C4* and the choke coil *H*. This filter is a low-pass filter with a cut-off frequency of 200 c/s, and has several functions. It has to separate the receiving relay from the local side and the subscriber line connected to same, in such a way that the receiving relay will operate under the same conditions independent of the qualities of the lines and equipment connected, but it also has to make the receiving relay independent of variations in frequency, this being rather important especially when the transmitting current is taken from the emergency battery of the exchange, which at small exchanges is made very simple for the sake of economy, so that there will be no guarantee against variations in frequency. Moreover, the filter has to prevent acoustic disturbances during transmission and to separate the receiving relay from the DC circuits of the local side; additional condensers are thus not needed at the automatic exchange side by incoming repeaters or at the trunk exchange side by outgoing repeaters.

The additional attenuation represented by this filter has proved to be very low. With a transit switching according to Fig. 9 via three lines with distances together making 82 km of cable 0.9 mm with a loading of 177 mH, increased attenuation as shown in the attenuation curve of Fig. 10 was the result.

Different Types of Repeaters

The AC repeaters according to Fig. 1 because of their temporary character are as simple as possible in construction, but without simplification being achieved at the expense of the signalling from the local exchange to such an extent that operation is made too difficult. The outgoing one-way repeater *VRU* has in the trunk position a jack for calling. Such a jack may be provided at all trunk positions or only at a small number of them, according to the system on which the exchange operates for the service of the trunk lines. In the former case all operators have access to the lines directly in the multiple, but in the latter case only those operators can use it whose special duty is to handle traffic in this direction. In cases where the switching cords are arranged in such a way that the signals from the repeater *VRU* cannot conveniently be transferred to the normal signal lamps of the cords, a special signal lamp for each repeater is fitted. This lamp is then placed close to the calling jack. When the line with the repeater *VRU* is accessible from more than one trunk position each repeater must also be provided with a busy lamp which remains lit as long as the line is busy. At a suitable place, usually where there is supervisory staff, a key is fitted by means of which the line may be blocked for further traffic as soon as any conversation that may have been

Fig. 9 X 5372

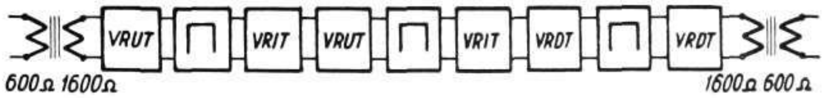
Diagram for transit traffic on three trunk lines

of together 82 km of 0,9 mm cables with a loading of 177 mH

VRDT two-way transit repeater

VRIT incoming transit repeater

VRUT outgoing transit repeater



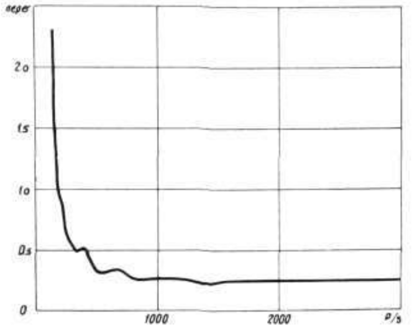


Fig. 10 X 3726

Additional attenuation curve

for repeaters in transit traffic according to Fig. 9

going on is finished. In addition two jacks are fitted at this same place. One of these is used for testing and measuring of the line on occasions when the branches ought not to be disconnected, for instance, the measuring of the signal tension. The other jack is used when faults occur in the repeater, so that this can be disconnected from the line and a spare set connected. This switching over is done by means of an ordinary two-wire cord with a plug at each end. The repeater, Fig. 11, consists of a relay set with 6 to 9 relays. The number of relays, of course, depends upon how complete the signalling has to be.

The one-way incoming repeater *VRI*, Fig. 1, is connected to an existing cord circuit for switching of calls from its own trunk exchange. This cord circuit has access to a register. This register also has been equipped with blocking key and jacks for testing and switching over in conformity with the repeater *VRU*.

The repeaters *VRD*, Fig. 2, are arranged for two-way traffic. In this case the repeaters have to be permanently connected to the trunk lines, and they are for that reason directly connected to group selectors and equipped with register finders; they thus include also the cord circuit equipment for the called subscriber. On the line side the repeaters are equipped in the same way as the repeaters *VRU* and *VRI*, and the relay equipment practically consists of these two repeaters together, except that the receiving equipment of the repeater *VRU* is excluded. When disengaged the repeater *VRD* is always switched on for incoming traffic, and the switching over for outgoing traffic is effected immediately the plug is inserted at the trunk position. When the line becomes engaged at one of the trunk exchanges it is indicated by the busy lamp at the other, and once a repeater is engaged for incoming traffic it cannot be disturbed by the operator of the trunk exchange. The register finder consists of a rapid step-by-step driven selector.

The repeaters, Fig. 4, are designed also for transit traffic. The one-way outgoing equipment *VRUT* is in the main similar to the repeater *VRU*, except that the repeater *VRUT* is also connected to the multiple of the group selectors for the incoming repeaters at the same exchange. The last mentioned repeater can also be called via this exchange, which is done for transit connections. When the line is engaged by calls in this way, a busy lamp at the trunk position indicates it. The incoming repeater *VRIT* has to operate for ordinary incoming traffic to subscribers of the exchange and also for transit traffic when a disengaged line is wanted in the direction in question. With transit traffic the repeater has to be switched over for a repeating of impulses and signals to the outgoing repeater of the wanted line, in the same way as if those impulses and signals were transmitted by the operator of the trunk exchange. This switching over is determined by the number dialled and is operated from the register. Repeaters *VRIT* and *VRUT* at the transit exchange then repeat all the signals in both directions. On release the repeater

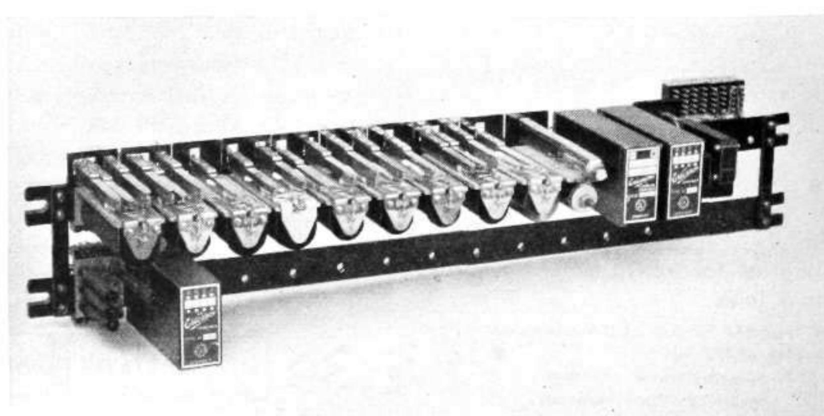


Fig. 11 X 5373

AC repeater

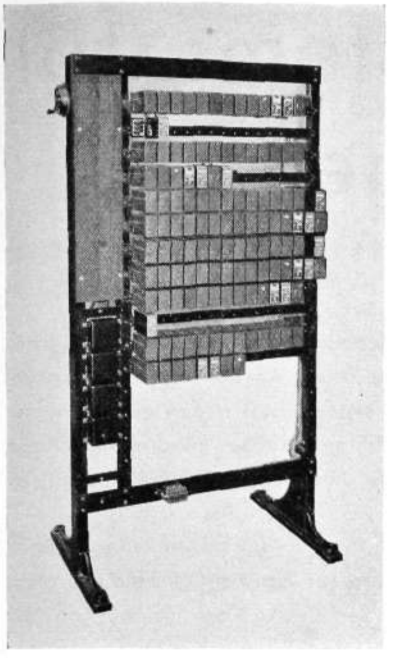


Fig. 12 X 3727

AC repeater bay for three trunk lines

from top downwards: outgoing transit repeater, incoming transit repeater, two two-way transit repeater, outgoing transit repeater and incoming transit repeater; left, register finders

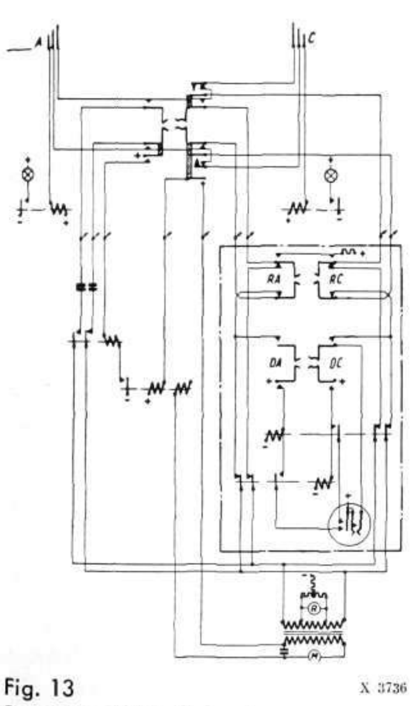


Fig. 13 X 3736

Diagram of trunk cord

with signalling equipment for automatic traffic

- A answering cord
- B calling cord
- DA dialling key for answering cord
- DC dialling key for ringing cord
- RA ringing key for answering cord
- RC ringing key for ringing cord

VRUT at this exchange is not operated until the repeater *VRIT* is disengaged and the group selector has started its restoring movement. The disengagement of the repeaters with a transit connection is thus effected gradually.

The repeaters shown in Fig. 5 are the same as the equipment according to Fig. 4, except that the repeaters *VRIT* and *VRUT* at the transit exchange are provided with arrangements for automatic switching on and adjustment of the telephone repeaters.

Impulse Equipment at the Trunk Positions

As the cord circuits of the trunk positions vary considerably at the different exchanges, it is of great importance that the impulse equipment to be connected to the cords is made very simple, so that it may be fitted to practically any cord circuit without extensive alteration to the existing equipment. Dials with make impulses are thus most suitable, partly for the reason that the DC circuits for holding or operating the impulse relays required when using dials with break impulses are generally difficult to introduce in existing manual equipment, and partly for the reason that the impulse can effected via one branch and the connection of the dial to this can be done very easily. Certainly the dial has to be used for both the cords of a cord circuit and difficulties may then occur on switching, but usually the speech wires of the two cords can be separated by means of the operating key thus making the switching much easier. By means of a two-way key fitted in the equipment of the position, the dial may be connected to one of the two cords and the disconnection of the speech wires of the other cord during the impulsing can be arranged by means of relays coming into operation at the winding of the dial, see Fig. 13. The connection of the dial ought not to be done in such a way that the speaking set is switched off when switching on the dial, because then difficulties may arise in transit traffic, if the operator has repeatedly to wait for new dialling tone before continuing with switching. The repeaters can certainly be arranged in such a way that a visible signal is given before resuming switching, but this would complicate the repeaters unnecessarily. For the transmitting of ringing signal a special key ought to be fitted in the equipment of the position. The usual signal equipment of the positions cannot be used for this purpose, as the repeaters have to be operated by means of DC from the trunk positions. This same key may be used also for releasing local calls in process.

Distribution Unit for AC

The AC required for signalling is usually taken from the mains, the voltage being transformed down to the required tension. Besides this transformer, each exchange must have for the feed an emergency generator to deliver signalling current if the mains supply fails. For small exchanges especially this generator has to be made as simple as possible, as of course the expense must not be allowed to represent any large part of the cost of the whole equipment. For this purpose Ericsson has designed a distribution unit consisting of a transformer connected to the mains and a pendulum alternator as emergency set. The primary side of the transformer has tappings for connection to the usual mains voltages, and from the secondary side various signalling tensions may be obtained. If the mains supply fails, the feed unit is switched over automatically, the transformer being switched off and the pendulum alternator being switched on to supply current. As soon as the mains supply is again available, the unit is changed back automatically.

New Telephone Systems for Small Rural Exchanges

O. SIEWERT & L. MJÖBERG, TELEFONAKTIEBOLAGET L.M. ERICSSON, STOCKHOLM

A large number of rural telephone exchanges consists of small manual magneto exchanges with only 10 or even fewer subscribers. At such exchanges manual service involves high operating expenses, especially if a day and night service has to be maintained. Automatic traffic on the other hand requires large capital investments, which are difficult to amortize at the low intensity of traffic usually existing in rural districts.

In this article a few new systems are described, by the introduction of which at a low first cost the telephone service can be improved and the operating expenses considerably reduced.

As rural telephone density is low, it would mean very high line costs to bring the subscribers from different villages together to a common exchange, many rural exchanges having only 10 subscribers or even not so many. In 1935 no fewer than 1 680 of all the 4 480 telephone exchanges in Sweden, or 37.5 %, were small exchanges having 1 to 9 subscribers. There were besides 1 062 public telephones, *i. e.*, telephone instruments installed at some central spot in the village, *e. g.*, a shop or a post office, from where telephone calls could be made against payment. In France the total number of exchanges in 1935 was 26 850, of which 17 486 or 62.5 % were small exchanges with 1 to 10 subscribers. The number of public telephones was 3 229.

These figures show that considerable numbers of the telephone exchanges in the countries referred to consist of small exchanges; the conditions are probably the same in many other countries. For that reason it is of a rather great importance, that the small rural places are provided with economical equipment well adapted to its purpose. Up to now LB switchboards have usually been used for small exchanges, an operator being thus required for switching the calls. It is quite evident that the cost per subscriber for maintaining an operator becomes very great in such circumstances. In order to reduce these costs as much as possible, it has been necessary to restrict the service time at these exchanges to a few hours a day and to combine the service of the telephone exchange with other work such as running a post and telegraph office, service at a railway, running a shop or the like. In such case, however, the telephone loses one of its most important qualities; *i. e.*, the facility for rapid establishment at any time of the day of a wanted connection, and the service is not of a very high quality, even at the times when the exchange is in service.

A very efficient way to reduce operating expenses and to improve the telephone service is, of course, to convert the telephone networks in the country to the automatic system; and this has been put in practice with success at many places. Such complete automatization however requires a large capital outlay, as the cost is not limited to the furnishing of the expensive exchange equipment and telephone sets but is also affected by the network, this usually having to be rebuilt, as an automatic system requires lines of a higher quality than do LB systems. For this reason most telephone administrations have not considerad it advisable to make the small exchanges automatic, and for the present they have kept to the manual service, pending a less expensive scheme for the automatization.

Telefonaktiebolaget L. M. Ericsson has been investigating this problem for several years and has now succeeded in designing some especially inexpensive telephone systems. By the introduction of these the disadvantages of the manual service disappear and it is economically possible to provide telephone service during the 24 hours of the day even at the smallest country places. The principal saving arises through there being no need for manual service at the very small exchanges, and the operators can be concentrated at some bigger place for several exchanges in common. An increase in the number of operators at this place is usually not necessary, and the operators even there are not worked to full capacity. In all these systems the normal magneto instruments are retained without any alteration, and the equipment has been designed in such a way that the old network may be kept the same, and in some cases may even be simplified. By the introduction of these systems the expenses are thus limited to the supply and mounting cost of the equipment.

The frequency of calls of the subscribers connected to the small rural exchanges is as a rule low, very often lower than one call per subscriber a day. At an exchange where 10 subscribers are connected, the total number of calls per day thus amounts to about 10, which is less than for a normal subscriber lins of an urban telephone exchange. For this reason it has been considered justifiable to make certain of the new systems in such a way that there is facility for only one call at a time through them from or to the subscribers connected, and this allows of considerable simplification of the equipment. Furthermore a type of exchange has been designed for two simultaneous calls — one internal and one external call. In all the cases the maximum number of subscribers to be connected has been limited to 10. All these systems meet the condition that subscribers not concerned cannot listen into the call, and also that internal calls may be exchanged.

A further reduction in the cost of the systems allowing of one call at a time only has been attained by cutting out the expensive power plants or ringing equipment from the exchanges and the telephone instrument. All operating and ringing current is taken from the manual exchanges to which the punction lines are connected. In the telephone system which has facility for two calls simultaneously the ringing equipment also has been excluded; for this exchange, however, a 24 V dry-cell battery is required, which supplies the current during the time of switching. There is on the other hand no current needed during

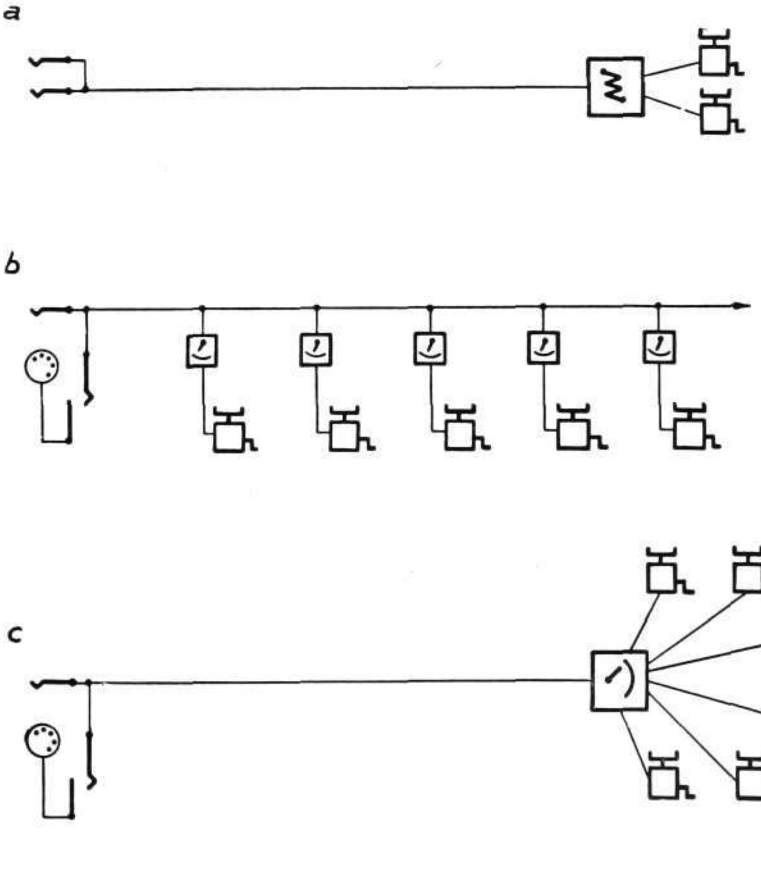


Fig. 1 X 5363
Circuit diagram of LB party system
a two-party system
b selective-calling party system
c party-exchange system

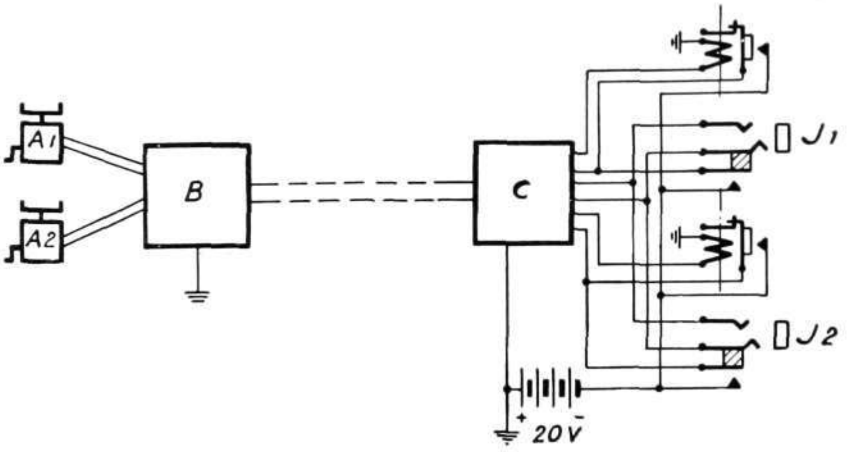


Fig. 2 X 5364
Diagram of two-party system

A_1, A_2	subscriber telephone instruments
B	junction equipment
C	line equipment
J_1, J_2	calling and answering devices

the time the conversation is going on. Because of this the current consumption is so small that the exchange can operate off a dry-cell battery. It has been the more desirable to cut out the power plant, as it very often happens that there is no electric power supply at the places where these systems are to be used.

The exchanges are made as complete units in dust-proof metal case, so that the mounting and maintainance expenses are reduced to a minimum; the whole equipment is so small, that it can readily be mounted on the wall of an ordinary living room.

It is characteristic of all of these systems that the subscribers via their equipment are connected to one and the same line, which then further connects them with a manual main exchange, see Fig. 1. According to the number of subscribers connected and the manner in which they are linked with the common line, three systems may be distinguished, *viz.* two-party systems, selective-calling party systems and party exchange systems; there are two types of the last-named system *viz.*, with facility for one or for two calls at a time.

Two-Party System

The two-party system provides the facility for connection of two subscribers to a common line, and then each subscriber is in the position of an independent subscriber in every respect, except that only one call can be established via the line at a time.

The diagram of the system is shown in Fig. 2. The two subscribers *A1* and *A2* are connected by means of two-wire lines to a common junction equipment *B*, from where a common junction line, also two-wire, goes out to the manual main exchange, where it is connected to the line equipment *C*. Equipment *C* is connected to calling and answering devices *J1* and *J2*, individual for each line at the switchboard. In this way the subscribers have individual calling numbers and individual metering of the calls can be done, if the exchange is equipped for it. The junction equipment *B* and also the line equipment *C* are fitted in small metal covers and consist chiefly of two relays and two condensers, see Fig. 3. At the manual exchange a 20 V battery with the positive connected to earth is also required to supply current for both of the relay equipments. The battery may consist of dry cells. At the junction point equipment no battery is needed.

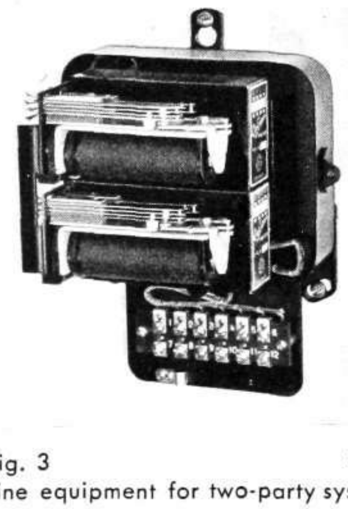


Fig. 3 X 3720
Line equipment for two-party system

When a call comes from one of the telephone instruments, the ringing current operates the indicator at the manual exchange corresponding to the calling instrument, this being done via one of the line branches and earth. When the indicator has dropped, the other instrument is switched off. The calling subscriber is now connected via two wires to the switchboard, and the other subscriber connected to the common line has no possibility of listening in to the call or of disturbing this by a ringing signal. The operator answers the call in the normal way and establishes the connection.

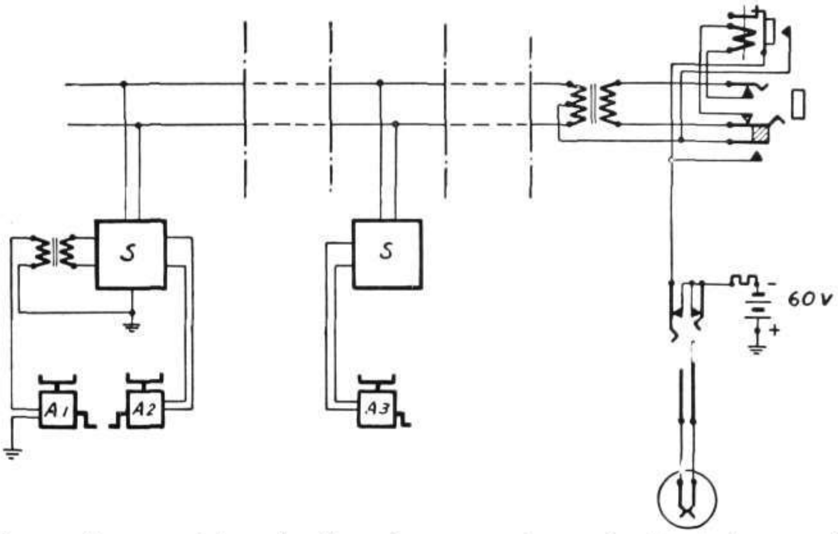


Fig. 4 X 5365

Diagram of selective-calling party system

A_1, A_2, A_3 subscriber telephone instruments
S selector unit

For a call to any of the subscribers the operator inserts the plug in the normal way into the corresponding jack, and then the connection to the other subscriber is switched off at the junction equipment. The ringing signal transmitted after this passes both of the line branches.

The establishment of an internal connection between the two subscribers connected to the same line is effected by the operator inserting the two plugs into the corresponding jacks, and then both of the relays at the junction equipment operate, and the subscribers are connected together. While sending out the ringing signal the answering plug ought to be taken out, so that the calling subscriber is prevented from hearing the ringing signal, and so that this telephone instrument may not shunt the instrument of the called subscriber. When the ringing signal has been sent out the plug is inserted again. For all calls, clearing signal is received in the normal way, and then the operator releases the connection by taking out the plugs.

A two-party line of this type is especially suitable to replace the arrangement often existing in rural districts where two subscribers are connected parallel to the same line, and the call is done by means of code signalling. For new subscribers the Ericsson two-party system may very often save the cost of a new line altogether.

Selective-Calling Party System

Selective-calling party system allows of the connection of a maximum of 10 subscribers to different points of a common line, each subscriber having an individual calling number, while the calls to and from the subscribers do not disturb the other subscribers connected to the line.

The diagram of the system is shown in Fig. 4. The normal magneto telephone instruments of the subscriber are connected to a selector unit *S*, which then via a two-wire line is connected to any point of the common two-wire junction line. The junction line terminates at the manual exchange in a line transformer and the normal calling and answering devices. There is required a common dial for several selective-calling party lines, with the arrangement for switching it on to the line, and also a 60 V dry-cell battery.

Fig. 5 X 3721

Selector unit for selective-calling party system

at the top, selector; below, calling relays for two subscribers

The selector unit *S*, Fig. 5, contains an Ericsson selector of the same type as used for railway selective-calling systems. The same selector instrument may be called by two different numbers, and because of this the selector unit is designed in such a way that two subscribers may be connected to it if wanted. The selector unit thus contains two calling relays one for each subscriber. Further the unit contains a couple of rectifiers and a choke coil. In Fig. 4 the subscriber *A1* is connected to the selector unit *S* by means of a single-wire line only. Such lines can also be used, if only one line transformer with a branch to earth is linked into the subscriber line.

When a subscriber makes a call, his telephone instrument is switched on via the selector unit to the common line, and the indicator of this line drops at the manual exchange. As a result of this a tension to earth is switched on to the line, so that current is transmitted to all the selectors connected to the line, and all the telephone instrument except the calling one are short-circuited, thus preventing all further switching on to the common line. If another subscriber should try to make a call, he will realise that the line is busy because the hand generator operates heavily. If the incoming call to the manual exchange is for a subscriber not connected to the party line, it is switched in the usual manner, but if the caller wants a connection with a subscriber on the same line, the operator switches on the dial to the impulsing jack of the line. The current to the selectors is then conducted through the dial, so that when the operator dials the wanter number just as many interruptions in the current are made as correspond to the wanted number, and by this all the selectors step forward. The selector which is set to the position of the number of the called subscriber then makes a contact for the current to the calling relay of this, and that relay operates. The telephone instrument is then switched on, and the operator takes down the dialling cord and sends out ringing signal. At the request of the operator the caller then ought to press down his microtelephone hook, so that he does not get the ringing signal in his ear.

When the operator has to switch a call to a subscriber connected to a selective-calling party line, she inserts the plug of the ringing cord into the corresponding jack and switches on the dial to the impulsing jack of the line and then dials the wanted number. After this she takes down the dialling cord and sends out ringing signal in the normal way, and not until then is the wanted subscriber called. When the conversation is finished, the subscribers give the clearing ringing signal in the usual way, and the clearing indicator at the switchboard is operated. The operator takes down the cords. Then the current to the line is cut off, and the selectors are immediately restored to the normal position by means of a restoring spring.

A party line of this type is especially suitable for use where several subscribers live along the same traffic route. The system can then with advantage replace a small manual exchange or a line with codesignalling.

Party-Exchange System

The Ericsson party-exchange system gives the facility for the connection of a maximum of 10 subscribers to the same point of a common line, each subscriber having an individual calling number, while calls to and from the subscribers do not disturb other subscribers connected to the party exchange.

Two types of exchanges have been designed with facility for one and two calls at a time respectively. For the first type the line to the manual exchange is used for internal calls as well, but for the second type both an internal and a junction line call can be exchanged at the same time. Furthermore the

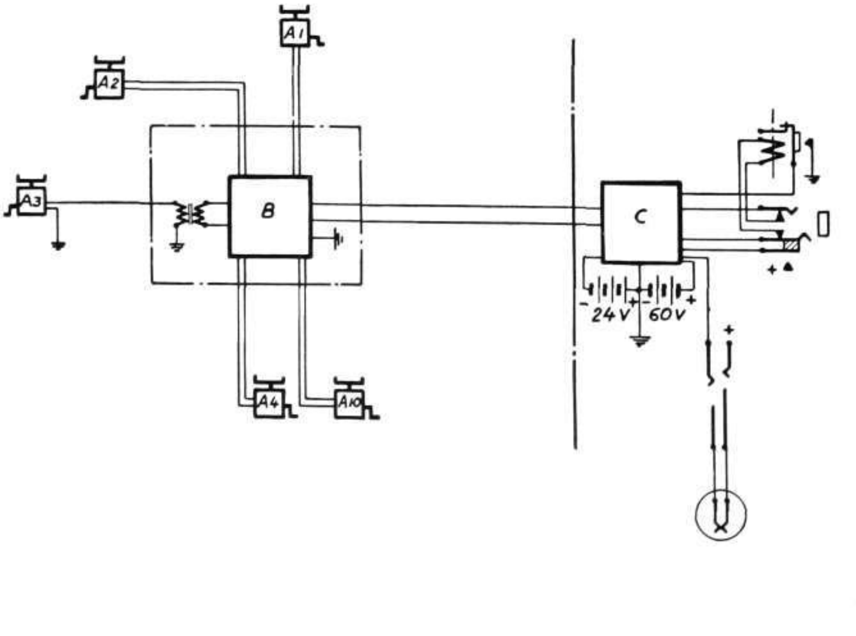


Fig. 6 X 5366

Diagram of party exchange with facility for one call at a time

A_1—A_{10} subscriber telephone instruments

B party exchange

C line equipment

latter type has an arrangement for keeping the waiting calls in a file, by means of which the utilization of the junction line is increased considerably.

10-line party exchange with facility for one call at a time

The diagram of the system is shown in Fig. 6. All the subscribers are connected via single-wire or two-wire lines to the common party exchange *B*, which is connected by means of a two-wire line to the line equipment *C* located at the manual main exchange. The party exchange, Fig. 7, contains ten calling relays with mechanical locking arrangement, a relay selector and a number of operating relays, of which one is used for the restoring of the calling relays when a call is finished. The line equipment, Fig. 8, contains a set of relays for the operation of the party exchange and is connected to normal calling and answering devices at the manual exchange. Further two batteries are required at the manual exchange, one for 24 V and the other for 60 V. As the current consumption is very small, both batteries may consist of dry cells. The party exchange does not consume any current during the conversation, and it does not require a battery.

When a subscriber makes a call, if the common line is disengaged he is switched via the party exchange to the main exchange, where the indicator drops. As a result of this the party exchange is indicated busy, which means that all the other subscriber lines are short circuited, and further calls are prevented. If the call is for a subscriber connected with an individual line to the exchange, the switching is done in the usual manner. If the caller on the other hand wants a connection with another subscriber connected to the same party exchange, the operator switches the dial by means of an additional cord on to the impulsing jack of the line and dials the wanted number. After doing this the operator takes down the dialling cord again and sends out ringing signal via the answering cord. During the time of the ringing signal the caller ought to press his hook at the request of the operator. Then the subscribers are connected together. When the call is finished and the clearing signal is given, the operator takes down the cord, whereupon the selector is restored and the party exchange indicated disengaged.

This type of exchange is suitable for places where the subscribers live comparatively close to one another but at a long distance from the main exchange. The equipment operates reliably at a very high line resistance, up to about 2 000 ohms, and a shunt between the branches and earth of 2 500 ohms. The subscriber lines do not need to be any better than for manual service.

10-line exchange with facility for two simultaneous calls

At places where many internal telephone calls are exchanged it is preferable to use an exchange where the line to the main exchange is not engaged during the whole internal call but only during the switching time, see Fig. 9. In the same way as for the system with facility for only one call at a time

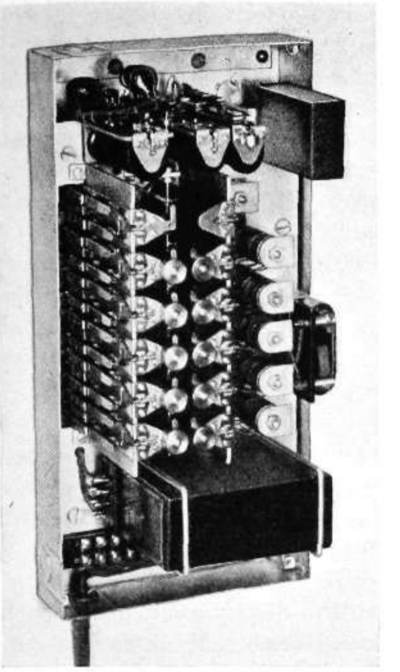


Fig. 7 X 3722
Party exchange with facility for one call at a time

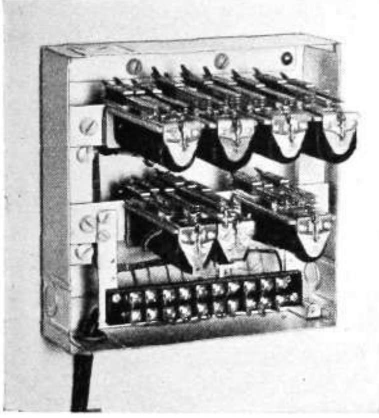


Fig. 8 X 3683
Line equipment for party exchange with facility for one call at a time

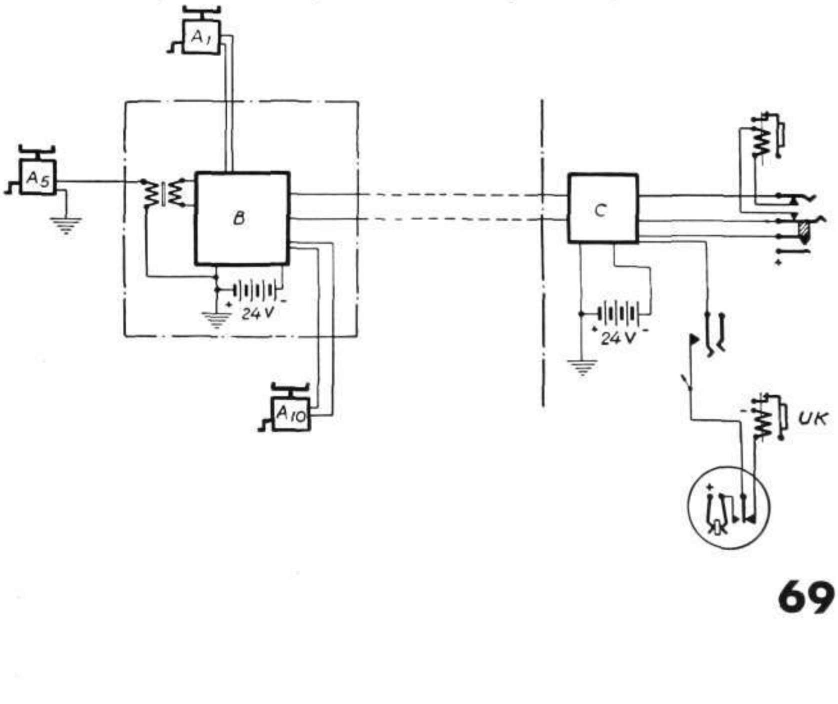


Fig. 9 X 5367
Diagram of exchange with facility for two simultaneous calls

A_1—A_{10}	subscriber telephone instruments
B	exchange
C	line equipment
UK	busy indicator

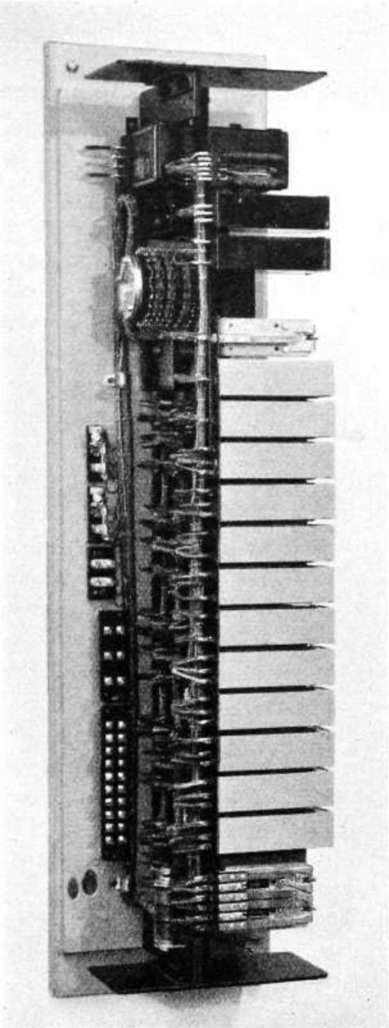


Fig. 10 X 3732
Exchange with facility for two simultaneous calls

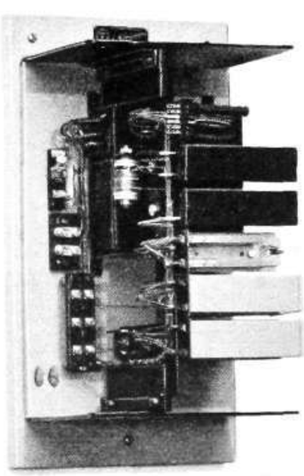


Fig. 11 X 3731
Line equipment for exchange with facility for two simultaneous calls

the subscribers are connected via single wire or two-wire lines to the common exchange *B*, which then is connected to the line equipment *C* at the manual exchange via a junction line; the subscribers are allotted the two-digit calling numbers *10—19*. The exchange, Fig. 10, contains a number of relays. The relays operating during a conversation are fitted with a locking arrangement mechanical or magnetic. Further the exchange contains several condensers and rectifiers, a line transformer and a 25-point selector, which last operates both as a line finder and a final selector. The line equipment, Fig. 11, contains a number of relays and condensers. For the equipment of the operator's position there is needed a dial and an indicator which indicates when the internal call facility is engaged. The batteries of the exchange as well as of the line equipment have a tension of 24 V and may consist of dry cells, as there is no current consumption during the conversation.

When a subscriber makes a call, the selector hunts for the calling subscriber line, and at the same time an impulse is transmitted via the junction line, so that the indicator at the manual exchange drops. When the operator has answered the call, the connection is established in the same way as for a subscriber with an individual line. If the caller on the other hand wants a conversation with another subscriber connected to the exchange, the operator switches on her dial and then dials the wanted number. If the internal call facility is engaged, the busy indicator *UK* drops, but if the call facility is not engaged, the operator has only to send out ringing signal. Then the answering cord may be taken down, whereupon the relays having no function during the conversation are released and the selector is restored to the normal position. The conversation connection is completed, and when the subscribers give the clearing signal the remaining relays are released automatically without the operator being troubled.

On calls from the main exchange to the common exchange the operator hears dialling tone. Then she switches on her dial and dials the wanted number, by which the selector is directed to the corresponding subscriber line. If the subscriber in question should be engaged, the indicator *UK* drops at the manual exchange. On the other hand if the subscriber be disengaged, the operator sends out ringing signal and the connection is completed. When the call is finished the subscribers give the clearing signal and the operator takes down the cords. Then the relays are restored at the line equipment and the exchange. The selector is restored to the normal position.

If the line to the main exchange should be busy when a subscriber makes a call, he gets the busy tone and replaces his handset. The caller is then placed »in a file», *i. e.*, his call is indicated at the exchange; and when the line becomes disengaged the selector hunts for the indicated subscriber, while at the same time a calling impulse is transmitted to the manual exchange.

In order to facilitate the establishing of calls via the junction line between the exchange and the main exchange when the exchange because of a fault has been put out of service, a relay operates and switches off the battery and the exchange and switches on a certain subscriber directly to the junction line.

In order to warn the staff at the main exchange in time when the battery at the exchange needs replacement, an automatic control of the tension has been introduced. On calls to the party exchange a dialling tone is transmitted if the battery tension is above 22.5 V. If the dialling tone fails to come, it means that the battery tension is below 22.5 V, or that there is a fault at the exchange. Still the party exchange is guaranteed to operate for a tension between 21 and 28 V.

Finally the operator can release internal calls at the party exchange in favour of more important incoming calls.

Manual Private Branch Exchanges

E. ENGQVIST, TELEFONAKTIEBOLAGET L.M. ERICSSON, STOCKHOLM

The main task of the operator at a private branch exchange is to switch the incoming calls from the public telephone system. At a manual private branch exchange (PBX) the operator also has to handle the internal and the outgoing traffic; at the automatic private branch exchange (PABX) on the other hand this traffic is switched automatically.

At exchanges of a size such that the internal traffic as well as the traffic from the public telephone system can be handled by one operator alone, a manual private branch exchange is often an advantage. To meet the interest which has appeared to exist in telephone exchanges of this type, Telefonaktiebolaget L.M. Ericsson has designed during the last years a number of manual private branch exchanges of quite a new type.

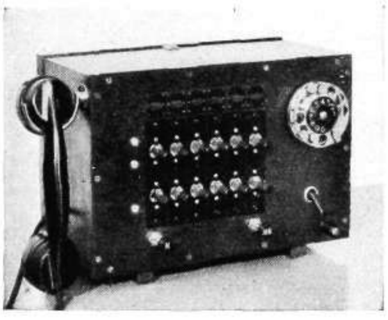
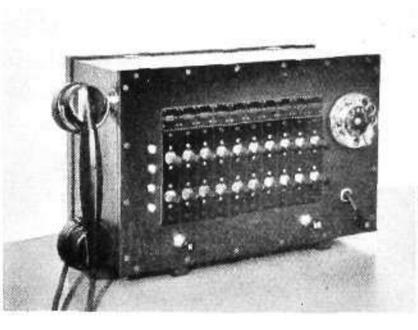


Fig. 1 X 3717
Private branch exchange, Type ADD 10
for 1+5 lines and 2 simultaneous calls

To begin with two main types of private branch exchanges may be distinguished, *viz.*, the cordless exchanges for plants with a maximum of about 10 lines and cord exchanges for plants with from 10 to 100 lines. Both of these types have, however, a great many features in common. The exchange lines thus may be connected to a manual central-battery exchange or an automatic exchange without any alterations in the equipment of the main exchange. By switching together the exchange line and the extension line, the extension comes into direct wire connection with the main exchange, so that the microphone feeding, the impulsing and all the signalling can be done without repetition at the private branch exchange. The instruments used for the extensions therefore have to be suitable for the microphone feeding system and the impulse ratio used at the main exchange. The calling devices of the exchange lines are arranged in such a way that they can obtain a signal from the main exchange also as soon as a call is finished, and without the connection necessarily having to be switched off at the private branch exchange. Night switching of an exchange line to any of the extension lines can be made by means of the normal switching devices. Two extension lines connected together receive microphone feed from the private branch exchange. Each private branch exchange requires for microphone feed and signalling a current supply having a tension of 24 V.

Cordless Exchanges

The cordless private branch exchanges, Type ADD 10, are made in two sizes, one smaller type, Fig. 1, for 1 exchange line and 5 extension lines and one bigger type, Fig. 2, for 2 exchange lines and 8 extension lines. They are



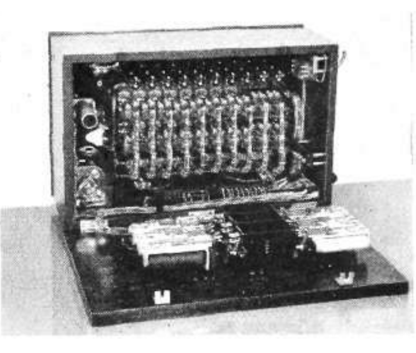


Fig. 2 X 5368
Private branch exchange, Type ADD 10
for 2+8 lines and 3 simultaneous calls

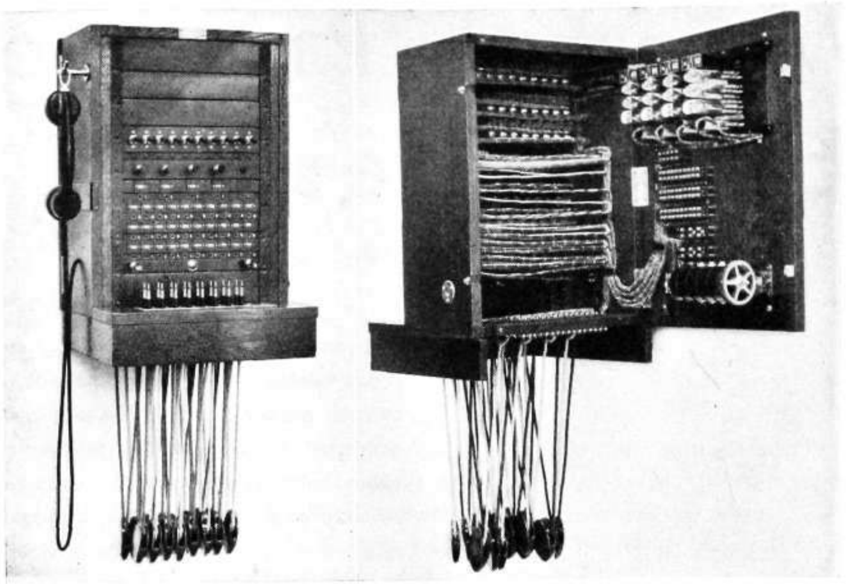


Fig. 3 X 5357
Private branch exchange, Type ADE 10
for 4+30 lines and 8 simultaneous calls, with visual indicators as calling devices

furthermore equipped in such a way that two or three simultanous calls respectively may be established. The exchanges are made either for fixed mounting on a wall or they may be placed on a table or the like. In the latter case a terminal block on the wall and a flexible cable are also required.

Visual indicators are used as calling devices for the exchange lines as well as for the extension lines, these being restored automatically when the call is answered. The switching of the calls is done by means of a lever key. The clearing signal is indicated by special lamps placed to the left of the lever keys and in the same line as the corresponding switching position. The signalling relays, the condensers etc. are placed in readily accessible positions at the rear of the exchange, see Fig. 2. Finally, each exchange has a complete switching common equipment including speaking set with induction coil, dial for impulsing on the exchange lines, hand generator for calling the extension lines and a bell for giving an acoustic calling signal when the exchange is left without supervision. A press-button key is fitted for switching off and on the bell; by means of another press-button key all current-consuming circuits are switched off when through connection of the exchange lines has to be done by night.

Private branch exchanges intended for connection to manual central-battery exchanges differ from exchanges intended for connection to automatic system only in the absence of the dial.

The smaller exchange has a net weight of about 10 kg; the height is 225 mm, the width 335 mm and the depth 178 mm. The bigger exchange has a weight of about 13.5 kg and the dimensions are 260×410×178 mm.

Cord Exchanges

Private branch exchanges with more than 10 lines are made as cord exchanges which contrary to the cordless exchanges are manufactured with a varying number of lines and cord circuits. Two sizes are made, which differ regarding the manner of mounting, *viz.*, a wall switch, Fig. 3, with a final capacity of 5 exchange lines, 30 extension lines and 8 cordcircuits, and a switchboard, Fig. 4, with a final capacity of 10 exchange lines, 100 extension lines and 14 cord circuits. The wall switch and the switchboard are identical as to the circuit diagram.

The exchange lines and the extension lines terminate in jacks, the calling devices consisting of visual indicators (combined with a relay set for the exchange lines). The cord circuits are made in such a way that the operator, by means of the answering cord, can answer a call from an exchange line as well as from an extension line, and the ringing cord may be used for calling an extension as well as the main exchange. Every cord circuit is equipped with a clearing lamp, two relays and a lever key for the connection of the cord circuit to the common equipment. This includes all devices required for conversation, ringing, impulsing and alarm transmission and has besides a couple of relays which automatically switch on the common equipment in such a way that microphone feeding and ringing may only be transmitted to an extension line, while impulsing is only possible on an exchange line.

Arrangements are made with the wall switch as well as with the switchboard to allow for any number of the extension lines to be barred by a simple reconnection from traffic facility to the main exchange. For this purpose each exchange line is fitted with a relay which acts to disconnect the call as soon as an extension line barred in such a way is switched on to the exchange line via a cord circuit.

With telephone plants including private branch exchanges the distance from the private branch exchange to the extension is usually very short and the line resistance negligible. If the resistance of the extension lines does not exceed 20—30 ohms, the visual indicators may be replaced by lamps directly connected into the line loop.

The wall switch with visual indicators, Type ADE 10, has with full equipment a net weight of 39 kg; the wall switch with lamps, Type ADE 11, has a net weight of 37 kg. The dimensions are: height 593 mm, width 390 mm and depth 377 mm.

The switchboard with visual indicators, Type ADF 11, has with full equipment a weight of about 107 kg, while the switchboard with lamps, Type ADF 13, has a weight of about 102 kg. The dimensions of the switchboard are: height 1 358 mm, width 740 mm and depth 700 mm.

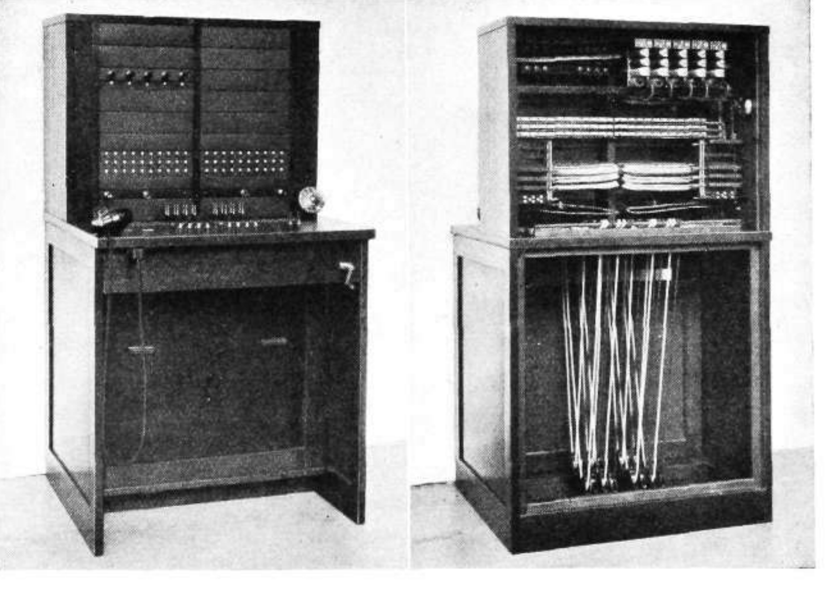


Fig. 4 X 5358
Private branch exchange, Type ADF 13
for 5+60 lines and 8 simultaneous calls, with lamps as calling devices

Telephone Coin Boxes

H. V. ALEXANDERSSON, TELEFONAKTIEBOLAGET L.M. ERICSSON, STOCKHOLM

In Ericsson Review No 1, 1935, a few types of coin boxes are described, including one of the prepayment type. This last has since been re-designed both electrically and mechanically, so that it can now be employed either for prepayment with automatic cashing in or for postpayment.
The new coin box is made as an addition to a normal telephone instrument, which may be of any type. The apparatus is made both in burglar-proof construction designed for public telephone cabins and also in simpler construction, suitable for use in places like the home, boarding-houses and cafés.

Coin boxes may be divided into three groups, *viz:* coin boxes for postpayment, coin boxes for prepayment with manual cashing in and coin box for prepayment with automatic cashing.

The first type is usually the simplest from the technical point of view. A typical example is the ordinary coin box designed for manual service with vibrating contact in the coin channel. The objections to such an apparatus are mainly that the caller may pay too soon and in that case lose the coin if the called subscriber does not answer, and the contrary condition that the payment takes place too late if it is made after the called subscriber has answered but has replaced the receiver, in which case also the amount is lost. This latter observation applies particularly in the case the call is to a subscriber connected to a PBX where the call is first answered by a trained telephonist who is busy. Apparatus of the postpayment type therefore are only used in telephone networks with manual operation. In automatic networks, apparatus of the prepayment type are generally used the coin being deposited in the box before the call. The cashing in for one type is manual, *e.g.*, by means of a press-button, while in the other type operation is automatic. Prepayment apparatus with manual cashing in suffer to a certain degree from the same weaknesses in principle as do the postpayment apparatus, though wrong operation is more easily avoided because of the depositing.

Prepayment apparatus with automatic cashing in are quite free from the weaknesses stated. Still many of the apparatus of this kind in the trade can be objected to on the ground of being complicated and liable to derangement. The apparatus of Ericsson design to be described here are, however, characterised by unusually simple and robust construction. The apparatus may be used for both outgoing and incoming calls. In the latter case, as also when calling special numbers, such as fire brigade and police, it can be used without a coin being inserted. One and the same apparatus may be used in any automatic or manual CB system. The only necessity imposed by the apparatus is that current reversal occurs on the line when the called instrument answers — or in a manual system when the operator rings. The apparatus may in certain conditions be employed for trunk calls at varying rates in automatic telephone networks with zone-duration metering. The apparatus works on a normal two-wire line without earth connection. The relays in the apparatus are so connected that attenuation due to the apparatus is quite insignificant. As the relays may be made with high resistance, large power is at disposal making the design reliable in operation.

Coin Box for Single Charge

Normally the Ericsson coin box is made as shown by Fig. 1. The equipment consists of two relays $R1$ and $R2$. Relay $R1$ is connected in series with a rectifier $Re1$ and relay $R2$ connected in parallel with a rectifier $Re2$. Each

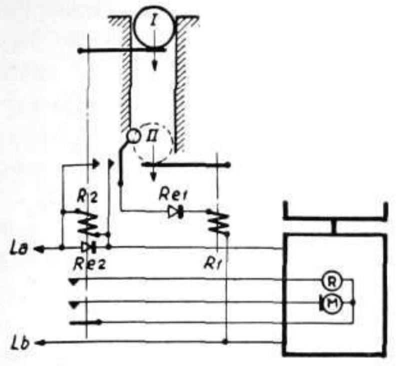


Fig 1
Diagram of coin box for prepayment

relay actuates a flap in the coin channel. Relay *R2* has in addition a contact which short-circuits the speaking device when the connection is to be blocked. In the coin channel is a contact actuated by the coin in its lowest position.

The method of working is as follows: on calling the current flows from *La* to *Lb*. Relay *R2* is then short-circuited by the rectifier *Re2*. The relay *R1* is not connected. Neither of the relays is acting therefore, and the telephone instrument may be used in the same way as an ordinary instrument. The coin may be placed in the slot, but it does no work and lies in such a position that it may be removed at any moment.

The exchange should be of such a nature that current reversal occurs on the coin-apparatus line when the called subscriber answers. When the current reversal takes place the rectifier's short-circuiting effect on relay *R2* ceases and this relay attracts and short-circuits the microphone and receiver of the telephone instrument. At the same time the flap in the upper part of the coin channel opens so that the coin may fall into the apparatus. The coin actuates at the bottom the contact in the coin channel, so that *R2* is short-circuited and falls, whereupon the short-circuit of the speaking set ceases and the conversation can take place. At the same time relay *R1* is also connected in parallel with the telephone instrument. The current direction is however such that rectifier *Re1* has higher resistance, so that the extra attenuation derived from it is exceedingly small. During the whole call the coin remains in the lower position. It is only when the current direction returns to what it was to begin with — from *La* to *Lb* — and when the handset is replaced that relay *R1* is actuated, whereupon the coin drops into the cash box and current to the relay is broken.

From this it will be seen that the coin-apparatus may be used in automatic systems with both single and double clearing signal, and likewise in systems with fixed or variable current reverse. Moreover it hinders a later caller from losing a coin placed in the slot before a new call has been connected.

Connected in this way the apparatus is a coin apparatus with *prepayment* and automatic cashing in. No extra paying operation needs to be made and the call is completely blocked if the charge is not paid. It is naturally possible also to connect the apparatus in such a way that it may serve as *postpayment* apparatus. For this it is only necessary to connect the short-circuiting contact on relay *R2* to the telephone instrument's microphone while the receiver is left free. In this case only outgoing speech is prevented and the calling subscriber can hear the called subscriber answer. To prevent abuse of the possibility of using the instrument for transmitting, relay *R2* is provided with two short-circuiting contacts, one of which short-circuits the microphone and the other connects the telephone receiver in parallel with a resistance so low that the instrument's capacity to act as transmitter is effectively reduced.

The apparatus may also be provided with a press button which blocks the action of the upper coin flap, see Fig. 2. This allows of the coin being first inserted in the coin slot without actually paying. The payment is made after answer is received by pressing on the button, when the coin falls and short-circuits relay *R2*. In this way the objection often made against postpayment coin apparatus, to the effect that payment is not made rapidly enough, loses most of its force. It takes less time to press a button than to insert a coin in the slot.

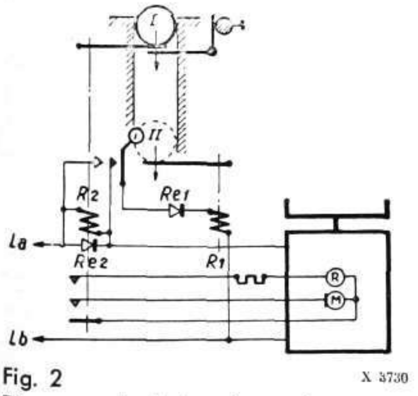


Fig. 2
Diagram of coin box for postpayment

Moreover the possibility of mistake by paying too soon is removed. It requires the button to be pressed and the relay *R2* to attract for the flap to leave the coin channel clear, so that the coin can fall down into the apparatus. Connected up in this fashion the apparatus is particularly suitable for use in manual CB exchanges. In these there is usually no current reversal on the caller's line when the called subscriber answers, but current reversal can be brought about on the line when the operator rings up the desired subscriber.

In such case there is usually metering of call, but it is possible to employ the same operation to actuate a relay which reverses the polarity of the line. By this the microphone is blocked but not the receiver. When the called subscriber answers, the button is pressed and the coin drops into the apparatus and actuates the coin contact so that relay *R2* is short-circuited and falls. As will be observed the operator's work for such a call is exactly the same as for a call from a normal instrument. A great advantage with such an arrangement is that on automatisation of the manual exchange the coin apparatus may be used unchanged, or possibly with modification of the connections so that the method of operation is changed to prepayment.

It may here be remarked that the coin box connected in this way may also be employed in automatic systems in which current reversal does not occur when the called subscriber answers. In that case the line wires on the line to which the coin box is connected can be changed between the line relay and the line selector or line finder. When idle the line will then have a certain polarity. Immediately a call is connected in over the selector or finder, the line polarity is changed so that the relay *R2* is attracted and short-circuits the microphone. Impulsing proceeds in the usual manner and when answer is received the button is pressed so that the coin falls and releases the speech blocking. After the call is ended the coin is cashed in by relay *R1* in the ordinary way.

Coin Box for Multiple Rate

The ever increasing automatisation of whole groups of networks with zone-duration metering to a certain extent makes the whole coin box problem more difficult to overcome. In groups of networks with zone rates it is possible in various ways to prevent coin boxes designed only for local traffic being employed for exchange of conversations subject to higher rates than local calls. For example, it may be done by the dial being made unuseable for connection of certain combinations of numbers. It is also possible to carry out the blocking at the automatic exchange. This, however, is not a real solution of the problem and manual working of the coin boxes, is often not practicable from an economic and technical point of view. It remains therefore to produce coin boxes which can be used for multiple rates. Technically these efforts have up to now met with considerable difficulties and the designs hitherto put forward have proved both expensive and complicated.

Payment for calls over different zones generally consists of a number of call meterings fixed for each zone distance, which are multiples of the basic rate per unit of time, ordinarily 3 min. Instead of such a rate the payment may be a fixed sum and the duration of call allowed for each payment made variable. This rate system thus means that, for the same charge, calls can be made over different zones but the time of conversation allowed is altered proportionately. It is simple enough to arrange the system so that a further unit may be had on fresh payment being made.

A coin box on these principles is designed in accordance with Fig. 3. As long as only local traffic is to be exchanged over this instrument, there is no need for any special device at the exchange. When automatic traffic with multiple rate is brought in, the circuit to the coin box must be provided with special relay equipment which is located at the automatic exchange. This relay equipment must be so designed that it reverses the current on the line after the duration of call fixed for the zone.

The operation is as follows: on answer from the called subscriber there is reversal of polarity on the line, relay *R2* attracts and the coin drops from the upper to the lower position. On this the relay is short-circuited and the coins remains in this position until the original current direction is restored. Now if double charge is to be paid the current is again reversed on the line 10 s before the expiry of the charge period (1.5 min) whereupon relay *R1* attracts and lets the coin pass into the coin box. This reversal of current is brought about by a relay in the line equipment. At the same time there is connected a characteristic signal, *e.g.*, a weak intermittent buzzer tone on the line, which intimates that a new coin must be inserted if the call is to continue. After 10 s the relay in the line equipment falls and the current direction is once more the same as when the called subscriber answered. Relay $R2$ attracts and blocks the telephone instrument. If a further coin has already been inserted in the slot, this drops and short-circuits in its turn $R2$, so that the call can proceed for another time unit as fixed by the line equipment. In this way the call can proceed for as many units as desired.

The advantages of a coin apparatus as above are obvious: the coin box is particularly simple and inexpensive and the accessory device at the exchange is comparatively simple; the coin apparatus works without any extra relay equipment so long as only single payment is required, and its method of working is exceedingly simple; changes in rates may be applied without modification of the apparatus and stipulations; finally, the public have no need to trouble whether day or night rate is applied.

Call Metering

As a rule call metering for coin box instruments is of small importance, as no charging out based on the figures of the call meter is to be done. In cases where the subscriber himself empties the cash box and is debited with calls in the same way as ordinary subscribers it is desirable that the calls metered should agree exactly with the amount in the cash box. With coin boxes of the kind permitting ringing to and answer by the subscriber without coins needing to be paid this principle cannot be arranged without special measures. Most coin boxes of postpayment and prepayment type in general cannot be made to give agreement between the calls metered and the coins paid in.

Even with the Ericsson coin apparatus the agreement between coins and meter is not absolute. Absolute correspondence may, however, be attained if desired in the following manner: when the called subscriber answers and line polarity is reversed on the coin box line, the resistance of the line loop suddenly rises by a figure equivalent to the difference between the resistances which the relay $R2$ and the parallel connected rectifier $Re2$ have for the two current directions. When the coin actuates the contact in the coin channel the relay $R2$ is completely short-circuited, whereupon a reduction of resistance occurs in the loop. This, however, does not occur if no coin is paid in. With this it is simple to arrange at the exchange a device actuated by the change in resistance to make a record of call in the normal call meter. In this way obviously full agreement is achieved between the number of coins in the cash box and the position of the call meter.

Construction

The coin boxes are mades as additions to normal telephone instruments. This means considerable simplification in the mechanical construction and consequently cheapening of manufacture. Moreover the design is not governed by local requirements as to the construction of the telephone instruments. This means also a simplification from a constructive point of view, as the coin box, exposed as it is to injury, need not include such delicate parts as dial and switch hook. The reason why this construction is generally not used is due to the fact that the coin box's function usually depends on the action of the switch hook and must therefore necessarily be combined with it. Ericsson has departed from this principle, having succeeded in working out a diagram which meets all requirements for simple operation without the aid of switch hook or press-button of any kind. Naturally this does not mean that such a combined construction cannot be furnished, if so desired.

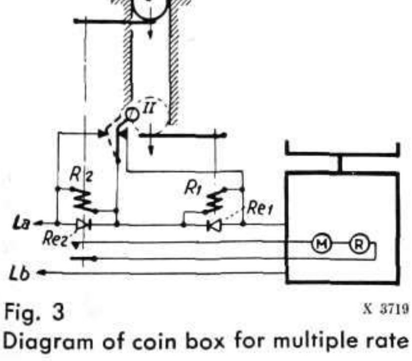


Fig. 3 X 3719
Diagram of coin box for multiple rate

Having the coin box distinct from the telephone instrument also makes it possible to connect a telephone instrument of wall or table type at will. The coin box, however, must always be mounted on the wall. This is important, *e.g.*, in cases where a coin box is to be installed in a residence, a boarding-house etc., when for various reasons it may be desirable to use table instrument. When the apparatus is to be used a coin is first inserted in the slot, after which the telephone instrument is used in the same way as any ordinary instrument. If for any reason the call is not obtained, the coin remains in the slot and may be recovered. In such cases it is also necessary that calls may be received free of payment. In general it may be said that coin boxes for this and similar purposes should differ as little as possible in operation from normal telephone instruments.

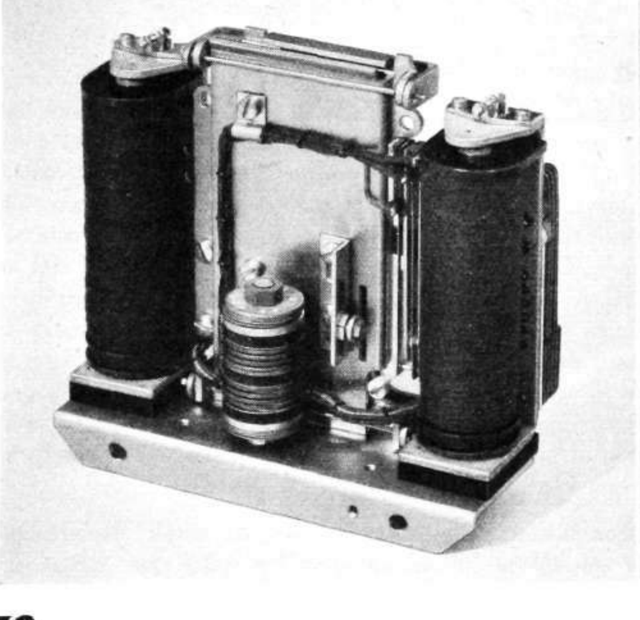
A characteristic feature of the Ericsson coin box is that all vital parts are built into one *inset*, which can be erected, connected and tested quite complete, independent of other parts. The inset, the appearance of which is seen in Fig. 4, has moreover the advantage that it may be adjusted for various sizes of coins in a simple manner. This has been rendered possible through the coin channel being made *straight*, which is usually not possible, but follows of itself in this case for reasons given below. The inset is mounted on a frame which carries the relays, the rectifiers and the other parts.

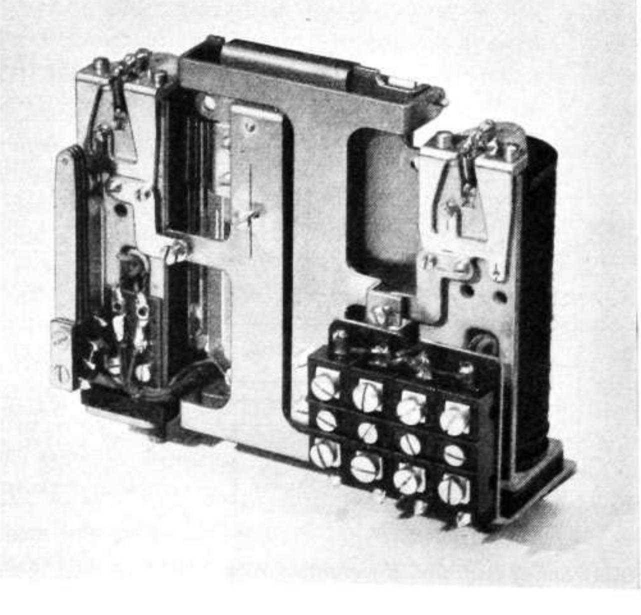
Each relay actuates a coin flap, one flap in the upper and the other in the lower part of the coin channel. The coin flaps are somewhat different in design. The upper consists of a wide flap covering the whole opening to the channel while the lower flap is so designed that the coin is prevented from falling out sideways. The lower part of the channel is quite open so that coins too small shall pass without actuating the contacts. The coin in its lower position lies held between the coin contact and the lower coin flap.

When this lower coin flap is moved from its position the coin channel opens at the side and the coin contact spring pushes the coin to the side, so that it falls into the cash box. This prevents a coin being for some reason held fast in the coin channel and not falling by its own weight. At the same time there is in this way achieved a design which permits of high contact pressure even with small coins. The whole kinetic energy of the coin can thus be applied to the contacts, so that even with small coins the contact pressure is sufficient. There is a coin block in the coin channel which prevents a coin that has fallen sufficiently low to actuate the contact being pulled back through the slot, *e.g.*, if attached to a thread.

Fig. 4 X 7113
Coin-box inset
between the two relays, coin channel and rectifier

The coin flaps are actuated by the relays *R1* and *R2*. The upper flap is actuated by relay *R2*, the lower by relay *R1*. The upper flap is actuated indirectly; when relay *R2* attracts, the flap follows under action of a spring





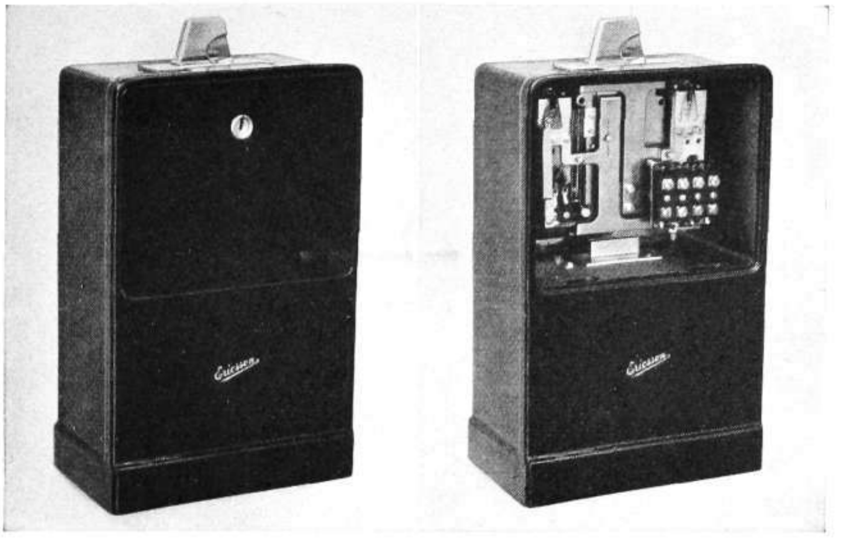


Fig. 5
Coin box
burglar-proof construction

X 5375

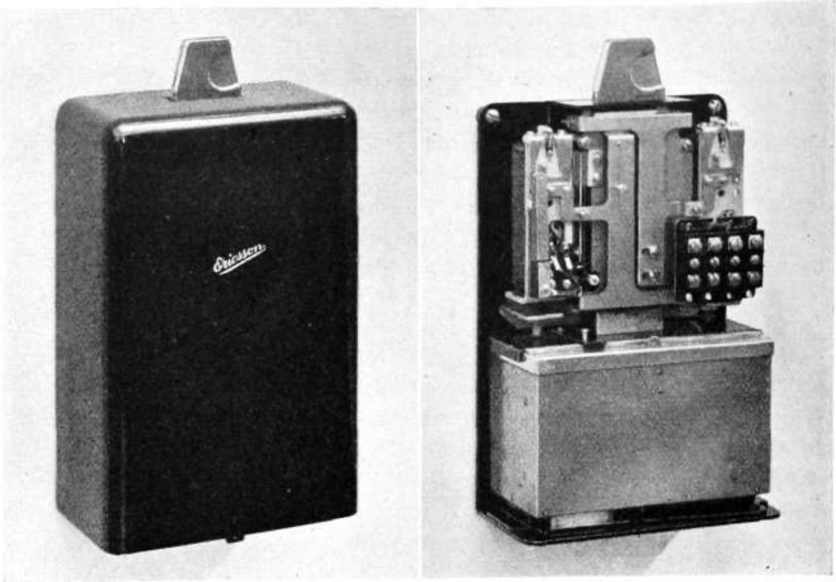
which works when the relay falls. This has the effect that it is not possible from outside to prevent the relay *R2* attracting and short-circuiting the speech device when answer comes, by hindering the movement of the flap, *e.g.* by pressing with the finger on a coin resting in the coin slot. If that could be done, it would be possible to obtain a call without requiring to pay. Another effect is that if the flap is forced to the side so that the coin channel is open at the top the relay is bound to actuate the short-circuiting contact for the speaking set. That is, before the telephone instrument can be used the coin slot must be covered by the flap. This means that it is not possible to obtain a call, *e.g.*, by actuating the coin contact with a metal wire as to do this the coin channel must be open at the top and consequently the telephone instrument be put out of operation.

As may be seen from the preceding, the mechanism is particularly robust and comprises no delicate parts difficult of adjustment, as is the case usually with coin boxes of this kind.

In certain cases it is required that the coin box shall be able to distinguish between magnetic coins and non-magnetic. For this purpose Ericsson has made a design of inset which allows of distinguishing the coins with the aid of a permanent magnet. The inset is provided with double coin channels, one behind the other. When the upper flap opens and the coin falls into the apparatus, magnetic coins are attracted by the permanent magnet so that they do not fall vertically as do the non-magnetic. The two kinds of coins are thus directed to different coin channels. The design is such that either the magnetic or the non-magnetic coin may be made to actuate the contact in the coin channel. Both cases may, of course, arise. The magnet used is made of cobalt steel and provided with adjustable yoke of soft iron with the aid of which the magnetic field in the coin channel may be set to the strength desired.

The inset may be mounted in various ways to suit different requirements. Normally, robust construction is required suitable for mounting in telephone cabins and the like where safety against burglary is important. For this purpose the construction shown in Fig. 5 is suitable.

The *case* is made of annealed cast iron and provided with two doors each fitted with lock. The apparatus is thus made in two compartments, each locking independently. The inset is mounted in the upper compartment and the cash box in the lower. The locks to the two compartments are not quite the same. The mechanism compartment has a simple lock while the lower compartment is fitted with a strong cylinder lock. The coin slot is in the top of the case above the mechanism. This slot is practically the only feature in the whole apparatus which requires modification for different sizes of coins.



X 5376

Fig. 6
Coin box
normal construction

The simplicity of the payment principle and the robust construction of the mechanical design, however, allows a coin box of this kind to be used also for residences, boarding-houses, cafés etc., in which case a more simple construction may be utilised, see Fig. 6. This case may not be considered as burglarproof, though provided with lock, which is not necessary either since there is a person responsible for the apparatus in this instance. The simplification of the construction applies only to the case, the inset and the method of operation remaining the same.

Such an apparatus can have a great range of use, not only where the money paid is collected by the telephone administration but also in those cases where the subscriber himself takes the money paid in for calls. This applies obviously to most apparatus installed in cafés, boarding-houses, shops etc.

In cases where the person for whom the apparatus is installed is to take the money it is advisable that he does not have access to the mechanism, as otherwise this might be involuntarily subjected to damage. At the same time it is also desirable that a fitter shall not be able to get at coins put in, without the responsible person's permission. The design shown in Fig. 6 is, however, equipped with only one lock which serves both purposes, the lock being combined with lead-sealing of the case. Unlocking has two effects, it opens a door in the bottom of the apparatus letting the coins fall out and it loosens the case so that it may be lifted off, but only by breaking the lead seal. The owner of the apparatus can thus empty the coin box. The fitter, however, having no key must apply to the owner to have access to the mechanism.

The *cash-box* is made of tinplate and is provided with a stop which blocks the coin opening when the box is removed. The box can therefore not be returned to its place until after it has been handed in at the proper department to be emptied and the stop once more set in position. This ensures that the collector has no possibility of taking coins from the box until the lead seal is broken. From the point of view of checking this is desirable as it makes dishonesty on the part of the collector very much more difficult.

In cases where the owner himself collects the coins such a stop device is not necessary on the cash box. For this purpose the cash box is provided with a funnel-like arrangement which gathers the coins over the door in the bottom of the apparatus, so that they fall out easily when the door is opened.

Cathode-Ray Oscillograph with All-Round Application

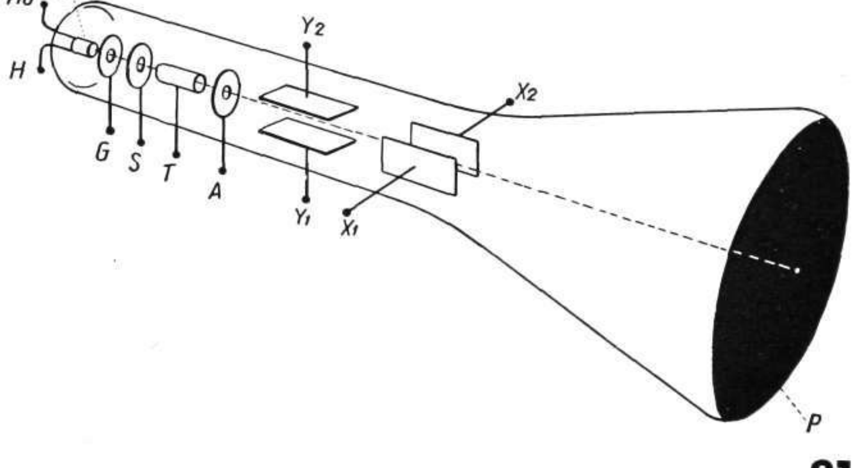
I. SVEDBERG, SVENSKA RADIOAKTIEBOLAGET, STOCKHOLM

In recent years the development of electrotechnics has among other things brought the cathode-ray tube to a high degree of perfection and the cathode-ray oscillograph itself has become an indispensable instrument examination of rapid electrical processes. An apparatus of this kind incorporating many valuable devices making it an instrument of particularly universal use is manufactured by Svenska Radioaktiebolaget.

Principle of the Cathode-Ray Oscillograph

In a glass vessel with a high degree of evacuation there is a cathode K heated by a filament $Ho—H$. In front of the cathode there is a row of electrodes with central holes and two pairs of plates $X_1—X_2$ and $Y_1—Y_2$, arranged perpendicularly to each other. The electrodes are connected so as to give S, T and A a positive voltage with respect to K. Electrons charged with negative electricity are thrown out from the cathode. They are attracted by the electrodes and given such a velocity that they pass through the above-mentioned holes and are shot as a ray between the plates. The ray impinges on a screen P, mounted inside the glass at the wider end of the vessel and consisting of a fluorescent material, *i.e.*, a matter which emits visible light when struck by electrons. The point of the screen impinged upon by the electron-ray is thus visible as a distinct luminous spot.

As the electron-ray consists of negatively charged particles the luminous spot will obviously move to another point of the screen if a voltage difference is applied between the plates of any of the two pairs. If, *e.g.*, the plate X_2 is made positive it will attract the electron ray which is deviated horizontally towards X_2. The luminous spot thus moves along the X-axis of a supposed diagram on the screen. In the same way voltage differences between Y_1 and Y_2 move the spot vertically, *i.e.*, along the Y-axis of the diagram.
The deviation of the luminous spot is proportional to the voltage difference at the pairs of plates. Thus, when moving, the spot draws a curve which directly gives the relation between the voltages at $X_1—X_2$ and $Y_1—Y_2$. The movement is free from inertia. At each moment, however, there is only one separate spot to be seen and in order to obtain a continuous curve it is necessary to photograph the screen or to repeat the process with such a speed that the different



X 5374

Fig. 1
Sketch of cathode-ray tube

A, G, S, T	electronic optics
H, Ho	filament
K	cathode
F	screen
X_1, x_2	pair of plates for the X-axis
Y_1, Y_2	pair of plates for the Y-axis

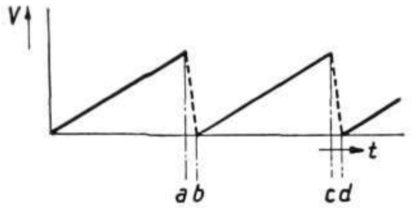


Fig. 2 X 3737
Tension curve of the time axis

positions of the moving spot are seen by the eye when the spot again and again runs through the same figure. Generally it is interesting to know how a certain electrical magnitude varies with time. The tension studied is applied to the plates Y_1—Y_2, and to the plates X_1—X_2 a tension which varies in saw-tooth shape with time. During the period this voltage increases from O to V, *e.g.*, the time *b—c*, Fig. 2, the spot moves across the screen with constant velocity, *e.g.*, from left to right, which gives a rectilinear time axis. During the period *c—d*, which is very short in comparison with *b—c*, the ray moves back to the left side and again begins its progress. If the voltage at Y_1—Y_2 is periodically repeated and the time tension has the same frequency, the spot at every period will take exactly the same path across the screen and thus a fixed picture of the process studied, *i.e.*, a diagram of the voltage at Y_1—Y_2 as a function of the time will be obtained. The voltage of the time axis is then *synchronized* with the process studied.

Using cathode-ray tubes with double electrode systems it will be possible to get pictures of two different processes at the same time.

Design

The fundamental idea when designing the cathode-ray oscillograph, Type OT 137, of Svenska Radioaktiebolaget, was to produce an instrument that would to the greatest extent possible combine versatility with simple connecting and handling. The oscillograph, Fig. 3, and the mains supply set are mounted each in a sheet-iron case giving protection against disturbance from magnetic fields. The cover is given an aluminium finish.

The oscillograph proper contains in addition to the cathode-ray tube all arrangements for the time axis, time marking, amplifier for the tension studied and an arrangement for the calibration of the voltage sensitivity. All dials frequently in use are to be found on the front, while the other dials, switches and terminals are placed on the right-hand side. The screen of the cathode-ray tube is covered by a lid as protection against disturbing light when opened.

The mains supply set designed for 50 c/s AC gives filament voltage and DC of different voltages for the oscillograph. The anode voltage can be chosen from 500, 1 000 and 2 000 V. Moreover, filament and anode voltages can be supplied to an extra amplifier. The anode voltages are taken in steps of 70 V from a gas-discharge potentiometer.

In the oscillograph there is a built-in amplifier which can be connected in series with the voltage studied. The amplification factor is about 110 and the

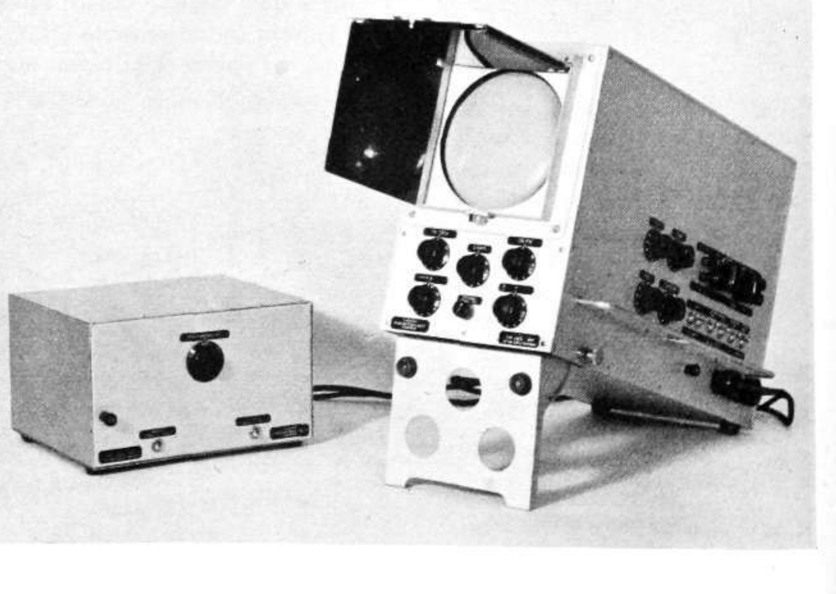
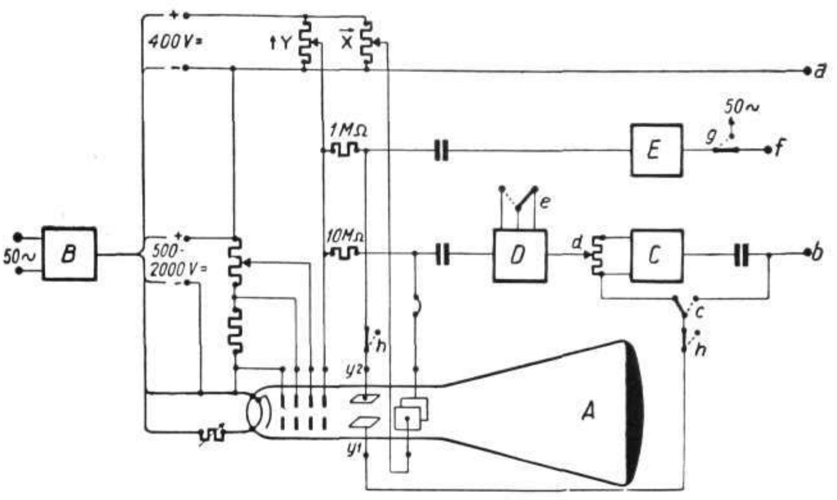


Fig. 3 X 5377
Cathode-ray oscillograph, Type OT 137
left, mains-supply set; right, oscillograph with built-in amplifier ready for use

Fig. 4 X 5378

Principle of cathode-ray oscillograph

A cathode-ray tube
B mains-supply set
C amplifier
D time axis
E time marking
a, b terminals for mains supply
c amplification switch
d control for synchronizing process
e switch for single or repeated process
f terminals for comparison tension
g switch for time marking
h switch for disconnection of the Y-plates



amplification is constant within the range 20—50 000 c/s. The voltage sensitivity is controlled in a simple manner by an arrangement incorporated in the rectifier, that gives 20 V or 0.2 V to the oscillograph according as the latter works with amplification or without.

The oscillograph is provided with cathode-ray tubes from Loewe, Berlin; either a high-vacuum tube with a single ray, Type KSH 20/1, which has sensitivity of about 0.7 mm/V at 1 000 V anode voltage and an effective screen diameter of 160 mm, or a high-vacuum tube with two rays, Type KSH 20/2, which contains two systems of electrodes with common arrangement for one of the coordinates, or time axis. For the other coordinate there is a common plate, placed between the two others. With this tube two different processes can be studied at the same time, giving very convenient methods for the comparison of frequencies, the study of phase angles etc.

Time Axis

The tension for the time axis varies in rectilinear manner with time. The frequency of the saw-tooth shaped time tension is variable within 3—100 000 c/s. The situation and the length of the picture of the curve may be chosen as desired. When using the two-ray tube the two pictures can be displaced in relation to one another.

Registration of Transients

The time axis is designed so as to give a picture also of a transient process. By pressing a switch the luminous spot passes only *once* across the screen with preadjusted constant velocity. This process can also be started by short-circuiting two terminals with an external contact to be combined with the mechanism of a camera. It is also of special interest that with a certain design it is possible to let *the tension studied start the voltage of the time axis* for a single period.

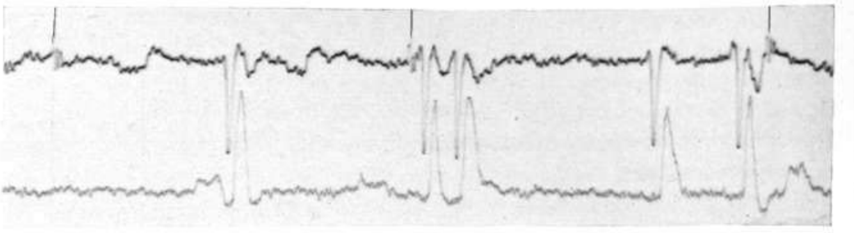
Time Marking

Marking of the scale on the time axis only requires a switch to be pushed, which gives thin cross-lines on the diagram, these having a width equivalent to 1 % of the distance between them. In case a distance of 1/50 s between the lines should be more suitable, the comparison voltage is taken from the mains. To obtain other calibration frequencies an external current source with suitable frequency is to be applied at the terminals provided for this purpose. Fig. 5 shows examples of oscillograms taken with an oscillograph having a two-ray tube. The frequency marking is plainly visible in one of the diagrams.

Fig. 5 X 5379

Oscillogram of two nerve impulses

registered simultaneousely with a double-ray tube; the short lines at the upper edge of the diagram give the time marking



Comparison of Frequencies

The time marking arrangement is also very useful for measuring frequencies by means of comparison with a standard frequency. The lower frequency is applied on the time marking plates and the higher one on the normal connecting terminals. Equidistant cross-lines on the curve, which are fixed or moving, will then be seen. From the number of periods on the curve between two cross-lines and from the velocity of the movement of the curve it is possible to determine the relation between the two frequencies. In certain cases this method is more simple than the ordinary method with figures of *Lissajou*, especially in case of fractional ratios between the frequencies or too great harmonics content. The latter method can, however, be employed as the two pairs of plates are available.

The arrangement of the time axis of the oscillograph can be used as a generator of frequencies with saw-tooth shaped curve, *e.g.*, when stroboscoping. For this purpose only one amplifier valve and a powerful gas-discharge lamp are required. The frequency is adjusted by means of the dials for the time axis and is easily synchronized.

Application

The fields in which the cathode-ray-oscillograph is of very great help are numerous. It may be used in every instance where one wants to study a varying voltage, the voltage being produced either by an electric power line or by the impulses of a sensory nerve. Mechanical pressures, movements and accelerations may be transformed into electrical tensions by using suitable means and may be studied with the oscillograph. Svenska Radioaktiebolaget manufacture also the additional devices necessary for measurements of this kind, *e.g.*, piezo-electric dynamometers, DC amplifiers etc.

Automatic Charging-Control Unit

E. FERNHOLM, TELEFONAKTIEBOLAGET L. M. ERICSSON, STOCKHOLM

In Ericsson Review No 1, 1933, an automatic charging-control unit for max. 6 A charging current is described. This unit has been much appreciated for supervision of battery charging at small local and private branch exchanges etc. There has, however, been expressed a desire that it should be possible to use the unit up to 10 A charging current, that it should operate so rapidly that it could be used to advantage with alkaline batteries, and further that both upper an upper and a lower tension limit could be directly set. Attempts were made to modify the existing unit but it was found more advantageous to change the design all over, which also made it possible to simplify the regulation of the apparatus and improve its reliability.

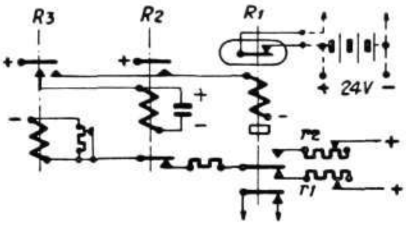


Fig. 1 X 3728
Diagram of automatic charging-control unit

R_1 charging relay
R_2 intermediate relay
R_3 test relay
r_1 rheostat for upper tension limit
r_2 rheostat for lower tension limit

Fig. 2 X 3733
Automatic charging-control unit, Type RH 52111

above, rheostats for regulation of tension limits; below, charging relay with mercury contact, intermediate relay and test relay

The new charging-control unit, Type RH 52111, Fig. 1, is like its predecessor based on charging of the battery until a certain adjustable upper tension limit is attained, whereupon the charging current is disconnected. When the battery tension falls to a lower tension limit, also adjustable, the current is again connected. The upper tension limit at which the charging current is disconnected is regulated by the rheostat *r1* and the lower at which the charging current is re-connected by the rheostat *r2*. For supervision of the two tension limits a common test relay *R3* is used. The charging current is led over a mercury contact on relay *R1* which has an extra contact group over which an alarm circuit may be connected.

When charging is going on the battery tension gradually rises to the figure shown by the setting of rheostat *r1*. Test relay *R3* is then attracted whereupon an intermediate relay *R2* and a charging relay *R1* receive current and attract. Relay *R1* breaks the charging current and relay *R2* the circuit to test relay *R3*, which falls. Relay *R2* in its turn receives current over a make contact on relay *R3* and is thus disconnected when that relay falls. Nevertheless, it remains connected a few seconds by discharge from condenser *C*. When relay *R2* falls, relay *R3* is again connected, whereupon the process is repeated once more. During the whole process the slow-acting charging relay *R1* remains attracted. Only when the battery tension sinks to the figure represented by the setting of rheostat *r2* can test relay *R3* no longer attract. Relays *R2* and *R1* fall, whereupon charging current is again connected. By the alternate connection and disconnection of relays *R2* and *R3* repeated testing of the battery is attained and the tension limits are thus accurately fixed.

The charging-control unit is normally made for control of 24 V batteries. The maximum charging current is 10 A. Both tension limits may be continuously adjusted between 20 and 30 V. The unit is mounted in a case of black-enamelled sheet iron, Fig. 2. The rheostats are set by knobs moving around a scale graduated from 20 to 30 V. The relays are normal telephone relays. The mercury contacts on the charging relay are mounted in a special group and so suspended that the connecting wires are subject to the least possible movement. The movement of the relay armature is transmitted by a lever to the mercury contact, thus ensuring adequate turning angle.

DC Fire-Alarm Bell

S.-Å. NILSSON, TELEFONAKTIEBOLAGET L.M. ERICSSON, STOCKHOLM

Telefonaktiebolaget L.M. Ericsson has placed on the market a new type of DC bell, chiefly designed for use as fire-alarm bell for small fire-alarm installations at hotels, boarding houses, etc.

It is often required that hotels and boarding houses install alarm installations with bells and press-buttons to give alarm in case of fire. Material hitherto available for these installations has, however, been comparatively expensive, making the outlay for such an installation far too heavy for smaller hotels and boarding houses. As there was thus a demand for a low-priced alarm bell, Ericsson has designed one which, despite its moderate cost, is both reliable and strong. This bell, Type KLD 20, Fig. 1, has now been placed on the market.

The bell is designed on a rather original principle, permitting a simple and cheap assembling of the parts. It consists of a base plate of cast-iron, carrying in its centre a pillar on which the gong, also of cast-iron, is screwed. At right angles to the fixing screw of the gong and against the pillar is mounted a perforated coil, inside which moves the clapper, its lower end being fitted with an insulating stud resting against a break spring. This spring, made of phosphorous bronze, has two silver contacts which lie against a lower spring while the clapper is resting against the upper spring. The upper spring has a special shape, see Fig. 1, to ensure breaking as late as possible.

When the coil is energized the clapper is drawn up and strikes the gong. The circuit is then broken in the spring group and the clapper falls, thus closing the circuit again. The process is repeated until the main current to the bell is cut off.

The bell is made for 6, 12 and 24 V. All the bells are provided with spark quenching resistance, wound outside the winding of the coil and connected in parallel with it.

The bell gives a loud ring at the rate of about 400 strokes/min. Its diameter is 163 mm and it weighs 2.3 kg.

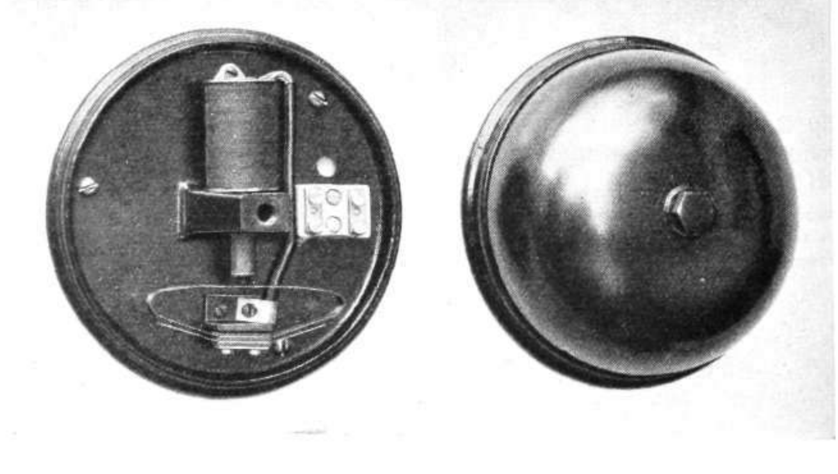


Fig. 1
DC bell, Type KLD 20

X 5336

Time Check

J. BJERKNES JOHANSEN, A/S ELEKTRISK BUREAU, OSLO

About two years ago, at the request of the Norwegian Telegraph Department and in co-operation with it A/S Elektrisk Bureau, Oslo, started the manufacture of a time check to be used when controlling the duration of calls at telephone exchanges. The time checks are fitted at the manual positions of the exchanges side by side with the ordinary operating keys.

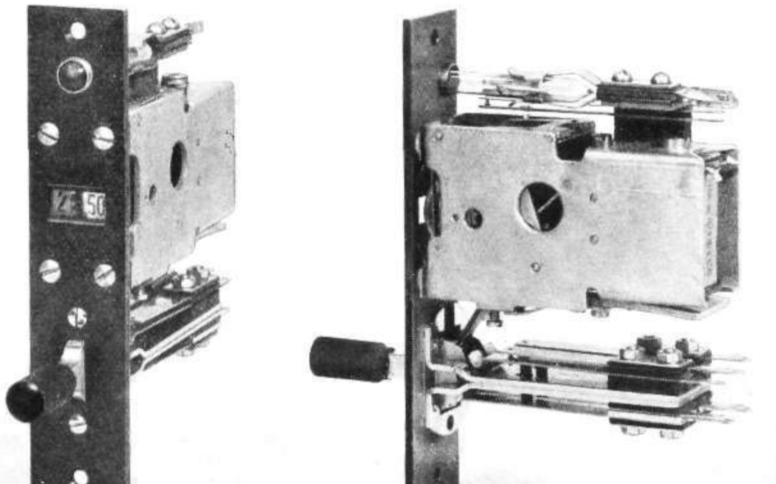
The time check, Fig. 1, consists of a metering mechanism, a key and a lamp fitted on a common plate. The metering mechanism is step-by-step driven by means of a DC impulse every tenth second. In order to ensure noiseless operation the driving magnet of the metering mechanism is fitted with a special armature. The metering mechanism is started, stopped and set back to zero by means of the key.

For replacement the time checker may be fitted with a four-pole plug for easy connection.

The time check registers every tenth second during 12 min. When this time has passed, the checker continues, starting zero again. The time is read off two drums with digits, which are to be seen through an opening in the plate. The drum for the seconds is white with black figures 0—10—20—30—40—50. The drum for the minutes is yellow with black figures 0—1—2—3 ......11.

The key is used for the operation of the time checker. It has three different positions, of which one is without locking. The time check is disconnected when the key is in the normal position. If the key lever is pressed in the direction towards the operator, the time check is switched on. When the key is pushed back again to normal position, the metering mechanism is stopped and the figures may be read off. Pushing the key lever in the direction from the operator sets the metering mechanism back to zero. This position is without locking, and the key thus comes back again to normal position. The time check is fitted with a red lamp, which is lit by a contact of the metering mechanism. The lamp lights up during the last 10 s of each period of 3 min.

The time checks for 24 V have DC resistance of 260 ohms. They are tested with and operate without fail at 18 V DC impulses with a duration of 200 ms. The time check has the following dimensions: width 25 mm, length 120 mm and depth 80 mm; the weight is 475 g.



X 5380

Fig. 1
Time check
from top downwards: lamp, metering mechanism and key

Ericsson Technics

Ericsson Technics No 1, 1937

C. Palm: Inhomogeneous Telephone Traffic in Full-Availability Groups

When telephone traffic problems are treated theoretically it is usually assumed that the traffic offered is homogeneous in the special sense that the durations of the different calls follow the same probability law. In the present paper an analysis is made of the conditions arising when the traffic is inhomogeneous in such a way that the total of the calls can be considered as containing any number of groups, the calls of each separate group having durations which follow the same probability law of pure exponential form. It is shown that the well known *Erlang* formulæ are obtained just as well if »lost calls» are assumed as if the assumption is made that every call originating when all lines are engaged is held until connection is obtained. Simultaneously a detailed investigation has been made as to the range within which the results are valid and in this connection the methods commonly used for deducing the *Erlang* formulæ are discussed. Finally investigation is made of the conditions which arise when the number of subscribers is considered to be limited, the results then obtained being rather interesting.

Ericsson Technics No 2, 1937

C. Palm: Étude des délais d'attente

When studying the congestion and the waiting times with circuit or selector groups in telephone systems with delay arrangements, it is generally assumed that all waiting subscribers wait until they obtain the communication desired. The probability that a call will have to wait is very slight, of course, with normally equipped systems but still the waiting times may sometimes become very long. It thus seems justifiable to assume that quite a considerable part of the calls made to wait may actually disappear without obtaining communication, on account of the subscribers growing tired of waiting. The conditions arising in this case are investigated in the present paper under the assumption that a principle similar to the distribution law found valid for the durations of local calls may also be applied to the reduction in the number of waiting subscribers brought about by subscribers getting tired of waiting. The investigation is limited to circuit groups with full availability for all calls, and it has further been assumed that the duration of the calls follows a simple exponential function.

The Ericsson Group

Associated Enterprises

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Deutschland Ericsson Verkaufsgesellschaft m. b. H.	*Berlin W62*, Kurfürstenstrasse 118
Eesti Tartu Telefonivabrik A/S	*Tartu*, Puiestee 9—11
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Technical Bases of the Automatic Operation of Rural Networks

H. BLOMBERG, TELEFONAKTIEBOLAGET L.M. ERICSSON, STOCKHOLM

Automatic operation of telephone exchanges is constantly increasing throughout the world. To begin with city exchanges were automatised, but now much consideration is being devoted to the automatisation of rural exchanges. The practical solution of the great technical and economic problems represented by rural automatic operation is therefore exercising the attention both of telephone makers and of telephone administrations in most countries. At the 5th congress of Scandinavian Electrical Engineers at Copenhagen in August 1937, one of the chief subjects for discussion was the automatisation of the telephone services in the Nordic lands, with contributions by representatives of the telephone administrations of the countries concerned. The opening paper consisted of the following exposition of the basic technical principles of the automatic operation of rural networks.

Life in rural districts has undergone considerable change in the last ten or twenty years. Electric power has been made more and more available and the isolation formerly a characteristic feature of rural districts has been broken as a result of the rapid development of broadcasting, motoring and bus traffic. These have served for good or ill to bring the rural populations into contact with the conditions and cultural life of the cities and larger communities in a manner which previously had been undreamt of. Progress has therefore been of unexampled rapidity. The ease of acqusition, the reliability, the high quality and comparative cheapness which characterise present-day broadcasting and bus services has had the result that the rural populations are justified in making corresponding demands for expansion in other means of communication. This is no less true in most countries in regard to the telephone, which in respect of number of stations has been far outdistanced by wireless. To expand the telephone service so that it is possible for the greatest number of people, both in town and in country, to communicate with one another by telephone is a problem quite as important as the development of, *e. g.*, power distribution, broadcasting and road communications.

The technical conditions for such expansion are available. As is known, the telephone has during the last decades undergone revolutionary changes, as regards trunk telephony through the introductions of repeaters and as regards local telephony through automatisation. While to begin with automatisation comprised city exchanges only, particularly in the large cities, where the greatest economic gain could be attained with automatic operation, it is now being extended more and more to comprise rural exchanges also. Here the economic advantages are not so obvious, but by means of automatisation it is possible to make even the rural telephone service into a modern and efficient means of communication and raise it to the level of the urban service, since it enables the fundamental principle to be realised of providing telephone facilities throughout the 24 hours of the day with great reliability and completely conserving the secrecy of speech. Thus it is that the great technical economic problem has arisen, briefly named rural automatic operation, on the practical solution of which both telephone manufacturers and the telephone administrations of most countries are engaged.

Extent of Automatic Operation

The term rural automatic operation covers first and foremost naturally such automatisation of the rural exchanges as provides for automatic establishment of connections between subscribers connected to the same exchange. This part of the matter offers no particular complication; it conforms to a great degree with the automatisation of a telephone exchange in a town, with the difference that in the country it is a question of smaller exchanges. With the simple and satisfactory technical construction and the low prices which nowadays characterise even small automatic exchanges in comparison with manual, with the constantly rising cost of wages for operators and the difficulty in obtaining suitable staff for the small exchanges of rural districts, there is no question that in building new telephone exchanges in the country these should be made as automatic ones. Rural automatisation, however, covers also the question of automatic operation of traffic *between* rural exchanges, and it is this phase of the problem which is incomparably the most weighty and at the same time the most difficult to survey. In this case the various geographic, demographic, economic, social and political conditions obtaining in different countries play the greatest part.

The question is, how far shall automatisation be carried out: shall it be restricted to the least possible, *i. e.*, the execution of the small rural exchanges on a semi-automatic system where the automatic connections within the exchange itself are not established by the subscribers themselves, but by operators located at certain main exchanges, who also handle the traffic between the rural exchanges and between these and the urban exchanges; or shall connections within the rural exchanges be allowed to be automatic while traffic between these exchanges is handled semi-automatically by operators; or shall even the last-named traffic be automatised and, in such case, shall it be to a small extent or such that it will gradually comprise the whole trunk traffic of the land? Installations executed in different lands display examples of all these kinds of rural automatic operation.

Seeing that automatisation of urban areas has shown the greatest advantages, economically and from the traffic point of view, in those large towns with several interworking local exchanges, it seems most reasonable to suppose that such would also be the case if automatic interconnection were arranged between a number of rural exchanges. Such a conclusion, however, cannot be drawn too hastily. The traffic conditions are indeed quite distinct in the two cases. In the urban areas it is a question of large exchanges with some thousands, even several tens of thousands subscribers. The exchanges are situated at comparatively short distances from each other and traffic between them is heavy, so that the junctions form large bundles with good efficiency of the individual lines. Rural exchanges on the other hand are small, from some ten subscribers upwards, and are located at great distances from each other. The junctions are therefore long and expensive and in view of the small traffic between the exchanges the bundles only contain a few lines, which on no-delay traffic give but low efficiency in comparison with that when traffic is handled by manual recording.

Full automatic operation, however, allows of quite a different arrangement of the junction layout network than does manual operation, enabling the junctions to be assembled in larger bundles. Moreover, greater decentralisation of the exchanges can be carried out, thus cheapening the subscriber lines. In this manner a more rational construction of the network is obtained, and this outweighs the lower efficiency of the individual junction with automatic direct connection than with manual recording. Now, the junction network constitutes incomparably the major part of the cost of a telephone plant, as a rule at least the half, and twice as much as exchange equipments. It must therefore be made clear to what extent the different manners of automatisation influence the planning of the junction network and its utilisation and how automatisation can be made possible without expensive extension of the junction network.

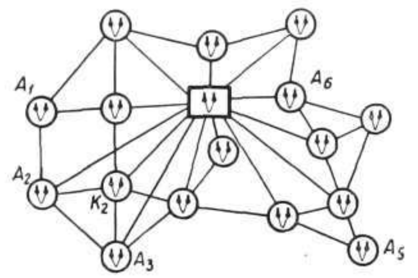

Fig. 1 X 3749
Area with manual local and area traffic

Rural Telephone Areas

Areas with Manual Local and Area Traffic

Fig. 1 shows an area with a number of manual telephone exchanges, *i. e.*, a manual area, consisting of rural exchanges grouped around a larger main exchange. Direct junctions exist both between the sub-exchanges and the main exchange and between adjacent sub-exchanges. Connections between the exchanges are handled by recording and most of the connections require the intervention of only two operators, those of the outgoing and the incoming exchanges, see Fig. 4. The junction network, therefore, is *diamond-shaped*, made up of a large number of bundles with few lines in each, especially between sub-exchanges. Often one line alone suffices between two adjacent sub-exchanges.

Areas with Automatic or Semi-Automatic Local Traffic and Manual Area Traffic

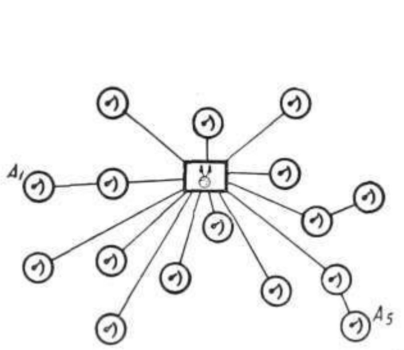

Fig. 2 X 3750
Area with automatic local traffic and manual area traffic

When on automatising an area only the *local traffic* of the various exchanges is automatised, while the traffic between the exchanges, area *traffic*, is retained as manual, the operators required for this may be concentrated at the main exchange. But few operators are required and night service may be organised without too great expense, thus providing 24 hours' operation for the whole area. The network will then be made up as shown in Fig. 2. The automatic sub-exchanges have direct junctions to the main exchange, while the tie lines between the sub-exchanges are mostly dispensed with. The number of bundles is thus smaller than in the manual area and as the same amount of traffic as before will be proceeding in the area, it is obvious that the traffic in each bundle will be increased correspondingly; partly for this reason and partly because of the lower grade of efficiency with automatic direct traffic to the main exchange a larger number of lines in the bundles is required. No appreciable improvement in the efficiency of the junctions is obtained. On the other hand it is possible to distribute the traffic over a large number of exchanges by arranging periphery exchanges, such as *A1* and *A5*, with junctions only to the nearest exchange.

Local calls are established by subscribers themselves with the dial in the usual way, see Fig. 5. Each exchange has subscriber numbers which are governed only by the size of the exchange. When a call to another exchange is desired, a certain number is dialled, usually *0*, by which connection to an operator at the main exchange is obtained. After recording the operator connects herself over a free junction to the required exchange and, by means of dial or of keybords, operates the selectors at said exchange for the called subscriber. The main exchange may be either manual or automatic: in either case, however, operators are required for area traffic and for the trunk traffic. Such rural automatic operation has been regularly employed to a large extent in Germany and England and other places.

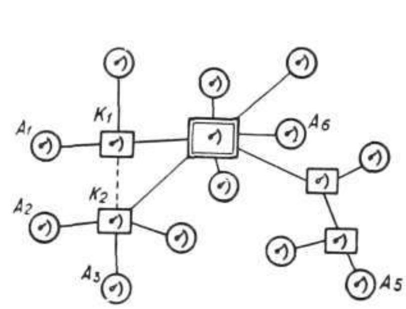

Fig. 3 X 3771
Area with automatic local area traffic

manual main exchange
manual sub-exchange
automatic main exchange
automatic centre exchange
automatic terminal exchange

The sub-exchanges may also be made *semi-automatic* instead of automatic. The junction network is made up in the same manner as for automatic sub-exchanges, as per Fig. 2. The operators at the main exchange then deal with the connection of local calls as well, and the subscribers therefore do not have automatic instruments but retain their old LB instruments. The expense for new material in such an automatisation is consequently smaller and this, together with lower electric demands made by the LB fed instruments on the subscriber lines, in certain cases obviating reconstruction of the network which would otherwise be necessary, is the reason why this system has been employed.

Call from a subscriber is connected automatically over a disengaged junction to the main exchange, see Fig. 6. The operator there takes the order and if a call to another exchange is required she makes the connection in the manner

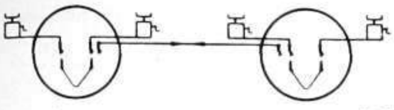

Fig. 4 X 3772
Rural exchanges with manual local and area traffic

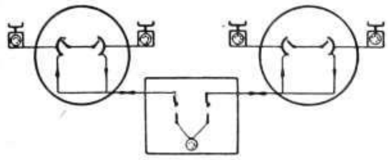

Fig. 5 X 3773
Rural exchanges with automatic local traffic and manual area traffic

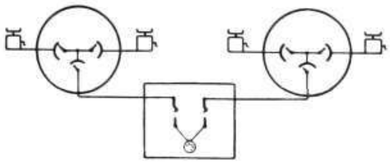

Fig. 6 X 3774
Rural exchanges with semi-automatic local traffic and manual area traffic

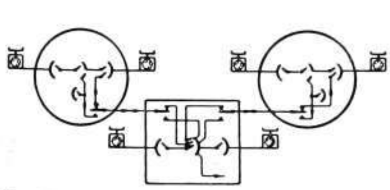

Fig. 7 X 3775
Rural exchanges with automatic local and area traffic

already described. If, however, it is a question of a local connection she operates, over the same junction, the selectors at the calling station, so that connection with the required subscriber is made. The operator and the junction are then disconnected and the call remains completely locally connected within the rural exchange. However, as the calling and establishing of the local connections are done on the junction, traffic on these becomes so much the greater. Still, to avoid the necessity of increasing the junctions the semi-automatic exchanges are often made with waiting device, by means of which calls which cannot get through immediately to the main exchange are stored up to be further connected when one junction line will be disengaged. Such rural automatic operation has been largely employed in France.

The semi-automatic exchanges can, however, be made for CB instruments, as can the automatic for LB instruments, which are then supplemented by dials.

Automatic or semi-automatic exchanges with manual area traffic often occur as the first stage of automatisation in manual areas. If a rural exchange requires reconstruction because it is worn out or if a new exchange is to be provided to make the telephone available in a district where it was formerly lacking, but for financial or other reasons more extensive automatisation is not to be carried through, then one must limit oneself to making the new exchange as an *isolated* automatic exchange in the otherwise manual area and connect it to a suitable manual main exchange. If this latter is not organised for 24 hours service then the subscribers of the automatic exchange will only have such service in respect of local connections, or not at all if their exchange is semi-automatic.

Area with Automatic Local and Area Traffic

Considerably better utilisation of the junction network is obtained if the whole area traffic be automatic. The network is arranged in that case as shown in Fig. 3. The direct junctions to the main exchange are retained only in respect of the nearest sub-exchanges but are dispensed with for those on the periphery and in between these. The periphery exchanges are instead linked with the nearest exchange that has direct junctions to the main exchange. There is in this way obtained the characteristic *radial* or *star-shaped* arrangement of the junction network. Such an area comprises a number of *centre exchanges* and radial *terminal exchanges* connected to them. The centre exchanges in turn are as a rule connected to a centre exchange in the traffic centre, the *main exchange* of the area. Occasionally two centre exchanges may be in series with each other.

As may be seen, the number of bundles in the star-shaped area is considerably reduced in comparison with those of the manual area, in the case presented to the half. As the total amount of traffic remains the same as before, the traffic in each bundle will be appreciably increased. A larger number of lines in the bundles involves therefore, though not in proportion to the increase in traffic, so much the better efficiency of each circuit. If the loss on automatic direct traffic is 1 %, for instance, the efficiency in a bundle consisting of only two lines is 5 min per line, rising to 20 min per line with 10 lines.

Now, the requisite number of junctions for the star-shaped area may in most cases be obtained without necessity of making new lines to any great extent. The junctions, in fact, do not take the shortest path between the exchanges, as Fig. 1 indicates, but are more or less radially carried together in open line or cable routes. Thus, for example, the junctions from exchanges *A2* and *A3* do not take the direct path to the main exchange, but proceed with the junctions to exchange *K2* and thence with its junctions continue on to the main exchange. Nor do the junctions between *A2* and *A3* take the direct way but proceed via exchange *K2*. In the manual areas therefore the junctions are to a large extent in respect of line routing already brought together in radial bundles, which however for traffic purposes are broken up into small bundles to avoid a large number of the connections being handled with the intervention of 3, 4 or 5 operators.

In an area with automatic area traffic, on the other hand, there is nothing to prevent the routing of traffic from different exchanges in large common bundles with better efficiency of the individual junctions, since the area traffic may without inconvenience be directed over a number of selectors located at different exchanges. A number of junctions, running direct between sub-exchanges, are either dispensed with or may be employed as *tie lines* between the said exchanges. By using automatic area traffic it is possible also to distribute the traffic over a larger number of exchanges, each covering a small area, thus appreciably reducing and consequently cheapening the subscriber lines. Such entirely automatic operation was first carried out in Bavaria and has since been adopted, *inter alia*, in Switzerland, Italy, Holland and to some extent in the Nordic countries.

Numbering

It is therefore by making both the local and the area traffic of the area automatic that the most rational arrangement of the network is obtained. On the other hand, the automatic exchanges themselves are not so simple as when the area traffic is dealt with manually, since special equipment is required at the automatic exchanges to provide for automatic interworking in the star-shaped area. These are governed by the traffic conditions to be fulfilled, in the first place the question of the *system of numbering* to be employed.

For an isolated automatic exchange, whether urban or rural, or for an urban network with several local exchanges having direct junctions among them, the numbering of subscribers gives rise to no trouble. The subscriber numbers are determined by the size of the exchange or the total capacity of the urban exchanges. With a star-shaped area, however, a call to a subscriber may be connected over a *varying number* of exchanges, according to the exchange to which the caller belongs. For instance, a connection from a subscriber in exchange *A1* to a subscriber in exchange *A6* goes over four exchanges, while a connection to *A6* from a subscriber in the main exchange passes over only two. Special measures are therefore required to enable connection in both cases to be made by using the same subscriber number.

The system of numbering should be as simple as possible and as easy to understand and convenient for the subscriber as possible. The best arrangement in this connection is that every subscriber to whom automatic connection can be made shall always be reached by a certain number given in the directory, irrespective of the exchange from which the call comes, *i. e.*, that subscriber numbers are comprised in a *uniform* numbering. That part of an automatic area in which such holds good we designate as a number area.

Number Areas

The size of the uniform number area should be such that the greatest benefit from the uniform numbering is derived both by subscribers and by the telephone administration. It should cover that portion of the automatic area where large community of interest and heavy traffic between subscribers exist and for which consequently uniform numbering is natural from the subscribers' point of view. The arrangement of the network within the number area may therefore vary considerably in character. The number area may thus consist of a single exchange as is the case with one city exchange, or of several exchanges with direct junctions between as in the larger cities, or of a simple centre area, *i. e.*, one centre exchange with terminal exchanges connected to it, or a more complex star-shaped area as shown in Fig. 3. These different kinds of areas may occur together in one large automatic area. Often the number area will vary in size and type according as automatisation proceeds. Isolated automatic terminal exchanges, which may be the first to be provided, will to begin with form their own number areas to constitute on the automatisation of the main exchange a larger number area in conjunction with same, this larger area at a more distant stage of automatisation comprising the whole of the star-shaped area. Automatic operation, however, involves a certain limitation respecting the type and size of the number areas, and in this connection the various systems present different possibilities. The different principles which may be employed can be shown by their application to an area as in Fig. 8.

Direct-Controlled System

If the *automatic* system employed in the area is *directly controlled, i. e.*, the selectors are actuated direct by the subscribers' dial impulses, each numerical selection movement corresponds to a digit in the number and obviously it must be arranged that an equal number of selector stages is taken in the chain, irrespective of the exchanges from which the call comes. This means that the numerical selecting must proceed from the main exchange and all calls from all the exchanges of the network are automatically connected to the main exchange before answering tone is received and the subscriber can dial the number. The subscriber numbers would be the top ones of those shown beside each subscriber' instrument in Fig. 8.

For example, when a subscriber *22 34* at terminal exchange *A2* wishes to call a subscriber at terminal exchange *A6*, he is connected over a switch at his own exchange to a free junction for centre exchange *K2*, over a switch at this exchange to a free junction for the main exchange and from this last he receives answering tone. Thereupon he dials the number *58 18*, consisting of the *exchange digits* — 58 — the first of which selects the centre exchange *K3* and the second the terminal exchange *A6*, followed by the *subscriber's digits* — 18 — how many of which there are being determined by the size of the exchange, in this case assumed to be 100 numbers; the number thus is four-digit. If on the other hand a connection is desired to a subscriber of the main exchange, which is usual larger, and in this example is assumed to be not more than 10 000 numbers, the subscriber digits will amount to four and the whole number consist of six digits, *e. g., 10 12 34*.

If connection is required to a subscriber *22 56* of the caller's own terminal exchange *A2* then the exchange digits *22* are dialled, the first of which selects the centre exchange *K2* and the second the terminal exchange *A2*, followed by the two subscriber digits *56*. The junctions into the main exchange not used by the call, being disconnected. This is done through the equipment at exchanges *A2* and *K2* being provided with simple marking switches, known as discriminators which are actuated by the impulses from the exchange digits at the same time as the selectors. When the first exchange digit has indicated that the call shall remain within the centre area of *K2*, the discriminator at exchange *K2* disconnects at this exchange the junction to the main exchange and when the second exchange digit shows that the call will be confined to the terminal exchange A2 the discriminator at this exchange disconnects the junction to *K2*, so that the call remains connected locally within the terminal exchange. This occupation of junctions during the process of connection not employed for the call itself we call *advance occupation*.

For a call to subscriber *45 21* at terminal exchange *A5* the selection must be made over two series-connected centre exchanges *K4* and *K5*, that is over still another selector stage, the number of exchange digits required on this account being augmented by one more for subscribers in the centre area *K5*. Recently, however, there has been introduced a method of connection by means of which this disadvantage is avoided. All exchanges within the two centre areas have two-digit exchange numbers, the first digit being *4*. This digit selects the centre area *K4*. The second digit, for centre exchange *K5* may be

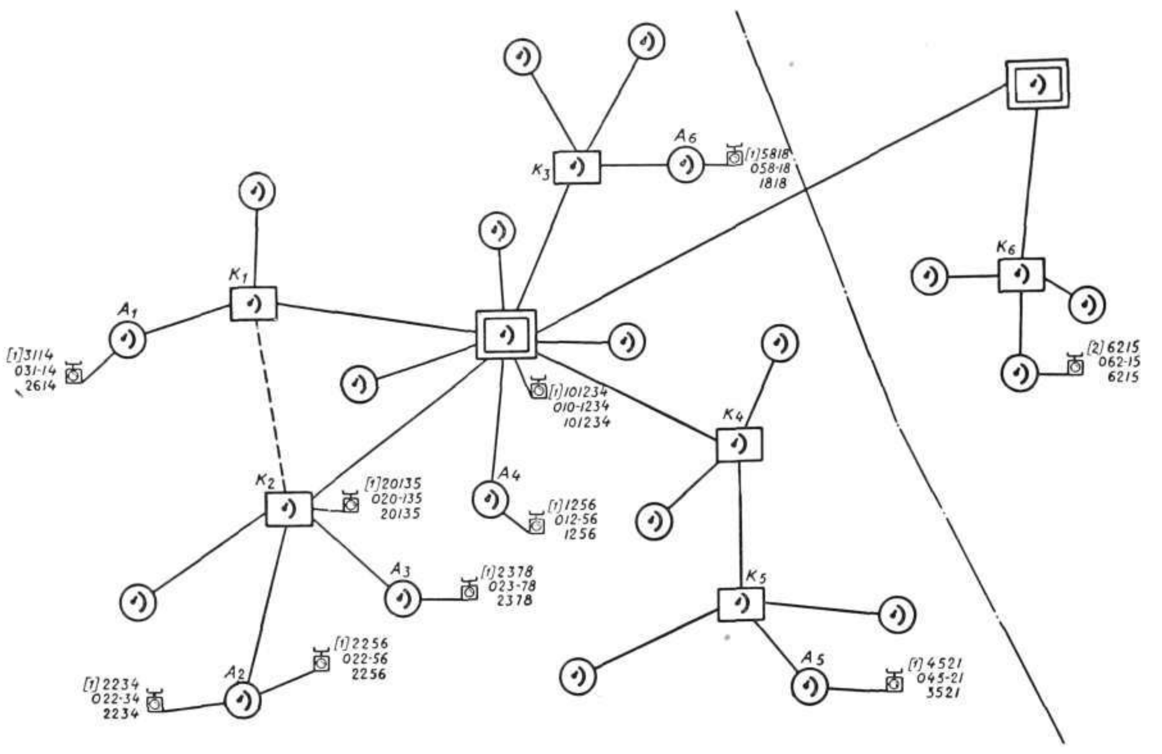

Fig. 8 X 7120

Area with automatic local and area traffic

automatic main exchange

automatic centre exchange

automatic terminal exchange

[1]2256 direct-controlled system with closed numbering

022-56 direct-controlled system with open numbering

2256 register-controlled system with closed numbering

3 and for terminal exchange *A5* it may be 5. On dialling either of these digits, the connection is made to centre exchange *K5*, but following this selection an operating signal is transmitted automatically from *K4* to *K5*, the nature of which is governed by whether the selected digit was *3* or *5* and which either localises the connection to *K5* or switches it on to the terminal exchange *A5*. Thereupon the selectors at the selected exchange are actuated by the digits *21* in the ordinary manner.

It has been assumed that direct junctions existed between centre exchanges *K1* and *K2* at the time the area was manual. These may be utilised as *tie lines* for traffic between these two centre areas. When on a call to a subscriber *31 14* at terminal exchange *A1* the first exchange digit determined that the call was for the centre area *K1* the discriminator at centre exchange *K2* disconnects the junction to the main exchange and connects the junction from exchange *K2* to exchange *K1*.

If traffic is to proceed automatically with other areas as well, the two exchange digits are supplemented by still another digit, which fixes the required area, *e. g.*, *1* for the area concerned and *2* for the adjacent area, comprising the centre area *K6*, as may be observed from the figures in brackets in Fig. 8.

As may be seen, a system such as that described means that the subscriber numbers will contain a large number of digits. Each centre area requires a first exchange digit, even if the exchanges in the centre area do not amount to ten. Consequently there is limitation right from the start in respect of numbering and the number series must contain a large reserve. Moreover, the advance occupation involves unnecessary taking up of the expensive junctions to the main exchange for calls which should be confined to their own centre area or terminal exchanges. To avoid these inconveniences in the direct controlled system, there is employed a method with *open* numbering or a prefix system instead of the *closed* numbering used in the above-described system. In the system with prefixes the uniform-number area does not cover the whole rural area, but each exchange forms its own number area and for local calls within the exchange numbers are used which contain only subscriber digits, being thus determined by the size of the exchange; they are thus two-digit for terminal exchange *A2* and four-digit for the main exchange. The call remains within the exchange of origin. When a connection to a subscriber at another exchange is required a prefix is first dialled, usually *0*, thus indicating that the call is for outside the exchange, and then the two digits indicating the exchange and the two digits indicating the subscriber. Subscriber numbers will then be as shown by the middle numbers beside each subscriber's instrument in Fig. 8.

When *o* is dialled the call is connected automatically to the main exchange, after which the numerical selection by the exchange and subscriber digits proceeds as previously. Thus dialling differs for the subscriber according to whether the call is for his own exchange or another, and he must therefore always make sure what exchange he is calling from. The directory must give directions regarding the dialling.

For main exchange subscribers, whose chief traffic is within their own exchange, and in general for subscribers at exchanges with considerable internal traffic, the system with prefixes is preferable, since fewer digits are required for the majority of calls than with closed exchange digits. Advance occupation is avoided for all calls within the originating exchange, but continue as regards calls to other exchanges in the same centre area. Both systems, with closed and open numbering may be used together in one area. For example, the main exchange subscribers may make calls within the exchange with only four-digit numbers and with prefixes for the other exchanges, while subscribers to these exchanges employ closed numbering.

It does not always happen that the uniform-number area consists of such a complex network as here described. Often the junctions may be so arranged that the area consists of a few centre areas with direct junctions between them, *e. g.*, if the area consists of the main exchange together with the centre exchanges *K1* and *K2* and terminal exchanges. In such case with a direct controlled automatic system advance occupation need only occur up to the nearest central exchange.

Register-Controlled System

By introducing *registers* for controlling the connections between the exchanges, the disadvantages of advance occupation and less convenient subscriber numbers may be removed. Such registers must not be confused with the translators required in automatic systems employing non-decade, machine-driven selectors. They find employment just as well in systems using decade selectors, *e. g.*, the Strowger system, as in the machine-driven system. We call them *area registers* and their purpose is to make the number of exchange digits independent of the number of stages in the selector chain, *i. e.*, to take care of the translation of the exchange digits' dial impulses to impulse series which actuate the selectors in conformity with the construction of the network.

There are two kinds of area registers, direct acting registers and repeating registers. With the *direct-acting registers*, when the exchange digits have been registered a number of impulse series is sent out, each of which actuates a selector of an exchange, exchange after exchange being selected until the one required is reached. With the *repeating registers* also impulse series are sent out when the exchange digits are registered, but after each series the receiving exchange sends an answering impulse which indicates whether the impulse series represents that exchange or whether the series shall be repeated to act on the selectors of a succeeding exchange. This repetition proceeds until the required exchange is reached.

The area registers will constitute a part of the automatic exchange equipment, which consequently will be more complicated. Still, in a register-controlled system all exchanges do not need to be provided with registers, but only those where traffic demands require it. If all exchanges, even the terminal exchanges, be provided with registers, the whole area forms a uniform number area with the smallest number of digits in the subscriber numbers and there is no advance occupation of junctions at all. The call remains in its own exchange and when the exchange digits or all digits of the number have been registered, the register controls the selection to the called subscriber, after which it is disconnected and ready to deal with the next call. The exchange figures are two-digit and may be chosen entirely at will, as shown by the bottom numbers against each subscriber's instrument in Fig. 8. Thus the exchanges in centre area *K3* may have the same first exchange digit as the main exchange, *viz:* *1*, while in the direct controlled system the digits are *1* and *5* respectively. The numbering system is thus exceptionally flexible and does not demand any special reserves of numbers. Connection to an exchange in another area may be carried out quite automatically without any special area digit preceding the exchange digits. The first exchange digit determines the centre area even in the case of adjoining areas, *e. g.*, digit *6* for a subscriber in the area *K6*.

Terminal exchanges as a rule, however, are small exchanges and the provision of registers for them constitutes an expense which should only occur when in a number area advance occupation to the nearest centre exchange may not be allowed. This would, however, usually be possible so that provision of area registers would only be done for the very few centre exchanges employed for the whole traffic of the centre area. The same subscriber numbers would apply as formerly. If advance occupation may be done right up to the main exchange, the area registers are located at the main exchange.

Prefixes may be used also in a register-controlled system. If it is not wished to have advance occupation to the centre exchange nor to equip the terminal exchanges with registers, the advantage derived from one uniform numbering for the whole area must be dispensed with and recourse made to the prefix system.

Rates and Metering

An important problem arising on automatic operation of traffic between different exchanges is how these calls shall be charged. In a manual area or an automatic area with manual area traffic, the operator supervises the calls and can record those calls which have to be specially debited. In an automatic area this charging must be done automatically, and it is therefore done on the subscriber's meter. This means that all automatic traffic, whether within one number area or between areas, can only be charged in the form of a number of metering impulses on the subscriber's meter. The number of impulses is governed by the time occupied and the distance between the exchanges. To determine these, the automatic exchanges are provided with *time-zone meters*, which on the basis of the number dialled transmit to the meter the number of impulses, corresponding to the distance, at each unit of time, usually 3 min. The charging of subscribers in such a system will as a rule consist of a certain flat rate independent of the number of calls and of a charge for each local call metered by an impulse to the meter and a charge for each connection within the automatic area representing a certain multiple of the local rate. In this way means is provided for great differentiation in respect of charges for inter-exchange connections. With manual operation it has often been necessary to allow an exceedingly large flat-rate area because it did not pay to debit specially such connections, as the recording expenses were too high. With the automatic time-zone meter, however, it is possible to charge the subscriber in a simple and cheap manner according to the cost of his connection in respect of occupation of lines and switches, thus obtaining a rate policy which is fairer and more economic both for the administration and for the subscriber. Developments in conjunction with rural automatic operation may be expected therefore to proceed on the lines of the flat rate area, in which connections only represent one rate irrespective of time consumed, being more and more restricted to comprise solely the subscriber's own exchange.

Rural automatic operation provides, in addition to the above, a number of problems, exceedingly interesting both technically and from a traffic point of view, *e. g.*, attenuation in the rural networks and the employment of amplifiers, various methods of dialling over junctions with DC and AC, for trunk disconnection, etc. The purpose of this article, however, being only to give a guide to the more basic technical principles of rural automatic operation, such questions cannot be dealt with here.

Maintenance Statistics for the Stockholm Automatic Exchanges

I. NORBERG, ROYAL TELEGRAPH ADMINISTRATION, STOCKHOLM

Superintendence of automatic telephone exchanges calls for more or less extensive operation control, based on operation statistics compiled in suitable manner. These are divided into maintenance statistics providing indications for the estimating of the exchange's running in the best manner from the technical and economic points of view, and traffic statistics comprising investigation and supervision of circuit requirements for different traffic routes etc.

The article below, constituting an abridged summary of two papers published in the »Technical Bulletin of the Swedish Royal Board of Telegraphs» No 11—12, 1936, and No 1—3, 1937, gives a description of the general features of the maintenance statistics for the Stockholm automatic exchanges and questions related to them.

Maintenance Work

The Stockholm automatic exchanges, all of which are built on the Ericsson automatic telephone system, are at present divided into two areas: the Stockholm inner area consisting of Stockholm proper, and the Stockholm suburban area comprising the outer parts and the suburbs of Stockholm, etc. The local exchanges at present consist of Centralen, Södra Vasa, Norra Vasa, Söder, Kungsholmen and Östermalm. The automatisation of the suburban area is only in its early stages and of the exchanges comprised in it Äppelviken is included for comparison with those of the local area.

The subscriber network of a local exchange, Fig. 1, consists of the subscriber instruments and subscriber cables and is maintained by a central institution, the fault office. The exchange consists of distribution frames, selector bays and manual trunk positions, which last are not found in the automatised suburban exchanges where trunk calls are connected over trunk selectors.

The staff of an exchange consists in general of superintendent for general service, certain supervision work etc.; trunk operators (with manual positions); cleaning staff for cleaning floors and the premises generally; staff

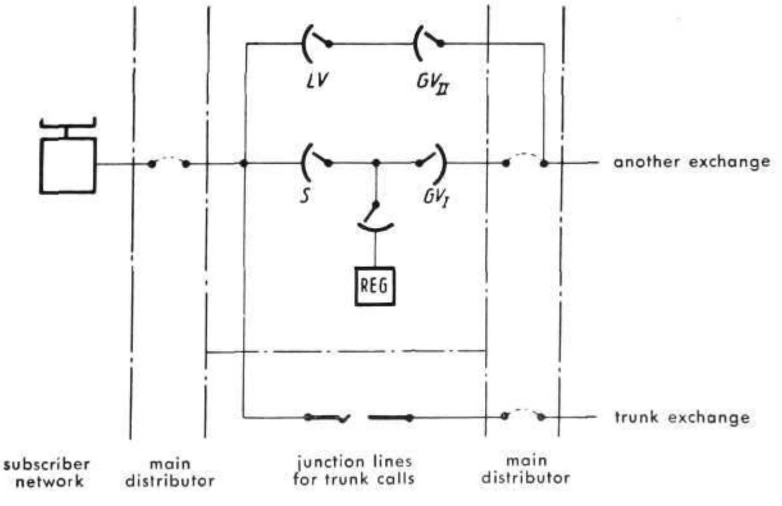

Fig. 1 X 5390
Trunking diagram of telephone exchange with subscriber network
GV$_I$ first group selector
GV$_{II}$ second group selector
LV final selector
S line finder

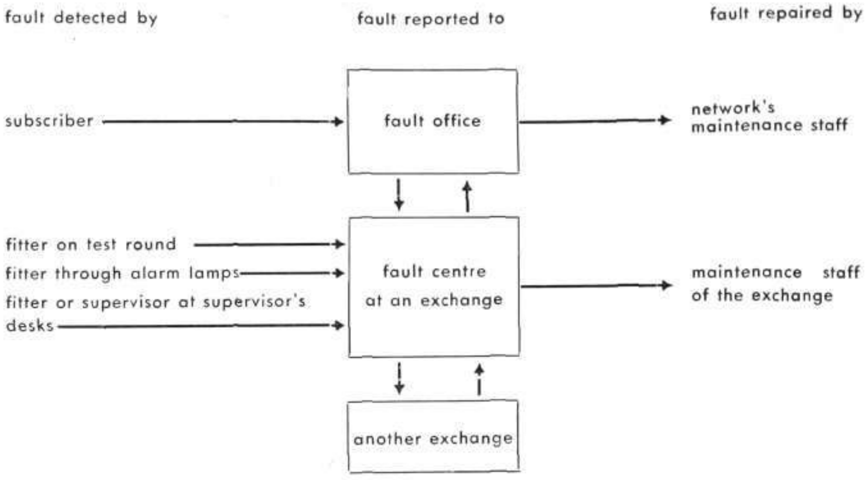

Fig. 2
Diagram of fault notification process

for work on the distribution frames; and maintenance staff in the true sense of the term. The distribution and maintenance staffs of the local exchanges are in charge of a foreman, while the suburban exchanges are supervised by a fitter dwelling on the premises.

The work of the distribution and maintenance staffs may be divided up in different ways according to the size of the exchange. In the smaller exchanges the staff must share in all the duties, while in the larger ones a certain amount of specialisation may occur. The following working duties may be particularised:

work on *distribution frames* is largely governed by changes in the subscribers; in the Stockholm exchanges the staff required for this purpose normally amounts to from $^1/_2$ to 2 men;

the *fault centre* constitutes the centre of reception for all fault reports to and from an exchange, and the fault tracing work is largely directed from it, see Fig. 2; there all faults reported are entered in fault books of various kinds, to be collated later into fault statistics. The fault centre is generally located near the distribution frames, and the fitters of the distribution frames and the fault centre collaborate in their work; the staff normally required in the fault centre consists of $^1/_2$ to 1 man;

work in the *selector bays* may be divided into two groups, *viz:* supervision of the instruments and watch duty; supervision of instruments comprises periodic inspection, cleaning and adjustment of automatic devices, and systematic testing of the instruments, junction lines etc. all in accordance with a plan laid down and as far as possible employing female staff; the watch duty consists in supervising the faults that may arise during the run of the automatic exchange and comprises fault-tracing and fault-clearing indicated by pilot and alarm lamps of various kinds, fault reporting etc.;

care of the *power plant* comprises supervision of charging and discharging of batteries, regulation of operating tension as well as care of the exchange batteries, electric machines and rectifiers;

the exchanges should furnish each month certain *statistical reports*, mainly fault statistics and traffic statistics, compiled from fault books, traffic figures noted, etc.

Besides the above-mentioned routine maintenance work, the maintenance staff carries out a number of smaller jobs, consisting of making connections required by additions to subscriber and junction circuits and various other alterations at the exchanges. More comprehensive work of this nature, however, is dealt with by a special new-construction department. In addition to what is stated above, it should be observed that certain of the male staff are on fixed duty lists which provide the necessary stand-by staff for exchanges, *e. g.*, in the evenings, at night and on Sundays and holidays. The duty lists are to a certain extent standardised and made out for 3 to 8 men. Should an exchange require to increase its staff above that noted on the duty list, »permanent day-men» are appointed.

Operating Reliability and Faults

Supervision of the operating reliability of the exchanges is carried out at supervisor's position connected to the automatic registers of the exchange. The supervisor follows up a certain number of connections taken at random on all the registers and records the defects observed. In a month of such supervision the number of calls checked usually amounts to one per thousand of the total number of calls.

The checked calls are divided into *faultless connections* (including busy, no reply and the like), *subscriber faults* and *technical faults*. The number of technical faults detected in percentage of the number of calls checked constitutes the technical fault percentage p. The admissible value of p will be a figure dictated by experience, depending to a certain extent on how exacting the subscribers may be; in general it may be said that the technical fault percentage should be small in proportion to the percentage of faults caused by the subscribers themselves. An exchange where the maximum for p amounts to 0.5 % may nowadays be considered sufficiently good from the point of view of reliability; the mean figure for p for the Stockholm exchanges in 1936 was 0.14 %. As the subscribers themselves in the corresponding period were responsible for about 1.5 % faults on the average, it appears that the above requirement is well fulfilled.

To provide further check of the functioning of the exchange from the technical point of view, each month all faults notified are brought together into a fault report which indicates the distribution of the localised faults over the various connecting devices and other exchange equipment, and also the nature of the fault. The number of faults unlocalised is also given so that care may be taken that this does not become disproportionately large. Faults unlocalised are further divided into »no fault» meaning that the fitter found nothing indicating a fault and »clear during test» intimating that the fitter saw that a fault had occurred but could not be sufficiently certain of the source of the fault.

With the aid of the fault statistics it is possible to form a good idea of the nature of the faults which arise at the exchanges. The technical faults arising may be divided into permanent defects from the erection of the exchange, such as defects in construction, defects due to workers, defects in material; *tempo-*

	Centralen	Södra Vasa	Norra Vasa	Söder	Kungsholmen	Östermalm[2]
registers	330	234	144	287	162	266
localised register faults	348	137	38	105	132	159
localised register faults per register	1.05	0.59	0.26	0.37	0.81	0.60
millions of calls	87.04	40.24	14.33	51.19	34.00	44.79
millions of calls per register	0.264	0.173	0.100	0.178	0.210	0.168
p[1] %	0.28	0.04	0.08	0.05	0.22	0.17

[1] p here represents technical fault percentage for the calls which proceed from the different exchanges to all exchanges, both automatic and manual; the above figures for p therefore are practically speaking equal to technical fault percentage for the different exchanges

[2] the relatively high fault percentage for Östermalm, compared with Söder, Södra Vasa and Norra Vasa, is due to certain defects persisting from the time of erection of the exchange not having yet been removed

Table I

Operating statistics for registers of Stockholm automatic exchanges 1935

Table II
Faulty calls as function of technical fault percentage

p %	S/day	S_f/day	S/day	S_f/day
0.10	40 000	40	250 000	250
0.30	40 000	120	250 000	750
0.50	40 000	200	250 000	1 250

rary faults, such as faults due to variations in tension, faults due to work and faults due to injury; and *wear faults,* such as contact faults, winding faults due to overheating and electrical break-down, mechanical faults due to friction and the like.

There is obviously a certain relation between operating reliability and the number of faults, as is also seen in the statistical reports. If the operating reliability decreases it is due to augmentation of the number of faults developing. Thanks to existing alarm devices and the rational arrangement of tests these new faults are rapidly detected and the number of faults investigated as also the number of localised faults increase.

To make an elementary investigation of the relation between faults and operating reliability it may be assumed that the defective devices cause faults in calls at regular intervals until they are localised. This assumption may be regarded as an acceptable average of actual conditions. In certain cases there may arise a defect of such a nature that all calls subsequently passing over the device in question will be faulty. Other faults, such as constructive weaknesses and the like, cause faults in connections in certain combinations or in certain circumstances. A third kind of defect, such as dirty contacts and the like, appear first at long intervals and then more and more frequently.

As an application of the relation presented, an investigation is made in some cases of the operating reliability of the registers at the Stockholm exchanges during 1935, Table I. The registers lend themselves better to such an investigation than do the selectors, among the reasons being that the technical fault percentage p, strictly speaking, only applies to faults of establishing of connections, to which all register faults belong, while selector faults may also be connected with the restoring of a connecting device. Moreover the traffic on the registers is so large that defects in them are more noticeable.

The following designations are introduced:
p = percentage technical faults during a short period t,
S = calls during period t,
S_f = faulty calls during period t.
It is obvious that

$$p = \frac{S_f}{S}$$

In this equation p is known from the above with sufficient accuracy while S is obtained from traffic statistics; thus S_f may be calculated. Even though p be small, the absolute number of faulty calls at an exchange with heavy traffic may be large, as can be seen in Table II. An exchange with 40 000 calls a day corresponds to Norra Vasa at present and one with 250 000 calls to Centralen.

Fig. 3 X 3754
Trunking diagram of the automatic connecting devices at Stockholm telephone exchanges
GV_I first group selector
GV_{II} second group selector
LV final selector
S line finder

Since a certain number of the faulty calls are notified by subscribers or observed through the alarm lamps in the register or traffic supervision positions, it may be understood that the fault-tracing work at an exchange with heavy traffic may be considerable, even if operating reliability be good.

Now to determine the relation between the number of faulty calls S_f and the defective devices at an exchange, we turn to the trunking diagram of an automatic exchange, Fig. 3. We assume that defects, existing or in course of deve-

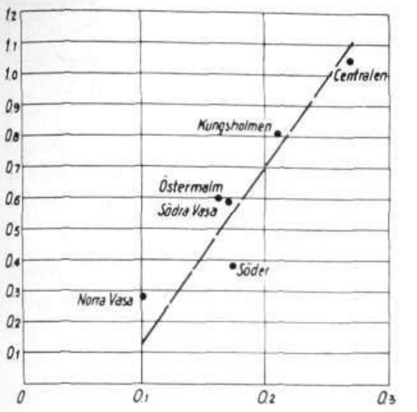

Fig. 4 X 3755

Localised faults as function of million calls per register, 1935

loping, in a device give rise to fault every nth time a call passes over the device in question. The connecting devices contained in the system are merged together in groups, the devices in one group being equivalent from a traffic point of view. For the sake of simplicity it is assumed that all selector stages have the same value, which means that they would have the same number of devices and that these are utilised to the same extent; there is therefore no question of grading. In this manner there are obtained two distinct groups, namely registers and selectors. Further it is assumed that a faulty call is never caused by more than one defective device. The following designations are introduced:

R = registers connected at the exchange during a certain short period t,
V = selectors connected at the exchange per selector step during period t,
R_f = faulty registers at the exchange during period t,
V_f = faulty selectors at the exchange during period t,
n = a faulty device causes fault each nth time it is used.

It is obvious that S_f is the number of calls on the faulty device multiplied by $\frac{1}{n}$, from which we get

$$p = \frac{S_f}{S} = \left(\frac{R_f}{R} + \frac{V_f}{V}\right) \cdot \frac{1}{n}$$

This equation gives the relation of p to the number of faulty devices at a certain moment. Let us investigate this somewhat more closely. If R and V are assumed to be constant and an exchange has only permanent faults, say of a constructive nature, this would mean that R_f and V_f are constant. Then p would also be constant and independent of the traffic intensity.

If we go on to assume that the device faults R_f and V_f are exclusively due to wear and as such a function of the number of calls per device, we get

$$p = f\left(\frac{S}{R} + \frac{S}{V}\right)$$

Other conditions being equal, it thus holds good that a part of the fault percentage due to wear is a function of the number of calls per device, which means that exchanges with heavier traffic per connecting device display a higher fault percentage than the others. This assumption seems to accord very well with actual conditions, see Fig. 4 and 5, where the tendency in the relation of the measured points is clear; still it is a matter of chance that the figures should lie so close together.

Naturally, it should not be supposed from what has been stated above that the differences obtaining in fault percentage between the exchanges of Stockholm are entirely due to the traffic on the connecting devices. A certain part of the technical fault percentage consists also of faults persisting from the erection of the exchange as well as of temporary faults. This portion is, as pointed out above, to a great extent constant and thus independent of the traffic flowing. An appreciable difference may naturally exist between exchanges, *e. g.*, because of censtructive dissimilarity, difference in the number of fitters and so on, but one cannot disregard the differences in technical fault percentages which are a direct result of traffic intensity.

The equation also indicates how the fault percentage is related to the distribution of faults over automatic devices of varying importance. We take, for example, that an exchange with 200 registers and 1 000 selectors per selector stage has altogether 20 faulty devices. Table III shows various figures for p, according as the 20 faults are to be found in the registers, in the selectors or in both. The importance of the registers being maintained with care is brought out by this with all the clearness one might wish.

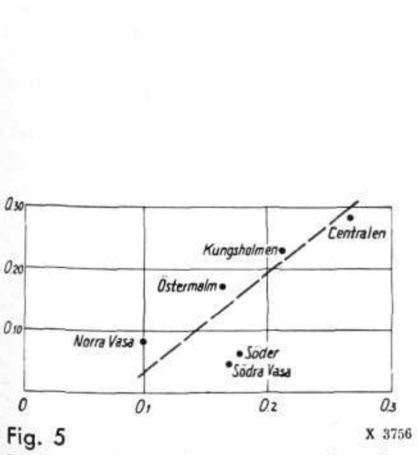

Fig. 5 X 3756

Technical fault percentage as function of million calls per register, 1935

Table III
Technical fault percentage for different fault distributions

R_f	V_f	p %	p %
		$n = 1$	$n = 10$
20	0	10	1.0
0	20	2	0.2
10	10	6	0.6

If each faulty device were localised and put right the first time a fault arose, the technical fault percentage would be obtained direct from the fault reports and the particulars of the number of calls. The exchange could then be regarded as free from fault, that is without permanent fault; some defect arises from time to time but this never succeeds in causing fault in more than one call before it is removed. Here then applies the following relation

$$p = \frac{S_f}{S} = \frac{\text{number localised faults}}{S}$$

In order to discover how near we are to the above ideal case, Table IV has been drawn up, showing the number of localised faults in the connecting devices (selectors and registers with accessory equipment) during 1935 in percentage of the number of calls a, fault percentage p during the same period and the ratio of p/a. If all faults had been localised and remedied the first time they appeared, p/a would be equal to *1*. The reasons that p/a in the table is so much higher are two: first, the number of remedied faults is considerably larger than the number of localised faults given by the fault statistics (certainly all faults met with are entered in the fault statistics, but numerous defects which were not found disappear through the cleaning and adjustment of the devices etc.; thus the figure for a above is too small); second, a faulty device may succeed in causing a number of faults in calls before the fault is detected, localised and remedied.

Size of Maintenance Staff

To compare the different exchanges in respect of efficiency of attendance, it is advisable to draw up staff requirement forms, based on work and time studies for the type of exchange concerned. From these are derived the requisite number of working hours that should be put in by the maintenance staff.

Recalling what has been stated regarding maintenance work at the Stockholm automatic exchanges, it may be seen that the requisite maintenance time for these exchanges may be distributed over the following four work groups, see Fig. 6: care of the exchange, comprising inspection, testing, cleaning, repair etc. of the automatic exchange devices; watch duty (fault tracing) during the period of the day with comparatively heavy traffic; stand-by duty during low traffic times, and finally work in the fault centre, entering of statistics and sundry work.

Care of the exchange demands a number of working hours largely proportional to the number of connecting devices. In order to find the necessary time, a

Table IV
Localised faults in connecting devices in percentage of number of calls and technical fault percentage in Stockholm telephone exchanges 1935

	a %	p %	p/a
Centralen	0.0018	0.28	155
Södra Vasa	0.0020	0.04	20
Norra Vasa	0.0017	0.08	47
Söder	0.0019	0.05	26
Kungsholmen	0.0029	0.22	76
Östermalm	0.0016	0.17	106

Fig. 6 X 5392
Distribution of work at a telephone exchange in Stockholm

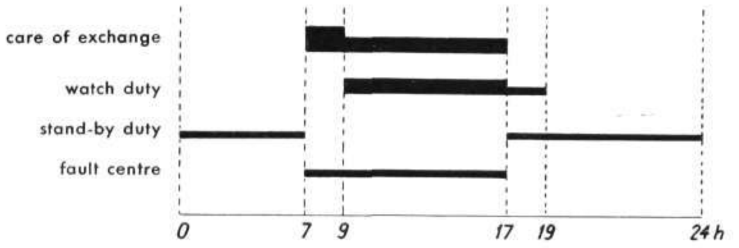

table has been drawn up covering all the routine tests, all rounds of inspection, adjustment and cleaning for the various devices, together with the time required for same during a year. An investigation of this kind made in the Stockholm automatic exchanges gave the result that each year on an average there is taken up maintenance time of:

2.3 hours per selector with sequence switch
1.6 hours per selector with relay set instead of sequence switch
18.0 hours per register
1.2 hours per relay repeater at the suburban exchanges.

In these times are included the maintenance of the devices referred to, along with maintenance of accessory shafts, motors, alarm devices and also maintenance of devices common to the exchange, such as battery and machine rooms, supervisors' positions etc., the times for which are divided proportionately among the connecting devices.

Watch duty comprises the work devoted to fault tracing caused by the traffic of the exchanges. The number of faults, inclusive of blocked circuits, is about proportional to the number of calls, as may be seen in Table V. In what follows it is taken that watch duty during ordinary weekdays normally falls between 9 o'clock and 17 o'clock (Saturdays between 9 and 13 o'clock), but that when working staff is required at an exchange beyond the fitter intended for stand-by duty, that working staff shall be counted in the regular duty.

Let us now take approximately that all calls fall within the time watch duty is proceeding, and that all faults arise during that time and are dealt with by the duty man. An investigation has shown that the number of hours of watch duty per year may be placed at 10^{-4} times the number of calls in the respective exchanges per year. That means that one hour's duty is reserved for 10 000 calls. According to Table V, the number of faults notified per 10 000 calls is on the average 2.5, for which therefore one hour's duty is taken up. Blocking constitutes one quarter to a half of these faults.

Stand-by duty means that a fitter shall be present at an exchange on duty for the event anything special occurs. The duty-man will naturally deal with faults that arise etc., but his working hours will not normally be taken up by such work. Only one man at a time is stand-by duty-man and he attends at the exchange before 7 and after 17 o'clock on weekdays, before 7 and after 13 o'clock on Saturdays and the days before holidays, and the whole of the 24 hours on Sundays and holidays. Table VI shows the stand-by duty-man's hours of attendance at the Stockholm inner exchanges. These times are constant for a certain duty list and are governed by the necessity of having someone in attendance at the exchange at certain periods. The Stockholm inner exchanges have permanent attendance, so that the stand-by duty times per year for them is in round figures 6 000 h. The outer exchanges for the present do not have night and Sunday and holiday duty men. An exchange like Äppelviken has at present a stand-by duty time of about 1 400 h per year.

Table V
Reports entered per 10 000 calls

	Centralen	Södra Vasa	Norra Vasa	Söder	Kungsholmen	Östermalm	average
1935	2.4	2.7	3.0	2.1	2.4	2.5	2.5
1936	2.4	2.4	2.9	2.2	2.8	2.2	2.5

Table VI
Stand-by time for exchanges with constant attendance

	period of stand-by duty h	days (average)	total period stand-by duty h
ordinary weekdays	0—7 and 17—24=14	250	3 500
saturdays and eve of holidays	0—7 and 13—24=18	54	872
sundays and holidays	0 — 24=24	61	1 464

In the formula sought there comes finally a constant time for *duty in the fault centre* and for *statistical work*. Even though work in the fault centre to a certain extent is proportional to the number of fault notifications, yet it is most frequently not of an extent to constitute full utilisation of the time. Keeping the fault books, attending the switchboard, compiling fault and traffic statistics demand within a wide range the same time at different exchanges. The above work is reckoned to take a man's whole time of duty between 7 and 17 o'clock (Saturdays 7—13) at the larger exchanges; at the smaller exchanges half this time is estimated. The total time taken for such work is therefore 1 400 h for Norra Vasa and the outer exchanges, and 2 800 hours for the other automatic exchanges.

The formula of staff requirements at an automatic exchange on the Ericsson system in Stockholm is thus made up of four components: the number of connecting devices, the number of calls and two constants representing stand-by duty and duty in the fault centre etc. We introduce the following designations:

A = maintenance time in working hours per year
V_s = selectors with sequence switches
V = selectors without sequence switches
R = registers
T = relay repeaters
S = calls originated per year
K_b, K_f = constants

The formula then takes the following appearance

$$A = 2.3 \cdot V_s + 1.6 \cdot V + 18 \cdot R + 1.2 \cdot T + 10^{-4} \cdot S + K_b + K_f$$

The formula does not take into account circumstances such as an exchange with larger traffic per device than another reasonably requiring inspection and testing more frequently than the latter, nor has any account been taken of the nature of the exchange building. It is obvious, *e. g.*, that an exchange on three floors is more troublesome to look after than an exchange on one floor. Still these and other considerations do not seem to have any decisive influence on staff requirements on the whole. Should, however, the actual

Table VII
Estimated and actual maintenance time

	Centralen	Södra Vasa	Norra Vasa	Söder	Kungsholmen	Östermalm	Äppelviken
$2.3 \cdot Vs + 1.6 \cdot V + 18 \cdot R + 1.2 \cdot T$	21 050	14 610	7 570	17 650	12 440	15 630	4 640
$10^{-4} \cdot S$	9 380	4 200	1 460	5 040	3 710	4 820	1 060
Kb (stand-by duty)	6 000	6 000	6 000	6 000	6 000	6 000	1 400
Kf (fault centre etc.)	2 800	2 800	1 400	2 800	2 800	2 800	1 400
estimated number maintenance hours A	39 230	27 610	16 430	31 490	24 950	29 250	8 500
actual number maintenance hours in 1936 incl. foreman's time	37 066	30 665	18 969	29 997	31 296	31 042	
difference between actual and estimated maintenance hours	— 2 164	+ 3 055	+ 2 539	— 1 493	+ 6 346	+ 1 792	
ratio between actual and estimated maintenance hours	0.94	1.11	1.15	0.95	1.25	1.06	

number of maintenance hours for an exchange deviate to any appreciable extent from the number estimated, the reason for this would naturally require to be investigated in each individual case. Nor is foreman's time reckoned in the formula, where a foreman is employed. Certain of the jobs included are such as would normally fall to a foreman, *e. g.* compiling statistics etc., but the greater part of a foreman's time would still, however, fall outside the estimated maintenance time.

Let us now see what the formula shows in respect of the Stockholm exchanges. In Table VII a comparison is made of the estimated times and the actual times occupied for the year 1936. The estimated time is divided into its components, by which one may see the influence of each portion. The difference between actual time and estimated time should in accordance with what has just been pointed out be normally about 2 000 h, representing the foreman's time. From the table it appears that Centralen and Söder had too few maintenance hours during the year. Both these exchanges consequently had their staffs increased at the beginning of 1937. Kungsholmen displays a certain excess of maintenance hours. This is due to the fact that the exchange was in a phase of expansion, by which transition was made from a duty schedule of 6 to one with 8 men. This caused a temporary surplus of staff. As the exchange is continuing to undergo strong development the surplus is, however, only apparent and should soon be absorbed. In respect of the other inner exchanges, Södra Vasa, Norra Vasa and Östermalm, the actual, number of maintenance hours would seem to accord well with the estimated number.

As regards Äppelviken the number of maintenance hours worked in the year 1936 could not be obtained, partly because the exchange was first opened in the spring of that year and partly because working conditions on a new exchange are not completely stabilised for some time. It would appear, however, as if the estimated maintenance hours will show good agreement with the actual number during the present year 1937. With reference to the requisite maintenance time for Äppelviken particular notice should be taken of the gain arising from the facility of restricting the night duty as also the Sunday and holiday duty, thus reducing stand-by duty to a minimum.

The number of hours obtained from the above formula includes also the time devoted to cleaning the connecting devices, generally undertaken by female labour. Female labour can, of course, in many cases replace or supplement male labour, so that the formula of requirements would be most correct with the combining of the working times of male and female staff. The necessary number of cleaning women should, however, be determined separately, and this is easily done since their work is fairly constant. Cleaning women clean the selectors and sequence switches at all exchanges. At certain exchanges they also help in the cleaning of registers. Moreover, they are employed to a certain extent for the compiling of statistics. The requisite number of hours for cleaning women may be set at

$$A_p = 1.2 \cdot V_s + 0.65 \cdot V + 4.0 \cdot R$$

Maintenance Statistics

Out of the statistic particulars furnished by the exchanges there is drawn up each year a summary for the control of the exchanges and comparison between them, mainly in the manner described above. Tables VIII—XI show such annual summaries for the Stockholm automatic exchanges for 1936. No complete statistics can yet be obtained from exchanges in the suburban area; still statistics from Äppelviken for the second half of 1936 have been included.

Table VIII

Traffic data[1]

	Centralen	Södra Vasa	Norra Vasa	Söder	Kungs-holmen	Östermalm	Äppelviken
exchange connected	spring 1929	spring 1932	spring 1924	spring 1931	spring 1928	spring 1933	spring 1936
numbers in 1936	20 000	30 000	10 000	40 000	27 000	25 000	9 000
500-line groups in 1936[2]	40	60	20	80	54	50	18
average subscribers connected during the year	16 200	20 707	6 733	26 604	18 710	19 514	5 580
outgoing calls during the year	93 813 914	42 009 808	14 569 517	50 041 716	37 086 599	42 223 075	5 305 806[3]
call minutes per busy hour[4] for outgoing calls	69 200[5]	37 455	17 045	50 435	32 530	43 485	12 030
call minutes per busy hour[4] for incoming calls	28 490	31 350	13 815	42 790	24 670	37 340	11 110
average of connected registers	330	234	144	287	161	266	89
average of connected line finders[6]	2 000 (2 000)	1 350 (1 350)	595 (595)	1 625 (1 625)	1 115 (1 115)	1 420 (1 420)	390 —
average of connected first group selectors[6]	2 000 (2 000)	1 350 —	595 (595)	1 625 —	1 115 (790)	1 420 —	390 —
average of connected second group selectors[6]	1 250 (1 250)	1 260 —	470 (470)	1 570 —	1 075 (640)	1 290 —	275[7] —
average of connected final selectors	1 305 (1 305)	1 355 (1 355)	505 (505)	1 585 (1 585)	1 075 (1 075)	1 410 (1 410)	460[8] —
average of connected repeaters	—	—	—	—	—	—	520

[1] figures are derived from traffic statistics of the exchanges and are designed to give a picture of the sizes and traffic flow of the exchanges

[2] indicates subscriber equipment capacity at close of year, not selector equipment capacity

[3] this figure would be about double for the whole year, as Äppelviken statistics only apply to half the year 1936

[4] the number of conversation minutes for call finders and final selectors during busy hours is determined for each exchange at least once a month; if the 10 000 line groups of the exchanges cannot be measured simultaneously, the maximum conversation minutes for each group are added together, thus giving the total number of conversation minutes for the exchanges; deduction is made from the twelve maximum monthly figures of the three lowest, representing certain months of low traffic; the means of the remaining nine figures are entered under above headings; determination of the number of conversation minutes is a factor of the traffic statistics; these figures are employed in the maintenance summary for comparison with maintenance costs

[5] outgoing traffic from Centralen is appreciably larger than incoming, proceeding mainly to name-call exchanges and group number exchanges

[6] the figures in brackets represent the average number of sequence switches attached to the connecting devices in question

[7] group selectors for local traffic from the Stockholm urban area as also trunk group selectors

[8] including trunk final selectors

Table IX Size of distribution, maintenance and cleaning staff

	Centralen		Södra Vasa		Norra Vasa		Söder		Kungs-holmen		Östermalm		Äppelviken	
	male	fe-male	male	fe-male	male	fe-male	male	fe-male	male	fe-male	male	fe-male	male	fe-male
foreman	(1)[1]		1		1		1		1		1		—	
main distributor	2		2		1		2		2		2		1/2	
fault centre	1		1		1/2		1		1		1		1/2	
apparatus room and trunk positions	11		8		5 1/2		8		8		8		3	
cleaning of automatic devices		3		3		1		3		3		3		(1)[2]
cleaning of premises		2		1		1		2		2		2		1
total	15	5	12	4	8	2	12	5	12	5	12	5	4	2

[1] at Centralen there is a head linesman replacing the foreman; he is also in charge of the maintenance staff at the trunk exchange etc.

[2] female staff for apparatus cleaning do not attend permanently at the suburban exchanges; the necessary number of cleaners move about from one exchange to another

Table X Operating reliability and faults[1]

	Cen-tralen	Norra Vasa	Södra Vasa	Söder	Kungs-holmen	Öster-malm	Äppel-viken
technical fault percentage p (outgoing calls)	0.41	0.05	0.05	0.06	0.19	0.09	0.03
localised faults in connecting devices (incl. clear on test)	2 093	758	346	1 153	960	760	220[3]
localised faults in other exchange devices (incl. clear on test)	535	267	96	423	342	298	53[3]
total localised exchange faults per subscriber	0.16	0.05	0.06	0.06	0.07	0.05	0.05[3]
total localised exchange faults per 10 000 calls	0.28	0.24	0.30	0.31	0.35	0.22	0.51
total of faults entered in exchange books[4]	22 570	10 011	4 289	11 172	10 413	10 406	2 587[3]
total of faults entered in exchange books per 10 000 calls	2.4	2.4	2.9	2.2	2.8	2.2	4.9

[1] figures derived from fault and operating statistics of exchanges

[2] these figures would be double for a full year

[3] in these are included faults in subscriber relays, strips and main distributor, excluding faults in manual trunk positions

[4] in these totals are included all localised and partly localised faults in the exchange itself, at other exchanges and by subscribers of the exchange including handset left off, as also all unlocalised faults

Table XI — Maintenance times and maintenance costs[1]

	Centralen	Södra Vasa	Norra Vasa	Söder	Kungsholmen	Östermalm	Äppelviken
working hours in apparatus rooms and manual trunk positions incl. foreman's time	27 330	21 846	15 436	21 692	21 780	21 732	
working hours in fault centre[2]	2 400	2 400	1 200	2 400	2 400	2 400	
working hours for cleaning automatic devices	7 336	6 419	2 333	5 905	7 116	6 910	
total maintenance hours	37 066	30 665	18 969	29 997	31 296	31 042	
estimated number maintenance hours A[3]	39 230	27 610	16 430	31 490	24 950	29 250	8 500
maintenance hours per subscriber[4]	0.94	1.11	1.15	0.95	1.25	1.06	1.0
wages for maintenance staff[5]	59 147: —	48 643: —	31 449: —	47 894: —	49 175: —	48 898: —	
costs of material and repairs etc. in the automatic system	2 618: —	392: —	418: —	727: —	693: —	663: —	
total maintenance costs U[6]	61 765: —	49 035: —	31 867: —	48 621: —	49 868: —	49 561: —	14 000: —
total maintenance costs per subscriber[7]	3.81	2.37	4.74	1.83	2.66	2.54	2.5
total maintenance costs per 10 000 outgoing calls[8]	6.59	11.67	21.90	9.73	13.45	10.28	13.2
total maintenance costs per outgoing call minute and incoming call minute in busy hours[9]	0.63	0.71	1.03	0.52	0.87	0.61	0.61
total maintenance costs per A[10]	1.57	1.77	1.94	1.54	2.00	1.69	1.65

[1] figures are derived from time-cards and collation of costs
[2] estimated time
[3] obtained by formula $A = 2.3 \cdot V_s + 1.6 \cdot V + 18 \cdot R + 1.2 \cdot T + 10^{-4} \cdot S + K_b \cdot K_f$
[4] the ratio between executed and estimated maintenance hours would normally lie between 1.00 and 1.10
[5] hours worked at each exchange have been multiplied by the mean cost per hour for all exchanges, *viz*: S. Kr. 1.76 for men and S. Kr. 0.93 for women; the mean cost has been calculated in such a way that all wages paid to maintenance staff at Stockholm automatic exchanges, including overtime, holiday and sick payments but excluding pension contributions, have been divided by the total number of hours worked
[6] sundry costs falling outside maintenance costs for the automatic system are not included in the annual statistics so as not to spoil the comparison between the exchanges; these sundries include among other things replacement of an exchange battery and certain administrative costs
[7] maintenance cost per subscriber is evidently a rather uncertain basis of comparison; in general it is found that the more subscribers an exchange has the cheaper is the cost per subscriber
[8] maintenance costs referred to the number of outgoing calls show great variation; were the number of incoming calls known the comparison would be better
[9] by dividing the maintenance costs by the number of call minutes per busy hour for outgoing and incoming traffic the costs are referred to the amount of traffic on the exchange concerned during busy hours; this would seem to be the safest basis for general comparison between different exchanges; if the tending of the exchange is the same at the exchanges concerned, the comparison per call minute brings out the differences between exchanges arising from dissimilarities in system and construction, attendance etc.; in respect of the Stockholm exchanges the replacement of sequence switches by relays, *e. g.*, constitutes an appreciable improvement from the maintenance standpoint
[10] the cost per number of estimated maintenance hours A varies approximately as the ratio between executed and estimated number of hours, which is natural since material costs may be ignored in considering labour costs

The Worlds Northernmost Automatic Telephone Exchange

E. WESTER, TELEFONAKTIEBOLAGET L.M. ERICSSON, STOCKHOLM

The city of Oulu in Finland has recently had an automatic telephone exchange delivered and installed by Telefonaktiebolaget L.M. Ericsson. The exchange is the only one in the world situated above latitude 65° N. The installations, consisting of a local exchange on the Ericsson automatic system with 500-line selectors and manual exchanges for the rural and trunk traffic, were put into service on the night of August 28th to 29th 1937.

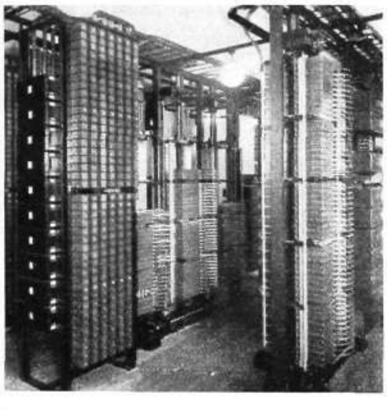

Fig. 1 X 3745
Automatic exchange room

The local automatic exchange is built for 2 500 subscribers but at present only about 1 500 of them are connected. Some 30 lines are routed to public telephone cabins provided with Ericsson telephone coin boxes for automatic cashing, described in the Ericsson Review No 2, 1937.

From a technical point of view the facilities for establishing trunk calls are of the greatest interest. The Finnish Post and Telegraph Administration, which handles all trunk connections in the country, after close study stipulated last year the facilities to be provided by Finnish telephone exchanges regarding the establishing of trunk calls. The installations in Oulu answer in every respect to the stipulations in question. The trunk connections are set up automatically and some 40 junction lines to the automatic exchange are available. The trunk operator, connected over a disengaged junction, dials the calling number wanted and is informed by different signals whether the subscriber is disengaged, locally engaged or trunk engaged. In the first case the subscriber is immediately marked engaged for local as well as trunk calls and the operator can transmit ringing signals. This facility also remains after answer by the called subscriber. If the subscriber wanted is engaged by a local conversation the operator is warned but is not connected in parallel on the conversation. On the other hand cutting in can be done by the operator and a weak warning buzzer informs the subscribers that a third person is listening. The operator then can cut off the subscriber not concerned.

In a country such as Finland, where the number of trunk lines is comparatively limited, it is advisable to increase the utilization of the lines by setting up the connections in advance of the calls. Pending the arrival of the trunk call the subscriber is able to make outgoing calls, although he is barred for incoming calls. For subscribers having several lines and a common calling number, *i.e.*, PBX subscribers, the system installed offers the advantage that the final selectors handling trunk calls can hunt twice over the bundle of lines. Should no disengaged line be obtainable during the first movement, the selector is started again and the line locally engaged first reached is connected.

Odense Telephone Exchange

J. VON LINSTOW, DIRECTOR OF TELEPHONES, FYNS KOMMUNALE TELEFONSELSKAB, ODENSE

On April 4th, 1937, the new Odense telephone exchange was put into service. The exchange delivered by Telefonaktiebolaget L.M. Ericsson replaces a manual CB-exchange and is designed in accordance with a system commonly adopted in Denmark, e.g., the automatic distribution system.
The following description of the new exchange is a report of a lecture held at the 5th congress of Scandinavian Electrical Engineers at Copenhagen in August 1937.

The concession of the Municipal Telephone Company of Fyn covers the diocese of Fyn, Fig. 1. The largest city, Odense, has a central position among the other 94 central exchanges. The situation of Odense and the fact that 90 000 of the 360 000 inhabitants of the diocese live in the Odense exchange area contribute to make Odense the main city of the diocese from the telephonic point of view, as in many other respects. This importance is further illustrated by the fact that 9 000 of the 27 000 subscribers of the Company belong to the Odense exchange, to which 40 % of the 11 000 000 interexchange calls of the Company are connected, and 17 000 000 local calls out of a total of 32 000 000 take place in Odense.

The main exchange at Odense, connected over direct junctions with 9 sub-exchanges, consists of two sections of approximately the same size, *e.g.*, a section for interexchange calls and a local exchange. Since the local exchange is of the greatest general interest, attention will be devoted chiefly to this exchange and only the main principles for establishing interexchange calls will be dealt with.

Choice of System

The calculations preceding the determination of the system for the local exchange made it clear that the two systems under comparison, *i.e.*, the full automatic system and the automatic distribution system were equivalent from the economic point of view. In respect of economy an entirely automatic system is not superior to an efficient manual system in cities not requiring more than one exchange for the telephone service. If a city is of such size that several exchanges are needed the conditions might not be the same, which does not, however, apply in this case.

Fig. 1
Map of Fyn

X 3769

The gain of a cheap 24 hours' service may affect the choice of the system to the advantage of the automatic system, a consideration not, however, applicable to Odense, as this city is surrounded by a manual network unlikely to be discarded for years. Consequently the night traffic between Odense and the remaining part of Fyn would have to be handled manually even with a full automatic exchange at Odense. The small increase of manual staff required in order to handle the local traffic simultaneously during the night was made clear by an investigation that was carried out, the result of which estimated for 1937 is shown in Fig. 2. Basing on this investigation it was decided that all night traffic, whether interexchange, local or trunk traffic, should be handled by a special small exchange, called the night exchange, working between 9 p.m. and 7 a.m. The fact is that the total night traffic can be handled by one or two operators, and it does not seem likely that this number could be further reduced, even if the local exchange was an automatic one.

The company had consequently no reason to choose an automatic system, since the latter would not involve lower running costs or additional ease in arranging 24 hour service.

From the subscribers' point of view it can hardly be denied on impartial consideration that there is no comparison between a really up-to-date manual system and on automatic system. In the former system the subscriber under any conditions — good as well as bad — has only to lift his handset, get a quick answer, give the number wanted and at the end of the conversation he gets immediate clearing. Besides, the presence of the multiple and the elasticity introduced by the latter renders it possible to grant further advantages to the subscribers as far as reference calls to the inquiry desk and correct calls in spite of change of number, are concerned.

In the automatic system the subscriber takes the place of the operator and in order to get the connection wanted he has to carry out the work that otherwise the operator is supposed to do. This fact does not add to the convenience of subscribers but just the contrary. Further it must be taken into consideration that under certain conditions the dial cannot be used, *e.g.*, in bad light or complete darkness, if spectacles are mislaid, when age or illness render the use of the telephone instrument difficult, and during other events of life; consequently from the subscriber's point of view a system offering skilled assistance under all conditions is to be preferred — provided that the two systems work with the same speed and reliability. As to speed, any desired degree can be attained. In manual systems it is merely a question of the service and staff available and depends in both systems on the number of switches. As regards reliability nobody can say that the number of faulty connections is smaller when a thousand individuals, all having different interests, have to set up for themselves the connections wanted, as against a well skilled staff of operators establishing the connections. That self-done as a rule is well-done but other people's faults are catastrophes is another point of view having no influence on the fitness of the system. From the social point of view it is unreasonable to reduce employment, when no economical advantage for the undertaking or the telephone subscribers is to be gained.

Fyns Kommunale Telefonselskab decided in view of these circumstances to install the new telephone exchange at Odense on a system giving the greatest possible efficiency and obtained the necessary license from the State Control Office for licensed telephone companies.

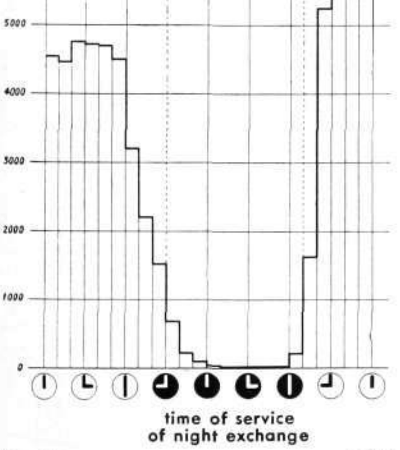

Fig. 2 X 3748

Number of connections per hour during the day

for interexchange traffic (above) and local traffic (below)

Charges

The constitution of the company requires that the same rates should be applied to all subscribers. The rates are therefore the same throughout the area, whether the subscriber is connected to a small rural exchange, a town exchange of medium size or the Odense exchange and also irrespective of whether the subscriber is located close to or remote from the exchange.

In considering the design of the Odense exchange it must be noted that two categories of subscribers are connected to the exchange; we will call them A and C-subscribers. The A-subscribers are entitled to have calls over the whole area while the C-subscribers are not entitled to calls beyond their own exchange area, *i.e.*, an area comprising subscribers connected to exchanges within a distance of 10 km from their own exchange. A subscriber belonging to either category may contract for an unlimited number of calls or else for a number limited to 1 200 calls per year. In the latter case all excess calls have to be paid at a rate per call, this rate, however, not being the same for the two categories.

When ordering calls beyond their own exchange area, in the following denoted as interexchange calls, those A-subscribers who have an unlimited number of calls at their disposal have not to be noted with a view to charging, and the A-subscribers having a limited number of calls only have to be charged with a call, since the destination of the call is of no importance. Such metering can take place in the local exchange and consequently as regards charging no A-subscribers are of interest to the exchange from which the interexchange calls are established. This exchange is called the interexchange office in the following.

As all C-subscribers have to pay a certain charge for all calls routed beyond the Odense exchange area, all their calls have to be recorded at the interexchange office for charge. Since these subscribers as well as the A-subscribers are charged with a call by ordering an interexchange call, the number of local calls on the quarterly bill is reduced by the number of interexchange calls. Consequently a subscriber having many interexchange calls does not contract at C-rate. This is the reason why the number of interexchange calls originated by the C-subscribers is only a very small part of the total number of interexchange calls.

With regard to the establishment of the calls, all calls are recorded at the interexchange office, whether ordered by an A- or a C-subscriber. If, however, on ordering an interexchange call it were possible to inform the operator at the interexchange office that the calling subscriber is an A or a C-subscriber, the calls could be divided into two groups, *e.g.*, those of the predominating A-group which after establishment of a call are of no more interest for bookkeeping, and those of the smaller C-group, which have to be entered in the books for charging purposes. This arrangement would cause an immense simplification of the metering department. The problem is solved by having different calling signals for calls originating from A and C-subscribers. The junction lines to the interexchange office are provided with an A and a C-jack and a call causes a white or a green lamp at the interexchange office to light up indicating an ordering call from an A or a C-subscriber respectively. By using two separate calling signals it is possible to add a third one, *viz.:* alternate flashing of the white and the green lamps. This signal is provided for the trunk exchange of the State, indicating subscribers who on account of arrears are barred for trunk calls. Such subscribers when calling the State trunk exchange are connected over a separate junction to the supervisor at the trunk exchange.

Design

Before inviting tenders, the company worked out circuit diagrams and descriptions of every category of lines and the properties required of them,

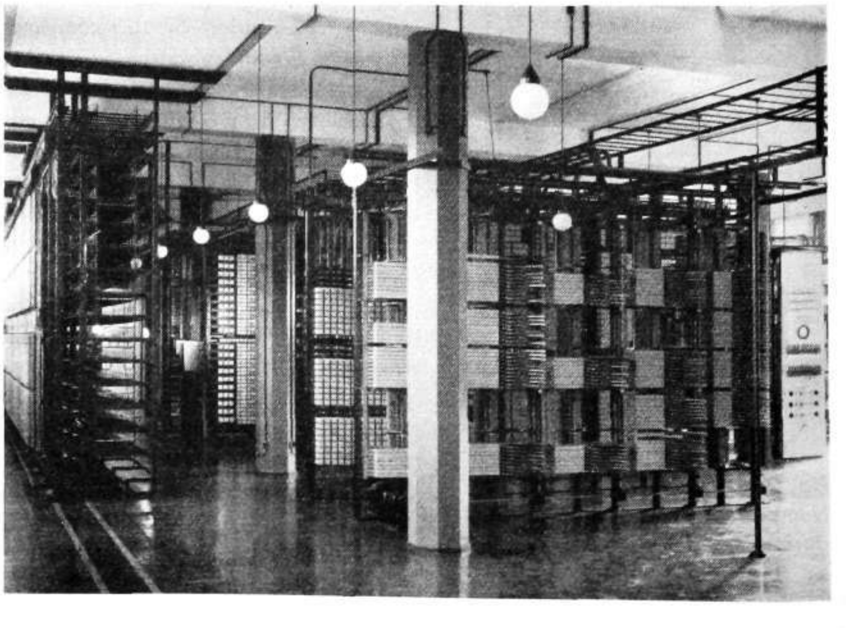

Fig. 3 X 5386
Automatic equipment room of Odense telephone exchange

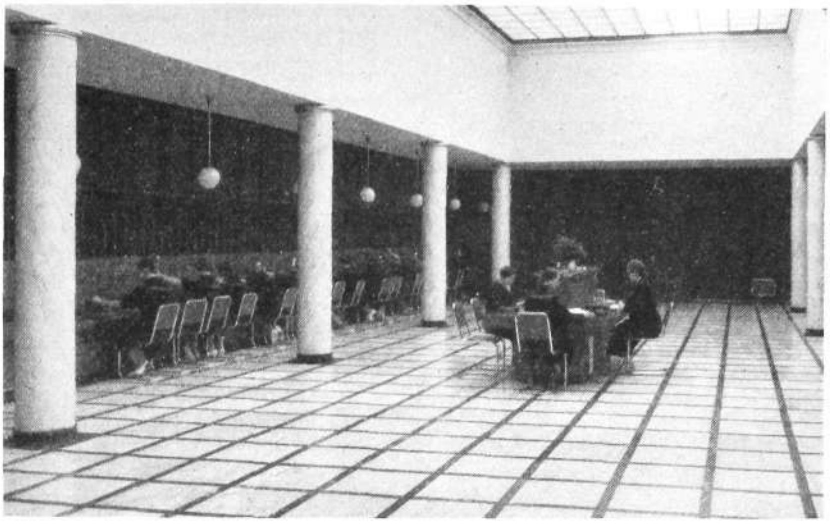

Fig. 4
Odense manual exchange

X 5387

stipulations that in all main respects remained unchanged apart from modifications suggested by Telefonaktiebolaget L.M. Ericsson which secured the order to build the exchange and which on its part, in view of its vast experience, did a great deal of good work in rearranging and improving the circuits proposed, to the advantage of the system and its reliability. Right from the beginning of the delivery of material and the erection it was a pleasure to see with what care and sense of fine installation work the exchange grew, so that it now illustrates the fact that complicated technics and beauty can very well be combined, see Fig. 3 and 4.

As already mentioned the system is an automatic distribution system, *i.e.*, a system that at any moment automatically distributes all incoming calls from subscribers and sub-exchanges as smoothly as possible to the attended manual positions. The staff of operators may therefore throughout the fluctuating traffic conditions during the day be adapted to the actual traffic flow, since a single attended position forms a complete exchange.

Automatization is carried out to the extent that the operators only have to receive a number and insert a plug. Thus the automatic devices have to hunt for the calling subscriber, connect him to a disengaged manual cord at a disengaged operator, light the calling lamp, connect the operator to the cord automatically, transmit answering signal, busy test and ringing signal and at the end of the conversation clearing signal. This last facility makes it possible for the two subscribers to make a new call immediately after replacing their handsets, whether the cord over which they were connected be taken down or not.

The selectors used for the connection of calling lines are the Ericsson 500-line selectors and the multiples belonging to the selectors contain four wires per subscriber's line to provide for the double calling signal. Every operator position is divided into two half-positions, each of which can receive a call. The first call is visible but the second one only when the first has been established. As already mentioned, the calling signals are different if A or C-subscribers are calling, *viz.*: a white or a green lamp. The automatic answering signal of the exchange consists of two parts, at first a continuous weak buzzer tone transmitted from the connection of the half-position to the moment the calling signal becomes visible, and then three stronger tone signals, the last of which is also heard by the operator.

The operators are not provided with microphones and are consequently debarred from conversation with the subscribers. This arrangement is made in order to ensure rapidity in establishing calls by precluding the possibility of calling the operator's attention to other matters than giving the calling

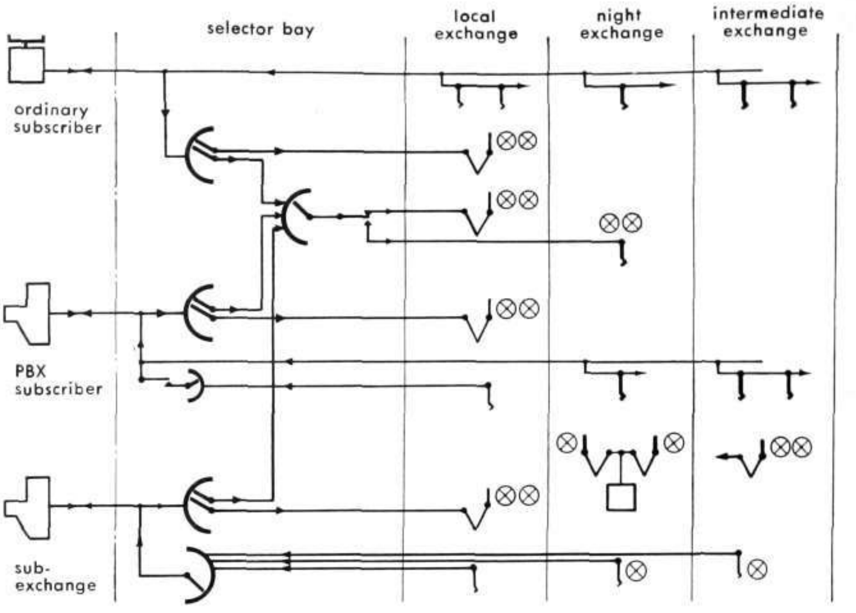

Fig. 5 X 5385
Trunking diagram of Odense telephone exchange

number. Another reason is to prevent discourteous answer being given on repeated call after, *e.g.*, a faulty connection, and possible impoliteness by subscriber to the operator who has to deal with the repeated call but in all probability was not the operator who established the first connection. If after the transmission of the answering signal the number wanted is not distinctly heard, the three signals can be repeated as a request to the subscriber to give the number again. In difficult cases the call can be routed to an auxiliary position, at which an operator can speak with the subscriber and forward his call. After receipt of the number wanted the connection is established without test. If the called subscriber is busy, the exchange transmits an interrupted buzzer tone; if he is disengaged, ringing signal is heard at intervals of a few seconds.

At the end of the conversation clearing takes place automatically. The operator is informed by a single clearing lamp that does not light up until both subscribers have replaced their handsets. The fact that both the subscribers must transmit clearing signal, coupled with the design of the selectors in the system, makes it possible without special technical devices to catch calling subscribers, who abuse the telephone with insulting or criminal intention. A subscriber reporting that he has been troubled is requested not to replace his handset if he again receives such a call. In this case the switches over which the call is routed give alarm, and the selector that has connected the caller as well as his number can thus be located.

Fig. 6 X 3770
Diagram of the answering time
the diagram shows the percentage of calls having an answering time of 0, 1, 2, 3 . . . 10 s; the average answering time is 2.3 s

The local exchange contains ordinary subscribers as well as PBX subscribers, *i.e.*, subscribers having 2, 3, 4 or 7 lines with common calling numbers and junction lines to the sub-exchanges including State trunk exchange and the interexchange office. The main routes of the local exchange appear from Fig. 5, showing an ordinary subscriber, a large subscriber, and a subexchange junction line. As may be seen each 500-line group has a number of ordinary selectors directly connected to the manual cords and also a few supplementary selectors routed to a multiple of a number of second selectors allotted to a bundle of supplementary cords. As long as a 500-line group contains a disengaged ordinary selector, no supplementary selectors can be started. The latter constitutes a common reserve for the whole exchange and is provided to deal with the traffic peaks, wherever such a peak may arise. The supplementary selectors are not only routed to the supplementary cords at the local exchange, but are also connected in parallel to jacks and lamps at the night exchange in such a manner that when the local exchange is put out of service and the night exchange is working, all ordinary selectors are disconnected and only the supplementary ones in function. The connections are established by means of cord pairs of such design that the inserting of an answering plug corresponds to the lifting of a single cord at the local exchange. The putting into service of the night exchange takes place quite automatically as the operators successively leave their places in the local exchange and the night attendants take up their positions. On answering the word »Odense» is used by the night operators.

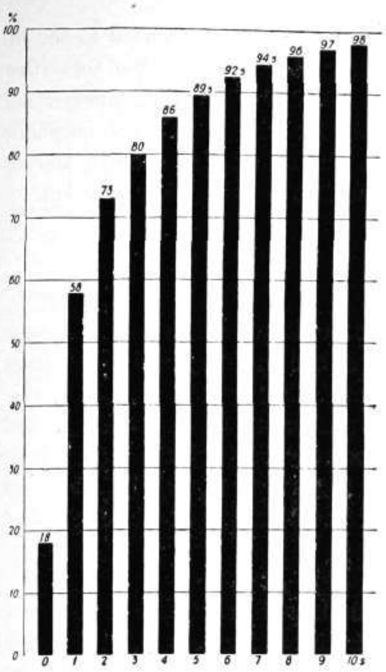

Fig. 7 X 3768

Diagram of the answering time

the diagram shows the percentage of calls handled in a given answering time

The ordinary subscribers are provided with multiples at the local exchange and at the intermediate exchange for interexchange and trunk calls and the night exchange. For large subscribers the first mentioned of these multiples is replaced by a special provision facilitating automatic connection without busy test to a disengaged line. This is done, by large subscribers with 2 or 3 lines being provided with one local jack (PBX subscriber's calling number) at each position and large subscribers with 4 and 7 lines with two local jacks. These jacks are wired to the contact segments of 25-point selectors, the number of which corresponds to the number of lines of the subscriber. By plugging in a local jack at any position, the disengaged selectors belonging to a bundle of lines are started and hunt for the calling position. The selector that first finds this position connects the line and the connection is established. Should all lines be occupied with calls to or from the subscriber or possibly in both directions, the inserting of the plug into any local jack would cause busy signal to be transmitted to the caller.

At the intermediate and the night exchanges, both of which require busy test, every line in the bundles of large subscribers is provided with multiple jacks in view of the requirement that interexchange and trunk calls shall have access to a certain line. These multiple jacks are mounted in vertical rows for each bundle of lines in order to point out clearly the lines belonging to the same subscriber.

The junction lines to the nine sub-exchanges belonging to the Odense area and the lines to the State trunk exchange are arranged in the same way as the large subscribers, but with considerably more lines and consequently a greater number of local jacks, up to six per position. These lines are provided with local jacks not only in the local exchange but also in the intermediate exchange and the night exchange, because at the latter two exchanges, at which busy tests as a rule have to be carried out, it would be too much waste of time to test on the large number of junction lines to the sub-exchanges. The only difference is that at the intermediate and the night exchanges each bundle of local jacks is provided with a lamp that lights up only when all junctions to the subexchange concerned are busy. If the lamp is not glowing any disengaged jack can be taken without test and a line finder will find a disengaged line of the subexchange. Due to the large amount of local jacks the selectors of these groups are of the common 500-line type, the movement of which, however, is restricted to a limited number of multiple frames. Calls from the subexchanges are routed to the Odense exchange as ordinary subscriber's calls.

Among other special facilities may be mentioned that the exchange can announce the time when a call is made to »time» and that a separate posi-

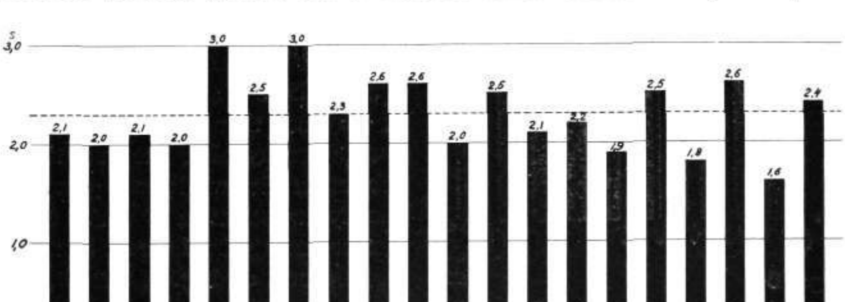

Fig. 8 X 5388

Average answering time within the 500-line groups

tion serves public coin boxes. Further subscribers can be connected to the information office. For this purpose the exchange equipment of the subscriber is connected to the position in question and his line to a calling number not known by him, in order to make it possible for him to use his telephone instrument for calls, if he is at home for a short time, for example during holidays. Further the exchange is provided with a routine test equipment.

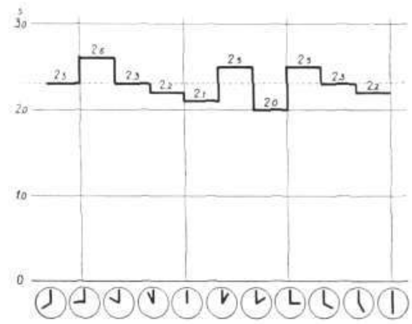

Fig. 9 X 3751
Fluctuation of the answering time during the day

Traffic Results

The initial capacity of the exchange is 10 000 ordinary subscribers and 1 000 large subscribers and its ultimate capacity 22 000 ordinary and 2 000 large subscribers. The intention with such a distributing system was to *ensure quick answer* to a call by distributing the total work of the exchange and avoiding accumulation of calls to positions already busy by the reduction of the manual work due to the automatization, and *to increase the efficiency of the operating staff, i.e.* to obtain a suitably increased number of calls established per operator and hour.

In considering the traffic results now to be dealt with it must be remembered that the exchange has only been working for three months, so that the staff is not yet trained to perfect operation of the new system which in several respects differs from the system formerly in use, and that the final distribution of switching devices and junction circuits could not be fixed before the above traffic results were known. With the distribution of switches and junction circuits, the Ericsson system offers great advantages in respect of elasticity. This is gained by the fact that selectors as well as junction circuits constitute loose apparatus to be connected to the system by means of jacks, thus rendering is possible to shift them from one group of subscribers to another at any time wanted.

Checking of the answering time, *i.e.*, the time elapsing between the moment a subscriber is ready to order a call and the answering tone being transmitted from the exchange, covers 20 000 calls and shows an average answering time of 2.3 s. However, such an average figure is no guide to the quality of the service unless its composition is known, especially the number of long answering times. On the diagrams, Fig. 6 and 7, the answering times are collected in groups of full seconds so that the answering time of 0 s contains all answering times up to 0.4 s, the answering time of 1 s all answering times between 0.5 and 1.4 s etc. Fig. 6 shows the percentage of calls corresponding to answering times 0, 1, 2, 3 .... 10 s. As may be seen 18 % were answered immediately, 40 % after 1 s etc. 2 %, however, having an answering time of more than 10 s with an average of 16 s. Fig. 7 shows the percentage of calls handled within a certain answering time indicating that 58 % were established within 1 s, 73 % within 2 s etc. up to 98 % within 10 s.

However, even these particulars regarding the composition of the average answering time are still insufficient. We require to know whether every subscriber connected to the exchange is well served. Fig. 8 shows the average answering time within the different 500-line groups of the exchange. The group marked PBX indicates the large subscribers group. As may be seen the highest average is 3.0 s, *i.e.*, 0.7 s above the total average. For the remainder the variations are comparatively small. Recognizing that the groups *4* and *6* have a somewhat too high average value and the groups *16* and *18* at the same time have a low one, we can make use of the elasticity of the system and equalize the variations by increasing the number of switching devices in the two former groups with switches taken from the latter ones. Finally investigation is made, as to whether the service is to some extent similar during the different hours of the day. The result of this investigation is, as shown on Fig. 9, that the fluctuations of the average answering times are so small that the quality of the service can be considered as homogeneous during the whole day.

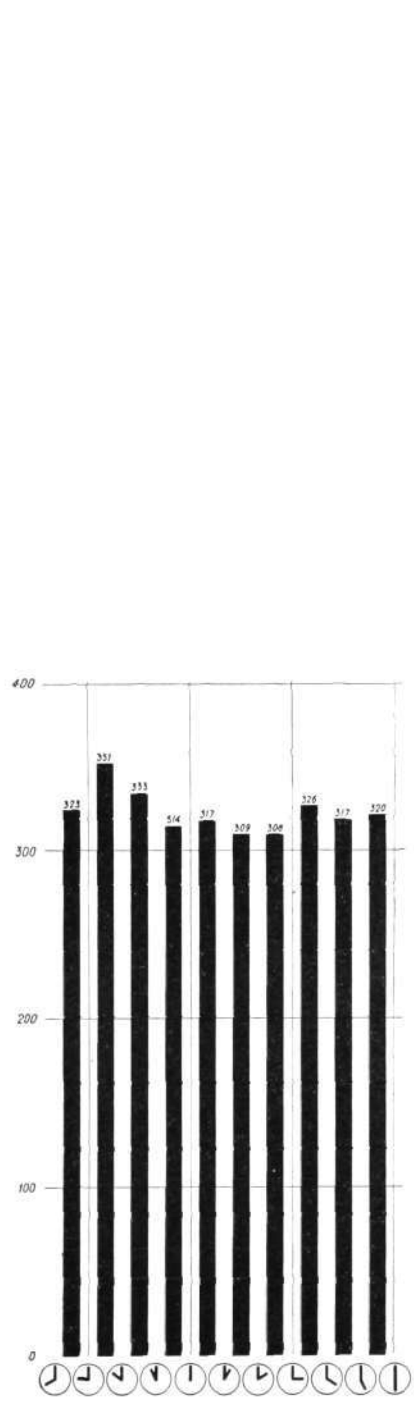

Fig. 10 X 3752
Number of calls handled during the day

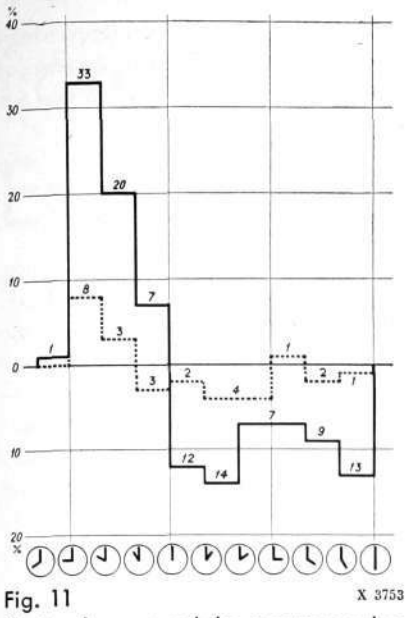

Fig. 11 X 3753
Fluctuation around the average value of the number of calls and the number of connections handled
— call curve
---- connection curve

Turning to investigation of the utilisation of the staff, Fig. 10, indicates that during the day, *i.e.*, from 8 a.m. to 6 p.m., the number of connections established per operator and hour was 308 to 351, an average of 323. This figure ought to be increased but for that purpose not only has the staff to be more practised, but the subscribers themselves must get accustomed to answering more rapidly and distinctly in order to reduce the number of repeated answering signals. In that respect, however, the greater slowness of the inhabitants in a provincial city, as compared with those of a large city, must be taken into consideration. On Fig. 11 are also shown the fluctuations around the average value of curves for the number of calls and connections established. Obviously the strongly fluctuating call curve is transformed into a considerably more even working curve. Being thus informed about these fluctuations it is possible to equalize the peak between 9 and 10 a.m. by increasing the number of operators, whereas the staff may be reduced to some extent between 1 p.m. and 3 p.m. Finally, Fig. 12 indicates the number of connections made by each of the positions. The deviations from the average figure 323 are not great except with regard to a few positions, but the system facilitates correction by transferring some junction circuits from the positions *6* and *9* to the positions *18* and *22* in the junction circuit intermediate field.

Connections beyond the Exchange Area

The interexchange calls coming in to Odense are twice as many as the outgoing interexchange calls from Odense. For the main part of the incoming calls a separate section is installed. This section is provided with the Odense subscribers' multiple and with the interexchange lines directly routed to the positions of this section in such a way that the greater part of the incoming interexchange calls can be handled as if they were local calls. Thus the cheapest possible operation is ensured. This section is called the intermediate exchange. The outgoing interexchange calls from Odense are established by a separate interexchange office without the subscribers' multiple. The interexchange lines as well as the ordering lines for interexchange calls from Odense subscribers are designed on the lamp-multiple system, causing all calls to be indicated by a row of signals distributed among the positions of the exchange. One third of the exchange staff is able to answer every call but only the operator who first inserts the plug can be connected. The calls ordered are recorded out by the operators, who forward the calls. When establishing connections the operators reach the Odense subscribers over a

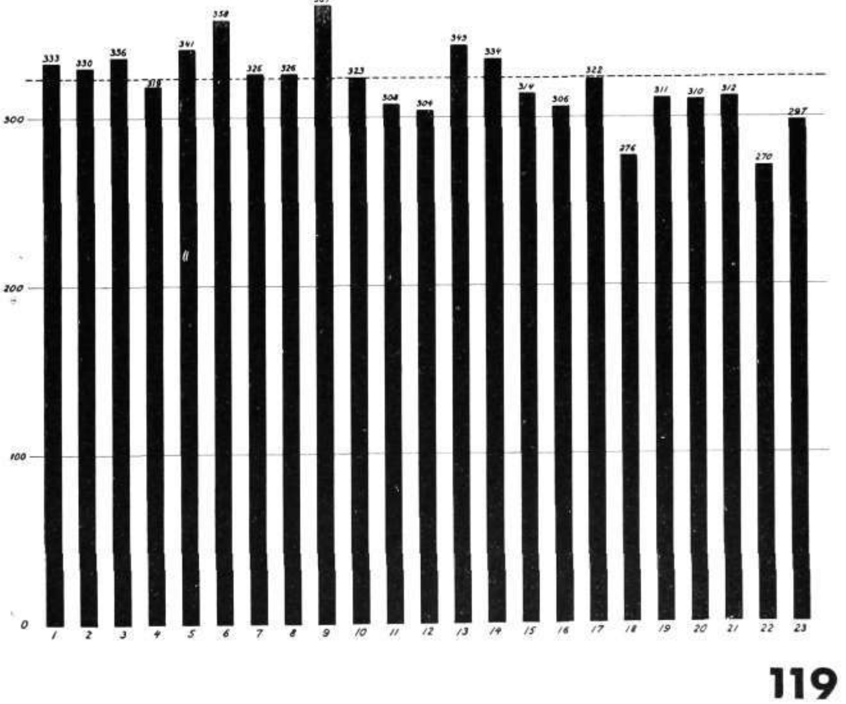

Fig. 12 X 5389
Number of connections handled by the different positions

bundle of junctions to the same intermediate exchange to which interexchange lines for *incoming* calls are routed. Automatic line finders hunt for disengaged junction lines. The State trunk exchange at Odense finds disengaged lines for the establishing of trunks calls in the same way.

Transit Connections

As may be seen from the map of Fyn, Fig. 1, and the situation of Odense, a not insignificant number of calls has to be routed transit over Odense. In the old exchange it was impossible in spite of all efforts, to reduce the waiting time for these calls to a reasonable value compared with calls to and from Odense. The reason evidently is to be found in the fact, that — consciously or not — the operators made a distinction between »own subscribers», *i.e.*, Odense subscribers, and »foreign subscribers» to the disadvantage of the latter. In order to eliminate this purely psychological factor, a separate branch exchange is detached from the interexhange office, to deal exclusively with the transit connections. The result of this arrangement is that the waiting time of the transit calls now is of the same value as that of interexchange calls to and from Odense subscribers. All calls, even those with transit destination, are routed to the interexchange office. When »transit» is asked for, the operator at the interexchange office has only to push a button, whereby the call lamp signal from the interexchange office will be forwarded to the transit exchange. The interexchange office as well as the transit exchange are provided with conversation time control devices on every line. This control is carried out as follows: When a plug is inserted in order to forward an interexchange call, a green lamp connected to the manual cord pair flashes. When the conversation is established, a button has to be pushed and the lamp goes out; when the 3 min. conversation period is over, the green lamp glows continuously again.

Large Private Automatic Branch Exchanges

E. WESTER & E. NILSSON, TELEFONAKTIEBOLAGET L.M. ERICSSON, STOCKHOLM

During the last few years a variation of the Ericsson automatic telephone system with 500-line selectors has been developed, which is called OS PABX, and is intended for large private automatic branch exchanges. This new system has already been put on the market. In the Ericsson Review No 4, 1935, a description was given of such an installation as delivered to the Victorian Railways in Melbourne. Below are given descriptions of the series of exchanges manufactured by Ericsson on this system, with particular reference to the provision for fulfilling all the demands which may be made on an up-to-date telephone exchange.

A telephone installation is nowadays considered an absolute necessity for any undertaking of importance and the facilities offered have become more and more comprehensive. The first requirement is the possibility of quickly and easily establishing internal telephone connections between persons within the undertaking as well as external connections over the public networks for a number of these persons. It was soon realised as automatisation progressed that it would be an advantage to arrange the internal traffic automatically in order to increase speed and reliability. At first separate telephone instruments were installed for internal connections and those requiring to make external calls were provided with a second instrument, connected directly or over a manual exchange to the public network. It was thus possible while carrying on an external call to make an enquiry call over the other instrument to persons within the undertaking. As it would hardly be necessary to converse simultaneously over the internal extension line and with the public exchange subscriber, it was proposed to introduce a switching device by which the one instrument could be connected for an internal or an external call as required. In this way the desk was relieved of one of the two instruments. At first these alternative connections were carried out by means of a switch on the instrument requiring two lines to be wired to the desk instrument, which had the disadvantage of making the instrument rather complicated.

In an up-to-date telephone installation on the OS PABX system these disadvantages are entirely removed while at the same time a number of additional facilities of considerable value are provided. Thus it is possible to originate outgoing calls automatically, to make inquiry calls over the branch exchange as well as the public exchange, to transfer a public call to another extension etc. All these connections are made by means of the dial of a quite ordinary subscriber's instrument, the manipulation of which is quite simple to grasp.

Normal Traffic Facilities

Internal Calls

To originate an internal call, the receiver is lifted and on receipt of dialling tone the required number is dialled. If the extension is disengaged ringing current will be transmitted. This current is cut off when the call is answered, and the connection is then established. The caller hears ringing tone as the ringing current is transmitted. If the called extension is busy the caller receives busy tone. Replacement of the handset causes disconnection and the switches are restored.

Exchange Calls

It may often be desirable to bar some extensions for public exchange calls, for example where a higher annual charge has to be paid for extensions entitled to public exchange calls. Apart from extensions completely barred in this way, it is possible to have extensions connected which have access to the public network only through the private branch operator. The public exchange to which the branch exchange is connected may be of any system, automatic or manual CB or magneto. The private exchange equipment will always be the same, but requires the addition of simple junction line repeaters if connected to an LB-exchange. This method has been adopted to avoid alteration in the branch exchange equipment should the existing LB-exchange be replaced by one on another system.

Outgoing public exchange calls are originated by dialling digit *o*, whereby a disengaged public exchange line is connected automatically. If the public exchange is automatic the PABX extension hears dialling tone from the public exchange and then dials the number of the subscriber wanted. If the public exchange is manual, the private branch extension communicates the wanted subscriber's number to the public operator. If all exchange lines are busy at the time or if the call is attempted from a barred extension, busy tone is heard after dialling *o*.

Incoming public exchange calls are received by an operator who forwards them to the persons wanted. As the OS PABX system is designed for rather large installations, it has been equipped with manual switchboard for incoming exchange calls, this being the best method for large installations. The exchange lines and all extensions not barred for incoming exchange calls are provided with jacks in the manual switchboard, and over these the operator can quickly and accurately connect exchange lines and extensions by means of cord pairs. One reason why cord pairs have been adopted is that any faults arising in the cords may not put exchange lines out of service. With heavy traffic, however, the operator's work may be made much easier by not removing the answering cord from the exchange jack. Connections are then made as in a single cord system.

An incoming exchange line call causes the calling lamp to light up, whereupon the operator answers and, by testing with the ringing plug on the jack sleeve, learns whether the extension required is busy. If the extension is disengaged the operator transmits ringing current. The cords of the manual switchboard may be provided with automatic ringing device. On insertion of such a cord in the jack of a busy extension the conversation proceeding is not disturbed but the call offering is held waiting and ringing current will be transmitted immediately the call ends. Before transmission of ringing current the clearing lamp flashes, informing the attendant that the connection has not yet been established. When the extension answers the lamp goes out but again lights up at the end of the call. The operator then has to restore the cord. If a new call arrives before the operator has had time to remove the cord, the calling lamp lights up in the usual manner but the extension to which the cord is plugged in is not connected to the new call.

As it is desirable that urgent calls, particularly trunk calls, may have access even to busy extensions, the attendant can cut in on calls proceeding, whereby the subscribers are notified by a faint buzzer tone that the operator is listening. The attendant may then disconnect the extension not concerned. If all exchange lines should be busy the trunk operator as usual is able to cut off an exchange line connection. The manual switchboard at the branch exchange is then called by ringing current, the occupied extension is disconnected, after which the operator can forward the new call in the usual manner.

Fig. 1 X 3763

Telephone instrument, Type DBK 11

all instruments are of normal pattern without push button and are connected over two-wire lines without additional wire or earth connection

Connections through Operator

On dialling the digit *9* the manual switchboard will be connected. Such a call cannot be forwarded to other lines and consequently extensions barred for external calls are prevented from obtaining calls in this way. The operator can, however, be requested to call a public exchange subscriber and connect same to a non-barred extension. As the operator can cut in on busy extensions, it is also possible to order the establishment by the operator of a particularly important internal call to a busy extension. The operator warns the two subscribers and cuts the connection, or he may wait intil the conversation going on is completed and then insert a plug in the jack of the wanted subscriber. When the line becomes disengaged, a lamp lights up and the operator can establish the connection ordered.

Call-Back

An extension connected to a public exchange line has the facility of making call-back by dialling the first digit on the dial, *i.e.,* usually the digit *1*. This disconnects the exchange line but clearing signal is not transmitted to the public exchange. The extension is then connected to the automatic equipment over a separate intermediate unit and the internal number wanted may be dialled. Having obtained the required information it is possible to return to the exchange line by again dialling *1*. Provided that the local extension called does not replace the handset, alternate connection with extension and exchange line may be effected by repeatedly dialling the digit *1*. If on the other hand the local extension's handset is replaced, the inquirer on making a new call-back is again connected to the automatic equipment and may make new call-back to any line. Call-back may be made to any line accessible to a normal call over the automatic exchange.

If the line wanted for call-back is already busy and the importance of the exchange call makes it a necessity for the inquirer to have the call-back connection, he calls the operator by dialling *9*. In this case the inquirer is connected with the manual switchboard over a separate junction unit, the exchange line being held busy. If the line wanted is available in the multiple field the attendant can forward the call as desired. To return to the exchange line the inquirer dials digit *1* in the usual way. Call-back can also be made to another exchange line.

Transfer

An exchange line connection may be transferred to another extension provided that this latter is not barred for such calls. After a call-back the inquirer replaces his handset and the connection is automatically transferred to the called extension. The first extension is immediately released and the second one, having now received the call, has in his turn the same facility of making call-back and transferring the call. Thus the transfer of a call is entirely under control of the one passing on the call. Periodic ringing current is then automatically transmitted and if this is not answered in a certain time the exchange line is connected automatically to the operator's position by means of the above-mentioned tie unit. If attempt is made to transfer an exchange call to a barred extension or to another exchange line, the first exchange line is in the same way connected to the manual board. The same also occurs on attempt to transfer the call to a busy extension. Thus the switching process is supervised and any call not correctly dealt with is automatically transferred to the operator. After a call-back forwarded by the operator the connection may also be transferred. As before the originating party has only to replace his receiver.

Night Service

During the times when the operator is not on duty, all or some of the exchange lines may be arranged for night service. If the public exchange is so designed that it is possible to call individual lines of the bundle connected to the PABX concerned, incoming calls can be routed to extensions specially allotted to predetermined exchange lines. Before going off duty the operator throws a number of night switching keys and inserts the plugs of the corresponding cords in the jacks of the lines assigned. An incoming exchange line call is connected thereafter to the appropriate extension automatically. If the extension is disengaged ringing current is transmitted. In the contrary case a warning tone indicates that an incoming call is waiting. The call is answered and if desired may be rerouted on the call-back and transfer method. An extension assigned for night service has the same facilities as others for internal and external calls.

If desired all incoming exchange calls may be routed to one extension. In this case a key is thrown which causes all incoming calls to be routed automatically to the extension in question. It may also be advisable to connect the tie units, by which call-backs and transfers to the manual switchboard are normally effected, to the night service devices. When the manual board is not attended, all calls handled by these tie units are routed to a certain extension, so that it is possible to ascertain whether exchange line connections already established are dealt with correctly. As the number of night service intermediate devices is limited it may occur that some incoming calls cannot be dealt with immediately. The system therefore comprises queue facilities for incoming calls awaiting attention.

Special Traffic Facilities

Conference Calls

The connection of several extensions for a conference is carried out as a rule by the operator. Extensions which may often be engaged in conferences are provided with individual connecting devices at the manual board, these consisting of connecting and ringing keys and a feeding relay that actuates a signal lamp. The device may be fitted with an additional relay making it possible without disturbing an existing conversation to ascertain whether the extension is busy or not. In addition to these special extensions, a limited number of other extensions may be connected by means of ordinary junction cords, provided these extensions are provided with jacks in the manual board.

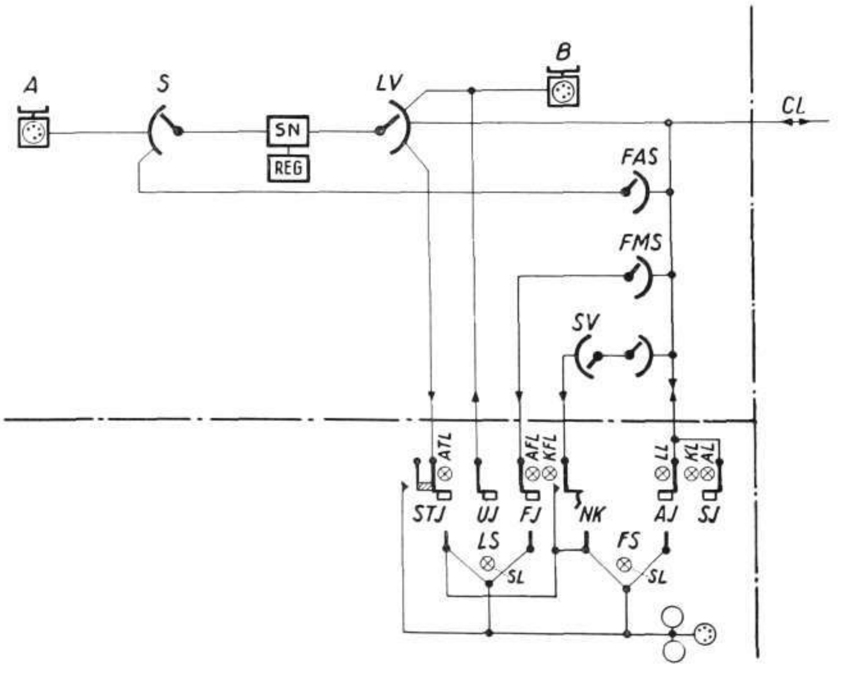

Fig. 2 X 5399
Routing diagram for 400-line branch exchange, System OS PABX

A, B	telephone instruments
AFL	calling lamp for FJ
AJ	calling jack for exchange line
AL	calling lamp for SJ
STJ	calling lamp for STJ
CL	two-direction exchange line
FAS	intermediate unit for automatic call-back and transfer
FJ	jack for call-back to operator
FMS	intermediate unit for manual call-back and transfer
FS	junction cord
KFL	supervisory lamp for FJ
KL	supervisory lamp for SJ
LL	idle indication lamp for AJ
LS	cord for internal connections
LV	final selector
NK	key for night service
REG	register
S	line finder
SJ	answering jack for CL
SL	clearing lamp
SN	automatic link circuit
STJ	answering jack for calls to operator
SV	night service equipment
UJ	multiple jack for non-barred extension

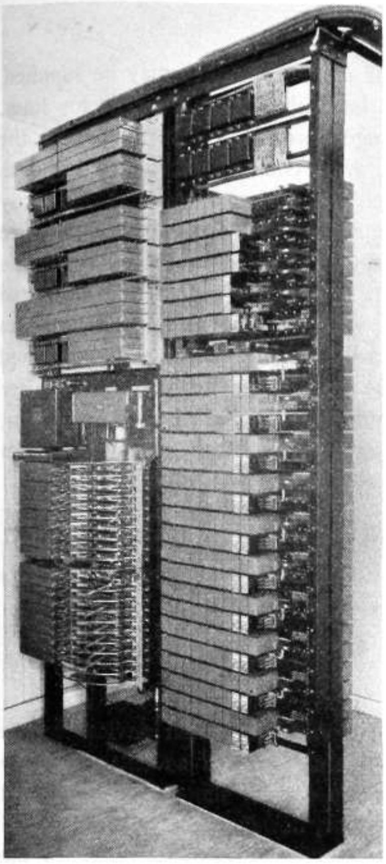

Fig. 3 X 3764

Automatic equipment for 90 lines

with 10 conversation facilities, 20 exchange lines, 2 automatic and 2 manual junction units and 2 night service devices; the bay is 2.4 m high and 1.4 m wide

By the introduction of special circuits in the automatic equipment and complementary units for the extensions concerned, the establishment of conference calls may be effected quite automatically. The extensions for conference are in this case requested to dial a special digit, which causes his line to be disconnected from the exchange equipment. In view of the greater convenience in establishing the connections and for economical reasons it is, however, preferable to have conference calls handled by the operator.

Preference Calls

Provision can be made for certain extensions allotted to the higher staff, whose calls are often of a specially urgent nature, to break in on calls established. As, however the normal design of the system allows of such breaking in with the aid the operator, the supplementary devices for automatic breaking in should only be introduced in exceptional cases.

Extensions provided with automatic preference facilities can listen in on calls proceedings with a view to supervising them. Still for this purpose also a manual supplementary device is preferable.

Staff Locater

Staff locating equipment is installed in order to facilitate the search for a person not available at his own extension. This equipment is connected over two lines to the automatic exchange. It actuates a number of lamp sets located at conspicuous spots in the various departments. For location of 15 persons four lamps per signal set are required and for 70 a maximum of eight lamps. The locating equipment is called in the same way as a normal extension. On hearing dialling tone from the staff locating equipment the originating party dials the special two-digit calling number assigned to the wanted person. The corresponding lamp combination is lighted and at the same time an audible signal is emitted. When the person sought observes the signal he obtains connection with the calling party by dialling the answering number of the locating equipment on the nearest extension. The staff locating equipment is intended for brief important communications. Consequently if a call of any length is necessary it is advisable to make a new call in the usual way, to avoid blocking the equipment.

Often it may be more advisable to have the operator operate the locater equipment. For this purpose a number of keys actuating the lamp sets are installed in the manual board in place of the locater board. The person sought calls the operator to get the necessary information.

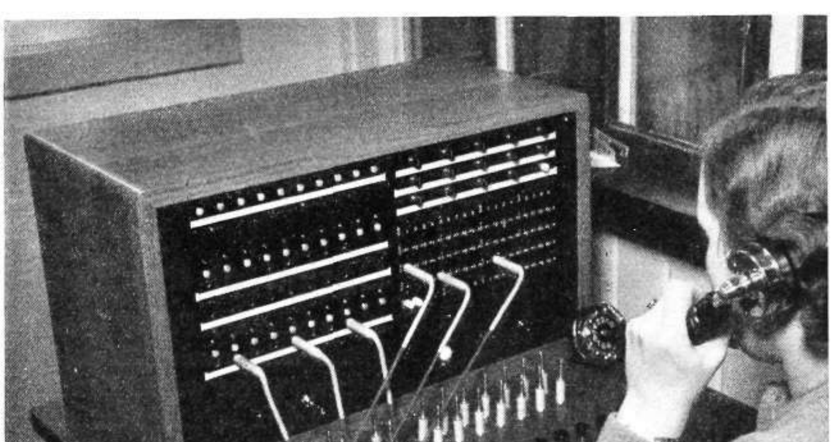

Fig. 4 X 5398

Manual Switchboard

the left-hand section contains, reading downwards: alarm lamps, jacks for operator's line and call-back lines, calling jacks for exchange lines, answering jacks for exchange lines; the right-hand section contains, reading downwards: night service keys and multiple field with jacks for non-barred extensions; the horisontal part contains a local cord pair and twelve junction cords with operating keys etc.

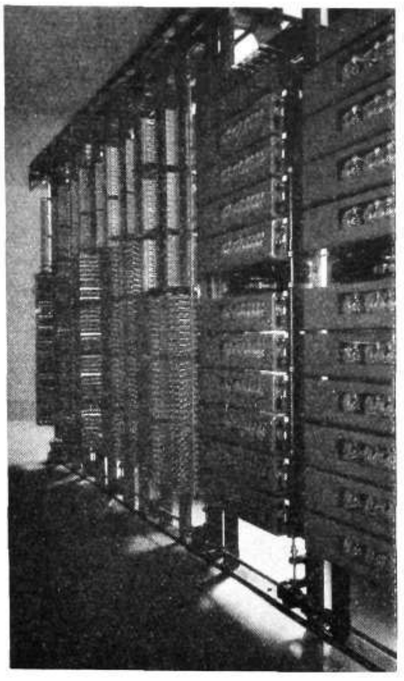

Fig. 5 X 3766

Bay for automatic switching devices for 800 line exchange

with 120 conversation facilities; the bay is 3.1 m high and 6.4 m wide

Tie-Line Service

Tie lines to provide service between two or more exchanges may be supplied. The method of connection is governed by local circumstances. Selector lines, LB-lines and junctions to remote exchanges are as a rule routed to the manual switchboard. Adjacent exchanges, with common traffic so large as to make the utilization of the lines sufficiently high, are connected directly to the automatic exchange over directed or double direction two or three-wire junction lines. Signalling over the lines can be effected by AC alone, if the lines are loaded or form a phantom circuit, so that DC cannot be transmitted over them. For traffic between exchanges, what are known as open direction digits are used as a rule. This means that the remote exchange is connected by dialling the single digit assigned to the tie line bundle in question, after which the calling number of the wanted line is dialled. All extensions, however, may be given numbers in the same series, if the technical design of the exchange allows. In such case direction digits are omitted.

Lines whose electrical properties are particularly bad may be connected to the automatic exchange, provided they are furnished with separate repeaters as described in the Ericsson Review No 4, 1935.

Call Supervision

A number of extensions can be provided with additional devices in the manual board causing all incoming calls internal as well as external to go first to the operator, who only forwards the call to the person concerned with his consent. In the absence of the operator, however, the calls are routed directly to the extension. Calls from such subscribers are not handled by the operator but are routed to the automatic exchange in the normal way and the telephone instruments are of the normal type.

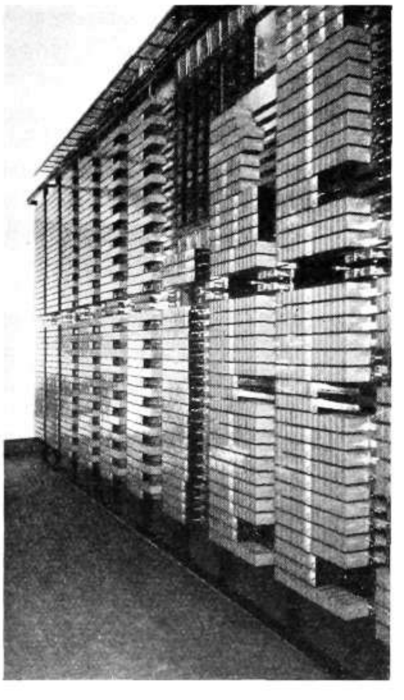

Fig. 6 X 3767

Bay for auxiliary devices for a 800-line exchange

with 80 exchange-line relay sets, 16 automatic and 4 manual junction units and 80 magneto-line relays; the bay is 3.1 m high and 5.8 m wide

Telephone Instruments

As stated earlier, one of the most noteworthy features of the Ericsson private branch exchanges is that the multitude of traffic facilities offered are effected by simple manipulation of the dial. Consequently quite normal telephone instruments without push buttons can be used. The instruments are connected to the exchange over two-wire lines and no additional wire, real or fictitious by connection of the instrument to earth, is required. A very suitable instrument for offices is the Ericsson bakelite instrument, Type DBK 11, Fig. 1, described in the Ericsson Review No 4, 1933. This instrument is provided with a buzzer giving a signal that is distinct but fainter than that of a bell. As a rule the instruments are placed on the desk where a strong signal would be too disturbing and therefore undesirable. Where instruments with bells are preferred, the Ericsson instruments, Type DBH11 and DBN11, are suitable. These are described in the Ericsson Review No 1, 1933. Where two instruments have to be connected to the same line, extension sets as described in the Ericsson Review No 1, 1935, should be used.

Design of the Exchanges

The system OS PABX is machine-driven and provided with automatic registers which receive the dial impulses transmitted from the dials and set the selectors to the wanted line. An up-to-date exchange of this kind comprises a number of switching facilities not required in a public automatic exchange. In spite of this fact, in elaborating the system OS PABX it has been possible to make use of the same components, *e. g.*, the 500-line selectors, the registers and the main part of the relay sets, as in the Ericsson system for public installations. The special switching tasks to be fulfilled by exchanges of this kind are concentrated at a few points, *viz:* the exchange relay sets and a small number of units for call-back, transfer, night service and similar special purposes, see Fig. 2. The maintenance of the exchanges is thus without complication, and they offer the same reliability as the system for public exchanges. The electrical properties also are the same as those of the latter system. The working voltage is 24 V; the feeding coils have a resistance of 2×400 ohms and are consequently calculated for normal Ericsson telephone instruments. The maximum permissible loop resistance of extension lines is 1 500 ohms and the minimum insulation resistance is 20 000 ohms wire-to-wire. The attenuation at 800 c/s does not exceed 0.06 neper and the lowest value of the cross-talk attenuation is 10 neper. Installations may also be furnished with feeding coils of other properties in order to allow of the connection of telephone instruments of other types. The electrical data, however, would then be changed accordingly.

Exchanges for not more than 90 extension lines have two-digit calling numbers. Exchanges for 800 or possibly 900 extensions have three-digit numbers and larger installations four-digit numbers. The digits *0* and *9* are as a rule reserved for calls to the public exchange and to the attendant's board.

The use of 500-line selectors enables 400 or possibly 460 extension lines, in addition to exchange lines and call-back lines, to be connected to the same group. At exchanges of this size the total traffic flow can consequently be handled by a single group of switches, and connections over several further switches are avoided. The total number of switches is exceedingly small and the risk of momentary overloading is reduced to a minimum, because a rush in traffic on a number of lines is likely to be neutralised by a simultaneous decrease in the traffic of some other lines connected to the same group of switching devices. All irregularities due to technical faults are notified by means of alarm circuits connected to the automatic exchange and the manual switchboard.

As a rule the exchanges consist of two parts, *viz:* bays for automatic switching devices and supplementary units, Fig. 3, and a manual switchboard, Fig. 4. At the larger exchanges the automatic equipment is mounted in two bays, the one containing the automatic switching devices, Fig. 5, and the second containing exchange line relay sets, junction units etc., Fig. 6. The various sizes

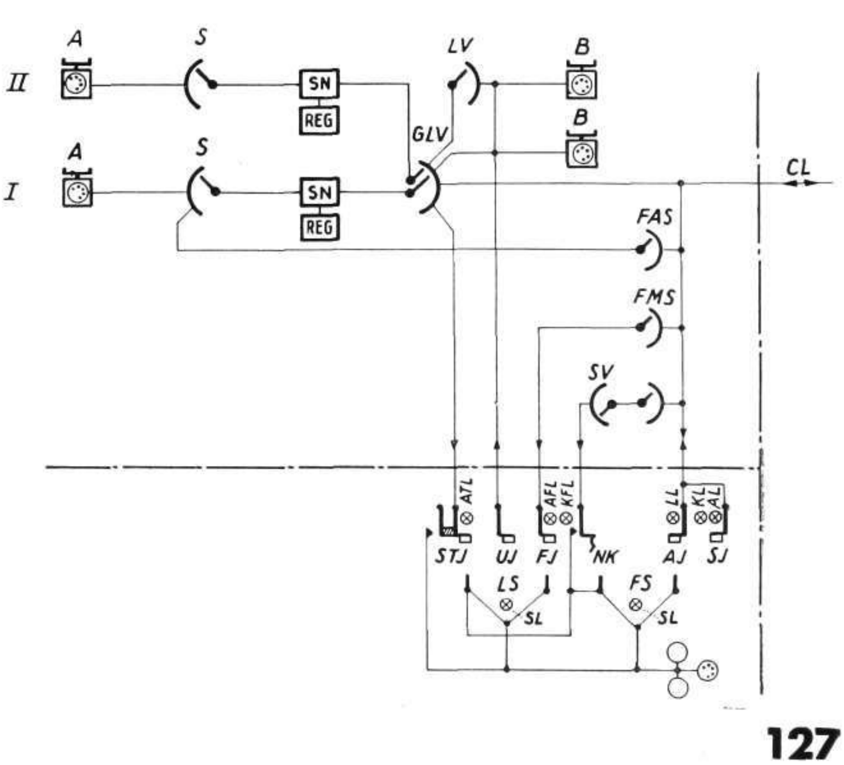

Fig. 7 X 5400

Routing diagram for 800-line branch exchange, System OS PABX

A, B	telephone instruments
AFL	calling lamp for FJ
AJ	calling jack for exchange line
AL	calling lamp for SJ
STJ	calling lamp for STJ
CL	two-direction exchange line
FAS	intermediate unit for automatic call-back and transfer
FJ	jack for call-back to operator
FMS	intermediate unit for manual call-back and transfer
FS	junction cord
GLV	final selector for first group
KFL	supervisory lamp for FJ
KL	supervisory lamp for SJ
LL	idle indication lamp for AJ
LS	cord for internal connections
LV	final selector for second group
NK	key for night service
REG	register
S	line finder
SJ	answering jack for CL
SL	clearing lamp
SN	automatic link circuit
STJ	answering jack for calls to operator
SV	night service equipment
UJ	multiple jack for non-barred extension

of these exchanges always contain the same kind of switching devices, which latter are provided with plugs assigned to corresponding jacks in the bays. Thus when inserting a unit in a rack no soldering is required. Consequently the capacity of an exchange may easily be increased by the addition of switching devices. The normal sizes are for up to 90, 280, 400 (possibly 460) and 800 (possibly 900) extensions.

Exchanges for 800 (900) extensions as maximum, the routing diagram for which is shown on Fig. 7, each consist of two groups but nevertheless no group selectors are required. All traffic relating to the first group is dealt with as in a 400-line exchange, but calls to the second group are led over one connecting stage more. The system OS PABX is also very suitable for installations comprising more than 900 extensions.

The power plant depends on local conditions, and particularly on the reliability of the mains supply. If AC is available, metal rectifiers are installed to convert the current to 24 V DC. Battery charging is operated quite automatically, and the power consumption is very low. The combined driving and signal unit which starts automatically when required consumes 2.5 A at 24 V. Without risk to the good working of the installation, automatic exchange and power plant and all other parts may be left unattended for long periods and only inspected occasionally.

Handset with Dial

E. BERGHOLM, TELEFONAKTIEBOLAGET L.M. ERICSSON, STOCKHOLM

Fig. 1 X 3778
Handset with dial

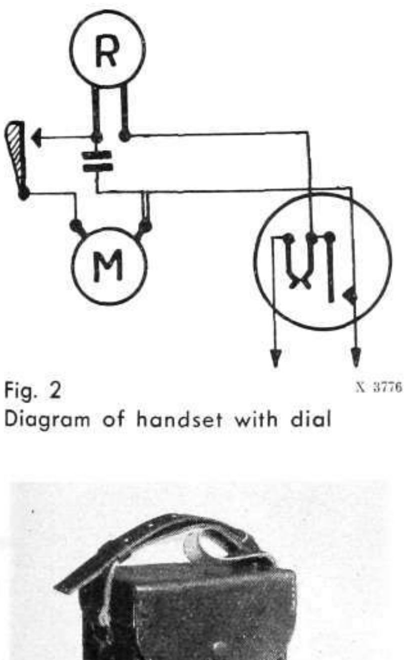

Fig. 2 X 3776
Diagram of handset with dial

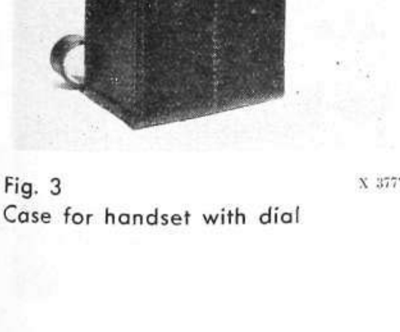

Fig. 3 X 3777
Case for handset with dial

Telefonaktiebolaget L.M. Ericsson has recently designed a portable telephone instrument for use in automatic systems, which in respect of small dimensions and compact construction meets a want long felt. The instrument is chiefly intended for exchange and line testing, but is suitable also for a number of other purposes.

The demands which may be imposed on a simple portable telephone instrument for exchange and line testing in automatic telephone networks are chiefly of a constructive nature; thus the instrument should have the lowest weight possible and small dimensions, it should be made as one unit, greatly facilitating its carrying, and finally standard parts should be used as far as possible, in order to simplify replacement of parts.

In the design of the Ericsson instrument, Fig. 1, these requirements together with convenience in use have been the determining factors. The instrument comprises all necessary parts for a telephone instrument with the exception of signal device for the receipt of calls, see Fig. 2; the signal device may be dispensed with since the instrument is not intended to be permanently connected in on the line. The induction coil also may be eliminated since calls with such instruments do not as a rule need to be transmitted over lines of appreciable length. On the other hand it must be possible for the instrument to be connected to the line without a call immediately taking place; to provide for this a condenser has been inserted in the microphone chamber, while the handset has been furnished with a key. When this key is not pressed the instrument is connected over the line in series with the condenser and it is easy to ascertain by listening whether the line is engaged or not. If the line is disengaged, the key is pressed, whereupon the transmitter is connected and call to the exchange is made. After buzzer tone has been received, impulsing can be done by means of the dial; the key is kept pressed down throughout the conversation.

All parts of the instrument are of normal Ericsson type and easily interchangeable. The connecting cord is normally provided with crocodile clips to facilitate connection to soldering tags, strips of fuses etc., but on request it may be furnished with any other connection, *e. g.*, with plug for connecting up with test jacks.

In view of its small weight, 0.75 kg, and small dimensions it may be carried in the tool-bag. In many cases, however, a special case may be more convenient; for this purpose a leather case has been made, see Fig. 3, its dimensions being 80 × 120 × 160 mm; this case contains a special compartment intended for small tools, spare parts, fuses and the like, and thus constitutes a complement to the lineman's tool equipment. Complete with case the instrument weighs 1.3 kg.

The sphere of employment of the instrument is by no means restricted to testing work. It may be used anywhere that simplicity and mobility is required, *e. g.*, for temporary connection on board ship, and when arranging temporary connection of instruments for military purposes, such as for listening posts at air defence centres connected to automatic telephone networks etc.

Fire and Police Alarm Installation

G. BERGH, TELEFONAKTIEBOLAGET L M. ERICSSON, STOCKHOLM

In March 1936 the Fire Committee of Kristianstad, Sweden, ordered from Ericsson a fire telegraph installation on the Morse supervisory-current system, which was subjected to final official inspection in July 1937. Prior to this the installation had already been connected up and in operation for a couple of months and also on a few occasions had been employed to alarm the fire brigade on outbreak of fires. The installation presents a novelty, in that it may also be utilised by the public for calling the police.

The installation comprises a central apparatus at the fire station with batteries and charging devices, along with motor alarm set and alarm bells to call the firemen in station quarters, alarm bells at the dwellings of the volunteer firemen and their places of employment in various parts of the town, a telephone instrument at the police station, together with fire and police boxes with lighting fittings set up in the streets of the town. All the material including the circuit network has been delivered by Telefonaktiebolaget L. M. Ericsson, but the erection has been carried out by the staff of the fire brigade. The connecting up of the central apparatus and final testing of the installation was done by a special mechanic.

The central apparatus, Fig. 1, which is of the normal type for this size of installation, consists of two instrument boards and a shelf table on which are two automatic telegraph instruments, Type TI 70, which start automatically on the arrival of signals and stop when the signal comes to an end. One of the boards is equipped with normal instruments for the connection of three circuit loops including the fire-police boxes and alarm bells located at the volunteer firemen's dwellings and places of employment. The other board is equipped with battery switches for stationary charging of the installation's four 24 V, 15 Ah Nife batteries and reserve battery. Above the respective battery switches are battery pilot lamps which light up if interruption occurs in a battery or if the tension falls below the tolerated figure. The board is moreover equipped with an alarm switch; in one position of the alarm switch,

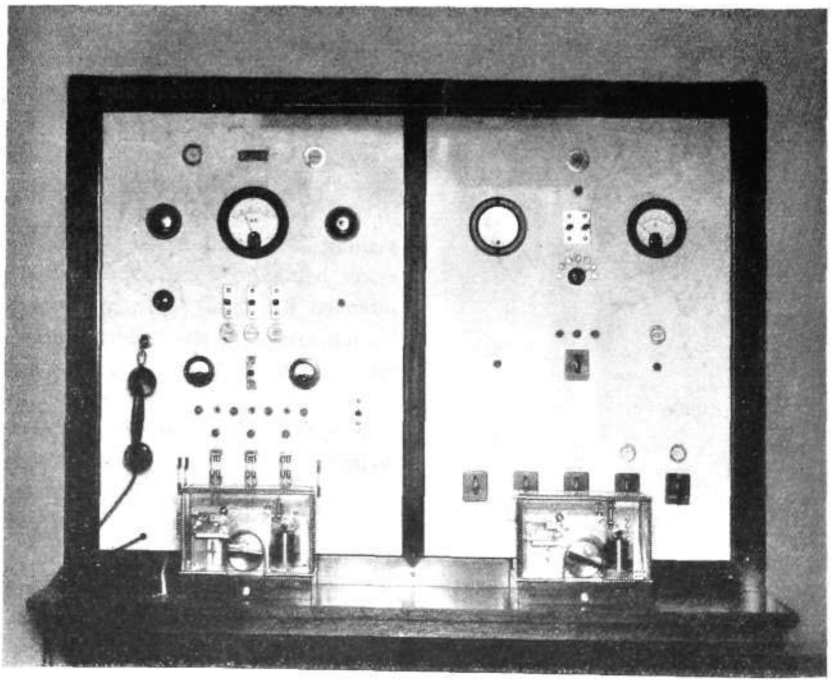

Fig. 1 X 5396

Central apparatus at fire station

connected to the left-hand board are the three alarm loops; the right-hand board contains battery switches and alarm switch

Fig. 2 X 3758
Fire and police box
the pull handle above is used for fire alarm; behind the sealed lower panel the police telephone instrument is mounted

alarm is given to the staff of the station by series connected 2 ohm AC bells, with DC bells as reserve, of which one is a large bell, Type RA 3001, mounted outdoors in the tower. On night alarm emergency lights appear in the quarters, staircases, corridors and garage. When the alarm bells are switched off, the lights continue to burn until a restoring button on the board is pressed, whereupon the pilot lamp above the button also goes out.

When alarm is sent out to the volunteer fire brigade outside the station, the alarm switch is moved over to another position, by which only the alarm set is started. The outgoing lines are then connected one after the other over separate connections to the alarm set, and 16 c/s AC is transmitted over the loops for ringing the 2 ohm AC bells set up in the houses of the members of the volunteer fire brigade.

A device for measuring the insulation and resistance of the outgoing lines is included in the board equipment. The figure obtained on measurement, read on a voltmeter which is also intended for measuring the tension of the batteries, is compared with a calibration curve, whereby the circuit resistance or insulation resistance may be obtained direct.

The central apparatus includes a handset for exchanging communications with the boxes, as also a device for transferring calls via a direct line to the telephone instrument in the police station.

The combined fire and police box, Fig. 2, is a modification of the standard box, Type TH 371, with pull handle for giving the alarm signal. The lower part of the box door has a panel which is normally kept closed and sealed. To call the police the sealed handle is turned, thus breaking the seal, the panel is opened and the handset is exposed. A telephone signal is transmitted automatically to the fire station where the caller on request is transferred to the police station. The speech transmission from all boxes has proved exceedingly good, this being achieved by employment of a special connection.

The placing of the fire boxes has been done in consultation with the fire chief and the object aimed at has been to have them mounted as far as possible at street corners and on posts, so that they may easily be seen. Above the box, on an arm projecting from the wall, red light globes are mounted, which are burning day and night and which further serve to distinguish the positions of the boxes.

The installation has been executed in such a way that it may in simple manner be supplemented by devices making it possible to call policemen on patrol from a signalling set at the police station, by means of flashes of the lamps above the boxes. This addition will probably be made in the near future.

Executed in the manner described, the combined fire and police alarm installation is very little more expensive than a simple fire alarm installation and since it makes it possible for the public to come into communication with the police in case of need, the authorities of various towns have displayed particularly keen interest in this kind of installation.

Precision Time Giving by Telephone

C. AHLBERG, TELEFONAKTIEBOLAGET L. M. ERICSSON, STOCKHOLM

In the Ericsson Review No 2, 1934, there was described a photo-electric talking machine for verbally communicating the time to telephone subscribers. At the time of the construction of that talking machine there existed no great demand for accuracy in the time given. In a number of cases one was content with statement of the hour and the minutes only, while in other cases the communication of the seconds was required. At the beginning therefore the machine was planned for communicating the time every tenth second, whether the seconds had to be given or not. Later however, a demand arose for great accuracy in the communication of the time. Without any other alteration to the machine than change of a cam disc this new requirement has been met in a simple manner.

The talking machine is normally synchronised every minute by control impulses from a precision clock. As the machine is usually connected to the telephone exchange battery and this is exposed to voltage variations, the synchronisation principle necessarily involved that the machine would be fast or slow in relation to the correct time by a number of seconds, the greater the variation of voltage the greater the deviation. By synchronising at shorter intervals the deviations in the machine's running could theoretically be reduced to any extent. In practice it has been found sufficient to carry out synchronisation every tenth second. In this way there can be attained an accuracy of ± 1 s deviation from the precision clock's impulses with a voltage variation in the exchange battery of from 22 to 26 V.

With this accuracy of running a definition must be given of which part of the time communication uttered may be considered as the correct time. Misunderstanding may easily arise among subscribers and even if directions for interpretation of the time communication were inserted in the telephone directory, it might happen that this latter was not available at the moment. To eliminate all misunderstanding and to give unequivocal time communication, the verbal communication is followed by a short tone emitted from the exchange voice-frequency generator; this does not proceed from the talking machine itself. The generator is connected to the voice-frequency circuit by a relay which in turn is attracted by a current impulse from the master clock. This determines the instant for the emission of the tone direct by the master clock and its accuracy is thus the same as that of the master clock. On account of variations in speed of the talking machine the interval between the word for seconds and the tone is variable. Synchronisation of the talking machine must thus, in view of the unavoidable battery tension variations, take place so often that the speech either with maximum lateness is ended when the tone arrives or with maximum fastness cannot be taken as connected with the preceding tone. Normally it has been found advisable to synchronise the machine every tenth second by which the same impulses from the head clock are used as those controlling the emission of the tone.

This method for the emission of precision time was first employed in Oslo, Norway, where the time communication plant was taken into service 1st April, 1937. The synchronising impulses are sent out from the observatory, which guarantees an accuracy of 0.1 s. In September 1937 a similar plant was delivered to Riga, Latvia. In that delivery a head clock was included, which sends out control impulses. This clock on its part is synchronised with second impulses from the observatory. The accuracy of running is thus determined by the observatory clock. On interruption of the line the clock of the plant continues to run independently so that no interruption of the time communication need take place.

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CONTENTS

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The Telephone in the Service of the Railways

O. SIEWERT, TELEFONAKTIEBOLAGET L. M. ERICSSON, STOCKHOLM

In recent years the telephone has been more and more employed in railway operation and the time should not be too far distant when all communications in railway service will be by telephone instead of by telegraph. In order to facilitate the planning of new railway telephone installations, a series of articles in this and the following issues of the Ericsson Review will give a survey of the different telephone systems made by Telefonaktiebolaget L.M. Ericsson for railways as well as their practical application by different railway administrations.

In the majority of railway enterprises the telephone has been supplanting the telegraph in recent years; this evolution which is due not only to the lower installation costs and the better economy of the telephone compared with the telegraph, but in a still higher degree to the fact that the telegraph is no longer able to give sufficiently rapid and efficient service with present day increased requirements in respect of greater train speed, denser traffic etc. The greatest disadvantage of the telegraph indeed lies in its slowness, as every communication must first be written down and thereafter sent out as Morse signals and finally received and decoded at the receiving station. The transmission of such a communication takes considerable time even with the high telegraph speeds possible with apparatus for high-speed telegraphy. A great inconvenience of the telegraph is further that the answer cannot be sent immediately, but only after an appreciable time. As long as the railway lines carried little traffic and the trains ran at a comparatively low speed, this slowness was not considered a disadvantage. However, since motor vehicles and air services have begun competing with the railways circumstances have entirely altered. In order to be able to compete successfully with other means of transport most railways have been compelled to rationalize their operation and adapt their traffic better to the exigences of modern life. This modernization would certainly not have been possible without replacing the telegraph by the telephone for the continuous communication of orders, train dispatching and in fact all communications in railway service.

In the countries where safetey regulations prevented the introduction of the telephone in place of the telegraph for communicating certain orders, the railway administration has requested the authorities to alter the regulations. Such request has invariably been acceded to and in most countries there is today nothing to prevent the substitution of the telephone for the telegraph for all communications in railway service. This also provides very good evidence of the fact that the telephone is considered superior to the telegraph even in regard to safety.

The qualities of the telephone which justify its replacing the telegraph may be summarised as follows: orders may be transmitted more rapidly without laborious conversion of the words to Morse signals with subsequent decoding at the receiving station; an answer is obtained immediately; personal contact is obtained between the sender and the receiver; it is thus possible to check immediately that the order has been correctly understood; the operating is cheaper and less staff is necessary, as telegraph operators may be entirely eliminated; no telegraph staff has to be trained and as this generally must be done at the cost of the administration quite a considerable saving is made;

the networks are better utilized, partly through the more rapid transmission of individual communications and partly through more rational construction of the network, which is rendered possible if trunk calls are established automatically instead of manually; the installation costs will be lower and the economy improved.

All these advantages of the telephone in comparison with the telegraph are sufficiently great to provide financial justification for transition from telegraph to telephone. However, they are surpassed many times by the considerable advantages derived by the railways from rational application of the telephone, which put into money would perhaps be worth ten times more than the actual monetary saving. Utilizing the rapidity of the telephone, the adaptability of the telephone system and rational train dispatching, the efficiency of the railway lines, of the rolling stock and the staff may be considerably increased and the economy of the railways still more improved. It is also easier to make up trains by means of the telephone and to reduce the empty running of trains. The most important indirect advantages obtained by the introduction of the telephone are the following: better utilization of rolling stock; better utilization of staff; better utilization of railway lines; more rapid making up of trains; less running of empty waggons; more rapid organization of emergency trains in case of accident; easier planning of extra trains.

In order to illustrate the development of the telephone in railway administration we will quote a few data from the Swedish State Railways. The first telephone system introduced by this administration was the *magneto telephone system with code signalling,* which was essentially used to supervise a track section. In the course of the years this system was very much extended and, though still more efficient systems have been designed in later years, the magneto system is still extensively used by the State Railways which had 10 500 km magneto lines with 4 050 instruments in 1935. The main disadvantage of this system is that all instruments on the same section will ring at each call. As soon as a telephone system where this disadvantage was eliminated, the *selective-calling system,* was designed the State Railways introduced this system on trial. The first selective-calling installation was put in service in 1914. Since then the State Railways had up to January 1, 1936, introduced selective-calling systems on altogether 12 000 km circuits with 1 250 instruments. Since about 1920, the State Railways have used their own circuits for establishing *long-distance service communications.* Telephone repeaters are inserted whereever necessary.

Up to 1930 the telephone could only be used to a limited extent by the State Railways as communications concerning the safety service as well as communications concerning freight and passenger traffic had to be established by the telegraph alone, in conformity with the safety regulations then prevailing. In 1930 the State Railways made an investigation concerning extension of the use of the telephone and all administrative districts were called on to submit economic reports and opinions. This investigation showed that the State Railways could make a *direct* saving of about 375 000 Kr./year by abolishing the telegraph. This sum is distributed as follows:

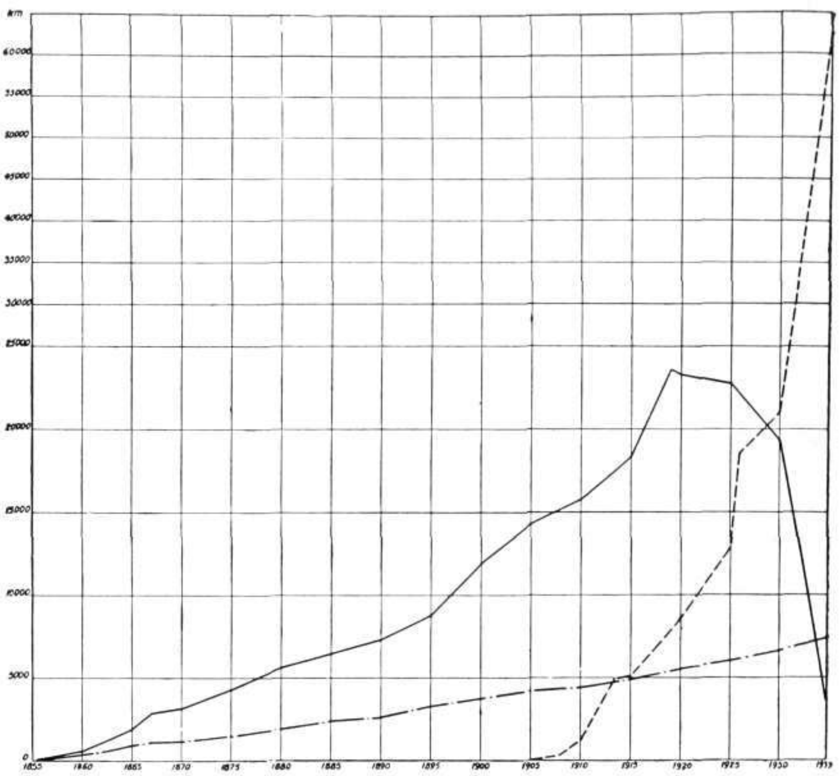
abolition of 62 telegraph operators	290 000 Kr.
abolition of the training of telegraph operators	78 000 Kr.
saving in paper and ink	7 000 Kr.
	375 000 Kr.

Only the direct savings are taken into account here, but the indirect gains are many times greater. After Parliament had approved the proposition of the State Railways and the necessary sums for alteration and new constructions required by the introduction of the telephone were granted, the State Railway Administration decided to abolish as soon as possible all telegraph communications inside the country and to retain them only for communications with foreign countries. In consequence the length of the telephone circuits rose

Fig. 1 X 5347

Development of the telegraph and the telephone network of the Swedish State Railways

——— telegraph circuits
— — — telephone circuits
—·—·— railroads in service



from 20 000 km to 60 000 km in the period 1931—1936. The length of the telegraph circuits was simultaneously reduced from 19 000 km to 3 500 km, see the diagram, Fig. 1. The number of telephone instruments now in service is about 8 000 against about 100 telegraph apparatus.

Railway Telephone Systems

For rational application of the telephone to the great and complicated organization of a railway the telephone systems must satisfy many requirements peculiar for railway operation and which are not found in commercial telephony. The most important domains in which the telephone has found application in railway undertakings may be distributed in the following classes:

magneto telephone for exchanging communications in a short track section, between two or several railway stations and generally without intercommunication with other line sections;

district telephone for exchanging communications on long track sections and between instruments connecting the line and the telephone installations at the stations, permitting intercommunication between the line sections;

long-distance telephone for exchange of communications over very long distances chiefly between the main points of a district;

dispatcher telephone for centralized train control and supervision of train movements along a railway line, generally without direct intercommunication with other telephone installations.

Though these four domains of utilization of the telephone in railway operation are quite distinct and require different technical solutions, they compose, as does the railway organization itself, a unit in which all parts must be adapted to each other if the telephone service is to give the best possible service and if absolute reliability is to be attained. Special consideration has been taken to this in the systems described in the following, which have been designed to avoid all difficulties when intercommunication is to be arranged between them and to make their operation as simple as possible so as to enable persons who only seldom use these systems to establish when necessary the desired communication without difficulties or delay.

Railway operation, however, is organized in very different manner in different countries and by different administrations; when an extensive introduction of the telephone for the service of the railway is to be planned, the administration will often be confronted with problems which are difficult to solve without a profound knowledge of the design and operation properties of the different telephone systems. It is in order to facilitate such planning that a survey of the different telephone systems for railways made by Ericsson as well as their practical application by different telephone administrations will be given.

Magneto Telephone

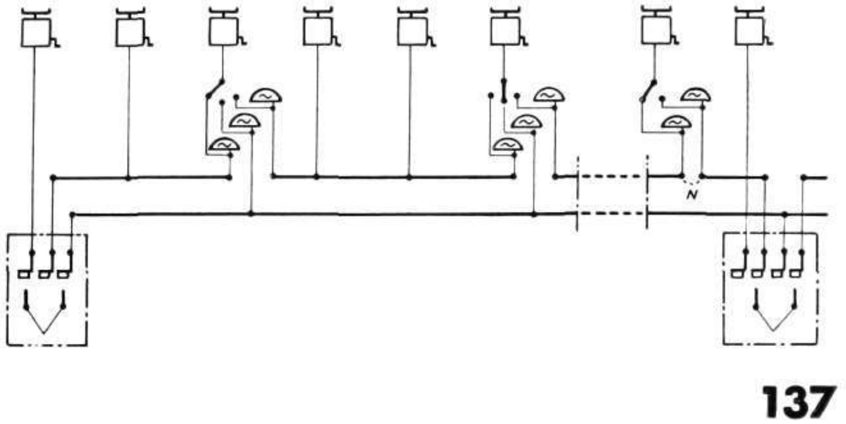
The magneto telephone is generally used by the railways to permit exchange of communications between two adjacent railway stations or several stations and the linemens' dwellings along a line section. Two parallel lines are used for this purpose, see Fig. 2. One line is divided into a great number of sections and used mainly for transmitting to adjacent stations communications concerning the arrival and departure of trains. During the night the sections are interconnected at the stations which have staff on duty only during the day. The other line on the other hand passes without being sectioned a great number of stations of which only the larger ones are connected to the line; it is used mainly for transmitting orders and other important communications relating to operation.

For such circuits the railways have for a long time been using magneto telephone systems with instruments connected in parallel. For intercommunication between two instruments connected on the same line signalling by Morse code is used, each instrument having a determined code signal. The emission of the different signals is made by means of the magneto, the dot in the Morse alphabet corresponding to, *e. g.*, one turn of the magneto crank and the dash to three. Where AC is available, current from the main is usually used instead of magneto; the AC is transformed by means of a transformer to about 100 V and transmitted on the line by a push-button with automatic release. The bells may be rendered sensible to all frequencies between 16 and 50 c/s, and main voltages having all frequencies comprised between these limits may be used.

Latterly certain railways have replaced magneto systems by selective-calling systems which offer many advantages compared with the former system. The magneto system, however, still enjoys very great popularity with the railways on account of its simple construction and great reliability and it may thus be expected that this system will continue to be largely used even in the future.

Instruments and Bells

Nowadays the lines are nearly without exception two-wire and the telephone instruments consist of magneto instruments having such electrical properties that the conversation and signalling currents will be certain to be received



X 5425

Fig. 2
Magneto telephone line
N night interconnection

Fig. 3 X 3807
Magneto telephone instrument, Type DAL 1001
table model

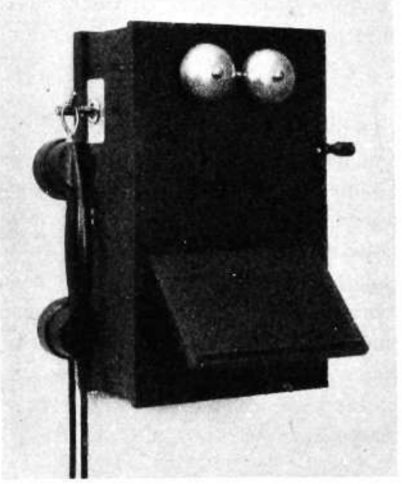


Fig. 4 X 3808
Magneto telephone instrument, Type DAS 2001
wall model

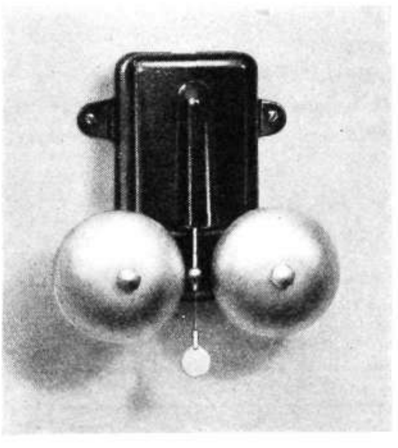


Fig. 5 X 3803
AC bell, Type KLA 1246
with vibrator

even when a great number of instruments are connected in parallel on the same line. The magnetos of the instruments have therefore extra powerful magnets and the bells a high impedance. In this way the signalling output emitted by the magnetos will be large but the current consumption in the bells small. In order to prevent an appreciable attenuation of the signalling current in case the microtelephones of a few instruments should for some reason not be replaced a small condenser of 1.0 μF has been inserted in the speech circuit of the instruments rendering their inductive resistance on lifting the microtelephone large for signalling frequencies (16—20 c/s) and small for vocal frequencies (about 800 c/s). Through these arrangements up to 20 instruments may be connected to a not too defective line without risking that the attenuation at vocal or signalling frequencies will exceed the admissible values (3—3.5 neper). In special circumstances the Swedish railway administration connect up to 27 instruments on the same line.

Suitable telephone instruments for this system are Type DAL 1001 and DAS 2001, Fig. 3 and 4, which have a very robust construction and have been very extensively employed for railway service. The former is a table instrument with metal case and bakelite microtelephone and a magneto with extra-powerful magnets as well as a high impedance bell. The batteries are situated outside the instrument in a battery box. A special bracket permits of mounting these instruments on the wall. If a specially designed wall instrument is desired, the instrument, Type DAS 2001, with case of polished oak and bakelite microtelephone should be used. It has, like the table instrument, a magneto with extra powerful magnet and high impedance bell. This instrument, however, does not require a separate battery box, a compartment for the batteries being provided in the case. If a smaller wall instrument is desired, there is an instrument, Type DAS 1201, which is designed like the above wall instrument, but without compartment for the batteries, these being situated outside in a separate battery box.

When several telephone circuits are connected to certain stations and it would therefore be unpractical and expensive to use an instrument for each circuit, separate AC bells are connected to the circuit instead and a single instrument is provided which may be connected to the desired circuit by means of a commutator when a call is to be exchanged. The bell, Type KLA 1306, which has a high impedance is generally used for this purpose. For commutator is used the two-way commutator, Type RL 201. The instrument is connected to one contact pair and the circuit to the other, which means that one commutator is required for each circuit. The same commutator allows also for the interconnection to line sections, for instance during the night when the station is without supervision. If a great number of line sections meet at a station and several bells are thus situated near each other, it may be difficult to decide which bell has rung. In such cases an AC bell with vibrator Type KLA 1246, Fig. 5, should be used. The clapper of this bell is fitted with a steel spring and a disc which continues to vibrate a short while after the bell has ceased to ring.

Manual Switchboards

When magneto lines are connected to large railway stations which also require internal telephone communications, they should be connected to small magneto switchboards which may be used partly for interconnecting the sections, partly for connecting the magneto lines to the different local instruments and finally for establishing the internal traffic. If magneto lines as well as automatic selective-calling lines are connected to the station it is often preferable to exchange the internal traffic automatically and it will then be uneconomical to provide the station also with a manual switchboard. The interconnection of magneto lines, selective calling lines and automatic exchanges may be done without using switchboards, as will be described later on. Here we suppose that the internal traffic is to be established manually and that the use of a switchboard is thus justified.

When the number of circuits to be connected to such a manual switchboard is comparatively limited, the railways generally use wall switches. Suitable for this purpose are the Ericsson wall switches, Type ABH 12, for 5 lines and 2 calls facilities, 10 lines and 3 calls facilities as well as 15 lines and 4 call facilities, Fig. 6. In stations having a great number of subscribers, a wall switch, Type ABH 13, Fig. 7, for 20 magneto lines and 4 call facilities or 30 lines and 6 call facilities should be chosen. The switchboards are of a very robust construction with case of dark polished oak. Drop indicators are used as calling signals, those connected to magneto lines having high-impedance coils.

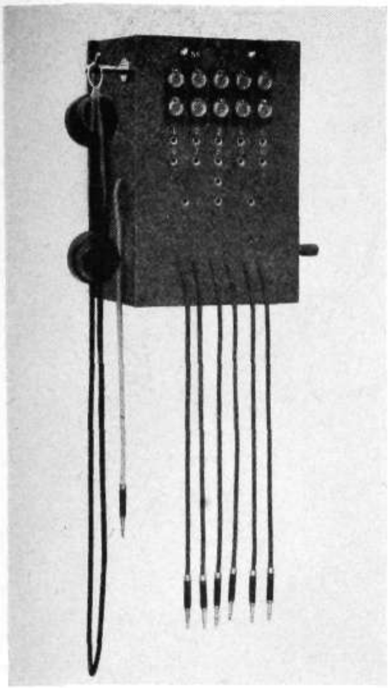


Fig. 6 X 3809
Magneto wall switch, Type ABH 12

Portable Telephone Instruments

Railway operation requires portable instruments which can be taken with the trains or on inspection tours. These instruments should allow of easy connection to the telephone line, thus enabling any instruments connected to the line to be called. When the magneto lines consist of bare wires on poles along the track the connection is made by means of a special hook mounted on a rod. The hooks and rods are available in various designs, the essential differences being in the material. If the magneto lines are led in cables, this simple connecting device cannot be used; instead a cable is fitted at regular intervals, for instance 1 km, with watertight contact boxes. If it is required to connect telephone instruments to the cable at any place along the track, the trains and the linemen must carry special portable cable drums with extension cable, *e. g.*, Type MH 2005. This cable must obviously be at least as long as half the distance between the contact boxes. Rapid determination of the direction in which the nearest contact box lies is facilitated by arrows mounted on poles along the track. Certain railway administrations also use arrows to indicate the direction towards the nearest permanent telephone station.

Ericsson has designed a suitable portable magneto telephone instrument, Type DPA 10, Fig. 8. In order to make the instrument as light as possible, the case is of bakelite, which has permitted a reduction of the total weight of the instrument to 4.2 kg. The microtelephone is of normal design, but fitted with a key for closing the microphone current. A dry cell battery of 3 V is used for microphone feeding and may be exchanged without taking the instrument chassis out of the case. The magneto is of a new design with cobalt steel magnets allowing of making the magneto smaller and lighter although it gives the same output as ordinary magnetos. The bells have a high impedance.

Line Protection Devices

When magneto telephone lines are made as open wire lines, the telephone instruments must have protecting devices. An efficient lighting arrester and overvoltage protector is obtained by means of a three-pole rare-gas tube, the circuit branches being connected each to one exterior pole, the mid point being connected to earth.

Delayed-Action Relays

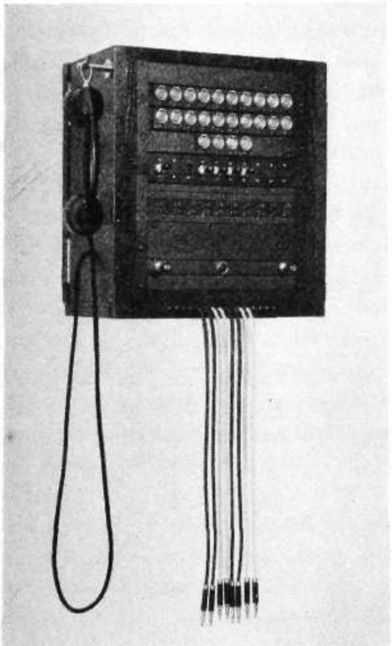


Fig. 7 X 3806
Magneto wall switch, Type ABH 13

As all instruments and bells along a magneto line are connected in parallel each calling signal actuates all bells connected to the line as well as all drop indicators in the switchboards. This, the greatest inconvenience of the magneto telephone system, has also been a cause of replacement of this system by the selective-calling system. There are, however, two methods permitting of making the calling signals individual; according to the first one certain instruments are called over the earth and both circuit branches connected

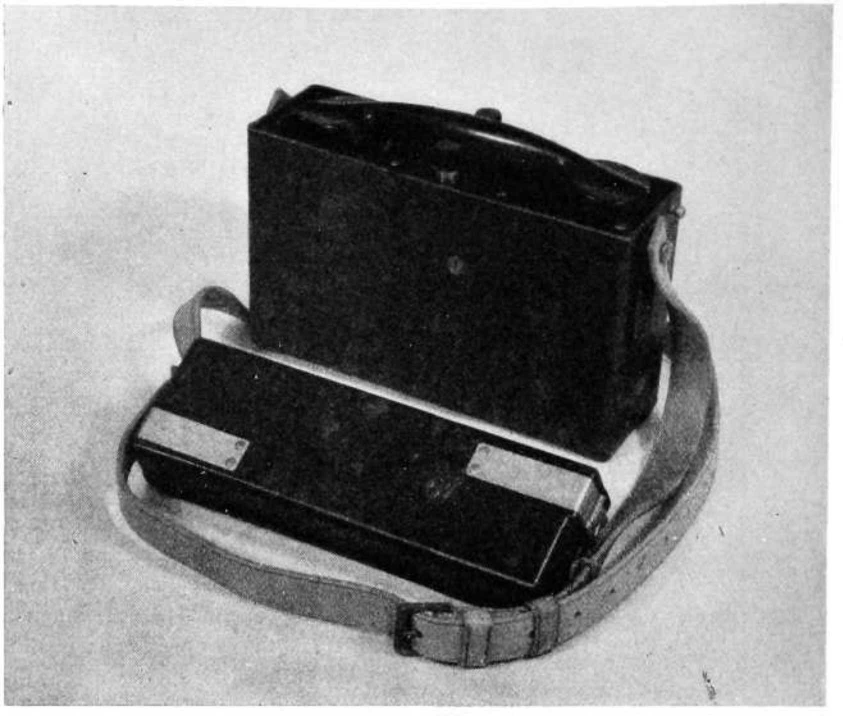


Fig. 8 X 5428
Magneto telephone instrument, Type DPA 10
portable model

in parallel, according to the other delayed action or code relays are inserted before certain instruments, admitting only determined signals. The disadvantage of a general calling signal is particularly disturbing at manual switchboards when the drop indicator falls (or the bell rings) for each signal, the operator being thus now and then disturbed by calls which do not concern her; for this reason it is in first place these signals which are separated from all other calls on the line.

When signalling over earth a choke coil is inserted between the branches of the circuit at the instrument and the switchboard. The mid point of the choke is connected to earth at the switchboard over the drop indicator (or bell) and at the instruments over the magneto and a push button. The push-buttons are designed in such a way that the magneto is normally connected between the branches but connected to earth when the button is pushed. All calls from the instruments to the switchboards are made by pushing the button and then only the drop indicator of the switchboard will be actuated, while calls to the other instruments on the line are made with the magneto only. This method requires comparatively good lines and has also several disadvantages, *e. g.*, only one instrument may be freed from the signal concerning the others; for this reason the railways have recently used delayed-action relays more and more. These relays make no demands on the quality of the lines, neither do they require any earth circuit. The introduction of these relays in an existing installation is very simple and they only have to be connected before the instruments which shall not be disturbed while the other instruments remain unchanged. Two kinds of such delayed-action relays, Type RN 135 229 and RN 143 828, Fig. 10, have been designed, of which the first should be used when only one point is to be freed from the calling signals touching the others, while the latter is required when several points along the same magneto line shall have individual calling signals.

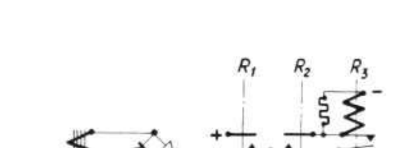


Fig. 9 X 3804
Diagram for delayed-action relay, Type RN 135 229
L line
S signalling circuit

The delayed-action relay, Type RN 135 229, works as shown in Fig. 9. The signalling current actuates relay *R1*, which closes current to relay *R2* and when this latter has been attracted, also to relay *R3*. This relay is energized over its own make contact and breaks the holding current for relay *R2* which, however, still remains attracted some time on account of current received from the pendulum contact of relay *R3*, which vibrates when the relay is attracted. The vibration time of the pendulum contact may be adjusted between

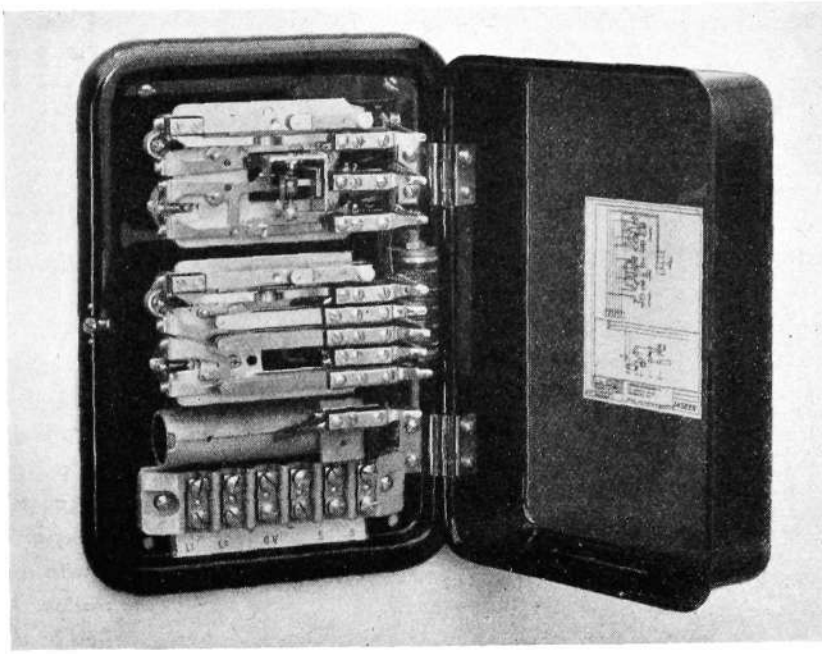


Fig. 10 X 5426
Delayed-action relay for selective calling, Type RN 143 828

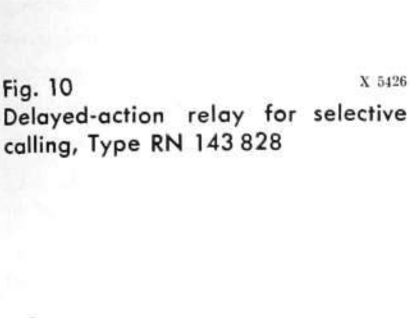


Fig. 11 X 3805
Diagram for delayed-action relay, Type RN 143 828
L line
S signalling circuit

1 and 3 s. If the duration of the calling signal is shorter than this time, the break contact of relay *R2* in the signalling circuit is broken and no signal will be transmitted to the bell or drop indicator inserted in this circuit. If, on the contrary, the calling signal has a longer duration than the vibration time of the pendulum contact, relay *R2* is released and a circuit is closed to the calling device connected in the circuit. A 6 V dry-cell battery is used to provide current for this signal. If the delayed action relay is connected as calling signal to a manual switchboard, the calling signals of this latter will be influenced only by a long signal having a duration of 3 to 4 s, sent out from an instrument on the line but not of code signals consisting of signals of short duration used for calls between the other instruments.

This delayed-action relay thus can only separate a long signal from short signals, and it cannot be adjusted for different kinds of code signals. The application of this relay is therefore comparatively limited and it must be replaced by the relay, Type RN 143 828, as soon as two or more points along the magneto line must receive individual calling numbers. This device contains the same delayed-action relays as before, which only admit signals of long duration and in addition a selector, which is made to progress by the different calling signals. The device can be adjusted for a certain number of short signals and a signal having a duration of 3 to 4 s, see Fig. 11. A calling signal actuates the magnet *S1* which in its turn energizes magnet *S2*. Simultaneously the selector progresses one step. When the signal is interrupted the magnet *S1* is released but *S2* remains attracted still for some time, obtaining current through its own pendulum contact as long as this latter vibrates. The next calling signal actuates the magnet *S1* anew and the selector progresses one step further. If this device is adjusted for two short signals and a long one, current is closed after two signals to the relays *R1* and *R2* which actuate in the same manner as before a calling device, bell or drop indicator, if the last calling signal has a sufficient duration, 3 to 4 s. A 6 V dry-cell battery should be used in this case also for operation.

Railway Interlocking Plant in Portugal

C. DE AZEVEDO NAZARETH, CHIEF ENGINEER, COMPANHIA DOS CAMINHOS DE FERRO PORTUGUESES, LISBON

Ermezinde is an important junction on the Minho and Douro lines and, after the opening of the Ermezinde—Leixoẽs line, tracks from four directions meet there; since the station was taked over by the Portuguese State it has been necessary for it to undergo a radical modernization. One of the arrangements necessary in this connection was a modern signalling and interlocking system, and the technical department of the Companhia dos Caminhos de Portugueses was charged with investigation of this question in conjunction with the extension of the station. Among the tenders asked for, the conditions prescribed were best satisfied by the project submitted by Compañía Española Ericsson for an electric interlocking plant of Signalbolaget's system. This company therefore was asked to supply the installation which was put in service on August 6, 1937.

The following description of the installation is reproduced by kind permission from »Boletim da CP», September 1937.

After a serious study of the different tenders which were received from specialized firms as well as existing similar installations installed by foreign railway administrations, the Portuguese State Railways decided to provide the station with one single interlocking cabin and to use electric local operation of certain points under the supervision of the cabin. All dependences between the signals, the points and the track circuits as well as the supervision devices on the interlocking machine are purely electrical and obtained by means of relays. In this manner an economic solution of the problem was also obtained from the point of view of operating costs, as it proved that the interlocking machine could be attended to by a single man per shift. Under the control of this operator, who acts as train dispatcher, were placed all the elements necessary for an efficient supervision of all train movements inside the station.

Fig. 1 X 3800
Interlocking cabin at Ermezinde

Interlocking Cabin

The interlocking cabin, Fig. 1, is an attractive building of reinforced concrete with modern lines. It was designed and constructed by the railway's own staff. The building has three stories. On the ground floor there are the cable intakes, a distribution panel, a reserve power plant and a room for the mechanic. On the first floor there are the relay group and lockers for the staff. Finally the second floor which is entirely surrounded by glass windows contains the interlocking machine room, Fig. 2. The machine comprises three panels and a table-top. On the panels there is on a black background a diagrammatic track plan of the station, made up of chromium-plated bars and small electric lamps which reproduce the position of the signals and the points inside the station and indicate whether the track circuits are occupied. Under the diagram there are three rows of operating switches; the upper row is used for operating the different points and for giving permission for their local operation; in the second row there are road switches, *i. e.,* a series of switches which check that all conditions necessary for setting a certain signal at »clear» have been fulfilled; finally small signal switches are mounted in the lower row. On the table there

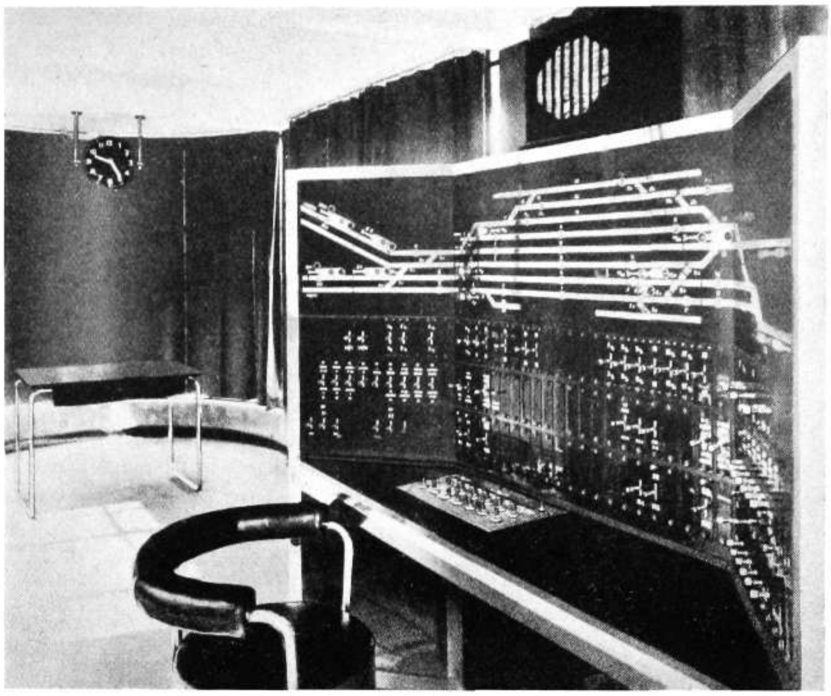


Fig. 2 X 5424
Interlocking machine
above track diagram, below point switches, road switches and signal switches; on the table-top telephone exchange

is a telephone exchange which is connected with adjacent stations, the station master's office and the telephone instruments mounted near the different tracks and platforms inside the station.

Track Circuits

The track diagram over Ermezinde station, Fig. 3, shows the disposition of the interlocking cabin, the signals and the points, and the division of the track system into insulated sections, *i. e.*, track circuits. The track sections are normally insulated from each other through insulating junctions of wood or through fibre junctions where there is no place for wood junctions. All electric circuits outside the cabin are of insulated signal cable of normal type. These cables are buried in the road-bed over a layer of sand to facilitate drainage and are protected above by bricks.

Each point or group of points composes a track circuit which is interlocked with the signals and prevents these being set at »clear» when the section in which they are comprised is occupied by vehicles; at the same time the track circuit locks the point or the group of points when it is passed by trains, also signalling to the cabin that the section is occupied. The track circuits are fed by low tension AC; in this manner the interlocking plant is protected against DC disturbance from adjacent traction circuits.

Track circuits are also arranged in the whole stretch of the tracks I, II, III, IV and V, partly to signal to the cabin when the tracks are occupied, partly to prevent a signal being put to »clear» for a track which is already occupied. The tracks VI, VII and VIII and the platform tracks are not

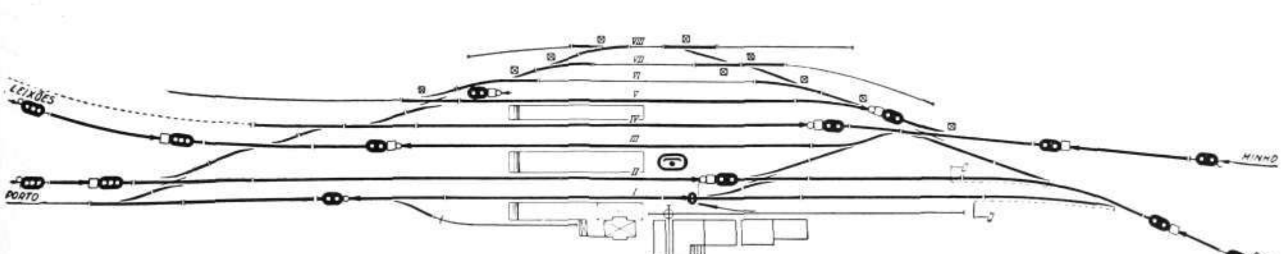


Fig. 3 X 7132
Track diagram of Ermezinde railway station

provided with track circuits, being used as side tracks which are generally occupied by vehicles and never used for train movements. Finally a track circuit is arranged before the main signal at the entrance of each track to the station in order to signal to the cabin when a vehicle passes a signal or when shunting movements are going on outside the entrance signal.

Fig. 4 X 3801
Main signal with luminous sign

Roads

When it is required to make up a road to receive or send off a train, all signals which are comprised in the road must be set at »clear». However, before it is possible to set at »clear» a signal which controls any of the entrance or departure roads to the station it is necessary that all points which are comprised in the road or give access to it should be in the right position, that these points are duly locked and that their position has been electrically supervised from the interlocking plant. There should be no vehicles on the track section which are comprised in the road, and all signals belonging to an opposed road should be set at »stop». If for some reason any of these safety measures has not been fulfilled, it is not possible to set the signal at »clear». A road which has been made up but which is not to be used may be cancelled in the interlocking plant by means of an emergency key which is normally sealed. When, however, the road has been made up and the train passes through the points, these are released one after another and the corresponding signals are automatically set at »stop».

The signals which control the shunting movements are not interlocked with the track circuits, which allows of carrying out shunting movements on sections already occupied by rolling stock.

Signals

The signals are luminous daylight signals with coloured lights in two or three positions and consist of a lamp with a two-lamp system, of which the external one is uncoloured and the internal one coloured. The electric lamp is situated at the focus of the optical system and gives a light with very great visibility even in strong sunlight. The main signals, Fig. 4, are provided with luminous signs made up as small lamps which compose a number or a letter indicating the entrance track or the departure direction. The signals have screens which prevent the reflexion of sunlight and are mounted on plates coloured black. Each signal with luminous sign is mounted on a tubular steel pole which stands on a concrete base and is fitted with a ladder and inspection platform.

Points

All the points inside the station are operated directly from the interlocking cabin, but certain points have a device for electric local operation, Fig. 5; this latter can be used only after permission has been obtained from the cabin, which always has the possibility to cancel the permission in case of emergency, *e. g.*, if the point is to be used in an entrance or departure road or if the cabin wants to take charge of the direct operation of the points. Near the points intended for local operation there is a pillar which supports a cabinet containing operating switches and a lamp which lights up when local operation is permitted by the interlocking cabin. The switch is operated by means of keys which are distributed to the employees who have the right of local operation.

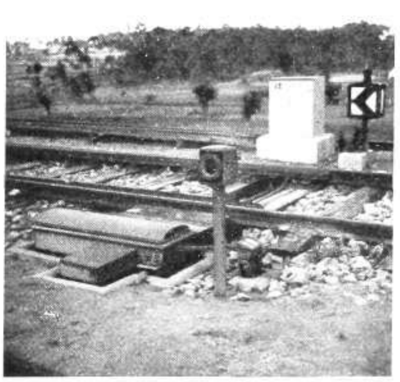


Fig. 5 X 3799
Point driving machine with local switch

The point driving machines are fed by 220 V AC and provided with internal locking; when the points are moved to one or the other position, they are locked in this position and simultaneously it is supervised by

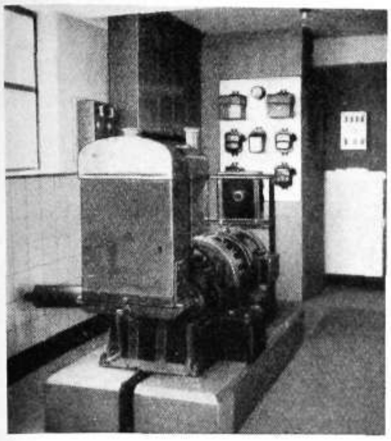


Fig. 6
Reserve power plant

X 3802

the interlocking machine that the point is in the correct position and that the point proper has come to the extreme position. In case of faults or current interruptions of long duration the point driving machines may be operated by hand by means of cranks which are usually stored in the cabin under the supervision of the operator.

Power Plant

The installation is normally fed from the electricity mains, but in case of interruption of that source of current there is a reserve power plant, Fig. 6, consisting of a motor generator group, composed of a petrol motor, direct coupled to an AC generator. This group is installed on the ground floor of the cabin and starts automatically in case of interruption on the mains current or in case of abnormal voltage drop. When automatic start is not used the group is started with a key.

In order to give an idea of the extent of the interlocking installation at Ermezinde station, it may be mentioned that it controls 28 points and 21 signals and comprises about 300 relays and over 20 000 connections. The electric junctions in the interlocking machine are about 8 600 and comprise 15 150 m insulated copper wire. The earth cables outside the cabin of which two are hundred-wire have a length of 7 840 m and represent 140 300 m single wire.

It is desirable that similar installations be generally introduced in all great stations, not so much for the facility of operation they offer, but above all for the increase in the traffic safety which they represent. This claim which might seem exaggerated to those not quite familiar with railway operation, is entirely confirmed by the following words, expressed by the French minister of public works in a speech which he delivered in Paris over the remains of the two hundred victims of the railway accident at Lagny on Christmas Eve 1933: »In everything that concerns the traffic safety of railways, whether it be question of material, brakes or signals, there should be no mention of any economy except that of human life.»

Utilization of the Centralograph in Textile Mills

H. ZILZER, CHIEF ENGINEER OF GOLDBERGER SAM. F. ÉS FIAI R.-T, BUDAPEST

The profits of textile undertakings depend primarily on the attainment of the highest degree of efficiency from the various machines. To obtain this it is necessary to supervise the machines as comprehensively and exactly as possible. The centralograph, which provides at a central point — e. g., in the mill manager's office — an easily surveyable record always available of the output of a large number of machines, constitutes a valuable aid to the efficiency engineer. With the centralograph a surprisingly perfect technical solution has been given to the problem of machine control and the production engineer has received a reliable and impartial instrument of supervision.

In the following some examples are given of quantity and quality supervision of cotton spinning and printing machines by means of the centralograph.

Control of Slubbing Frames

It is well known that the slubbing frames constitute one of the most important factors in a cotton mill, because the slightest variation in the physical condition of the cotton, the humidity of the atmosphere or the mixing necessitate immediate adjustment of the machines to prevent increase in the number of broken ends. Increase in the number of broken ends on the slubbers cause corresponding increases on the intermediate and roving frames, which means quite considerable production losses. Furthermore, a greater number of broken ends is caused on the ring spinning machines, that is to say deterioration arises in the quality of the finished goods. It is thus particularly important to ascertain continually the number of broken ends per hank and 100 spindles or per hour and 100 spindles on these machines. For a spinning expert no further explanation is necessary, the importance of an efficient and continuous control of the number of broken ends on slubbing frames being so evident that keen appreciation is felt that one has through the centralograph for the first time obtained a reliable instrument for providing such control.

Fig. 1 X 3746
Centralograph contact
fitted on the feed roller of a slubbing frame

The contact devices of the centralograph are fitted on the feed rollers, see Fig. 1. The impulse intervals should be chosen so that close recording is obtained; the stoppages caused by broken ends can then be easily distinguished.

In practice this mode of control has proved its worth remarkably well, inasmuch as it provides the means of establishing exactly the duration of every stoppage due to broken ends; the centralograph is thus the first to give not only a true picture of the working of the slubbing frames, but also of the work of the minders and of the correct setting of the machines.

It is possible by means of the centralograph to detect at once all setting faults, small or large, thus providing opportunity to carry out any necessary adjustments without delay. When changing the setting of a machine for spinning a fresh quality or another count it can be immediately checked whether the new setting has been made correctly. Furthermore, the centralograph diagram shows the exact point of the bobbin length at which break-

Fig. 2
Diagram of the main causes of production losses in ring spinning frames

ages occur, which gives an indication as to where the setting faults are to be found. Finally, centralograph control on slubbing frames has proved valuable in connection with wages calculations; thanks to the exact times given for stoppages, reliable figures are obtainable for bonus calculations, with the result that the protests and claims which frequently occurred in the past are eliminated.

In conclusion it can be mentioned that, thanks to the easy and continuous control provided by the centralograph, the production on the slubbing frames can be increased by 15 to 25 %, reversion to the old faults has been made impossible and still further improved results are to be expected.

Supervision of Ring-Spinning Frames

A ring-spinning mill which is correctly planned works in such a way that the output increases from one machine in the production chain to the next, all along the line from the ring-spinning frame to the scutcher. The narrowest cross-section of the mill lies therefore at the ring-spinning frames, the capacity of which determines the output of the mill as a whole. The production costs, therefore, depend directly on the output of these machines, losses here amounting in the end to from 300 to 600 % of the direct cost of wages, according to the count spun.

The above indicates the importance of checking losses on ring-spinning frames. The possibilities of loss on these machines vary greatly as is apparent from the tabulation of the main causes, Fig. 2. All these losses are recorded by the centralograph, Fig. 3. The contact devices for ring-spinning frames should be connected to the front roller, see Fig. 4. It is advisable to choose the gearing of the contacts so that the number of markings per centimetre can easily be read on the diagram, Fig. 5.

To derive full benefit from the centralograph diagrams, production report forms are necessary, Fig. 6. Against the horizontal lines the machine numbers have been arranged in numerical order, with in the vertical columns hours and minutes according to shifts. Such a form is made up every day for each department and shift by the foreman on duty. The duration

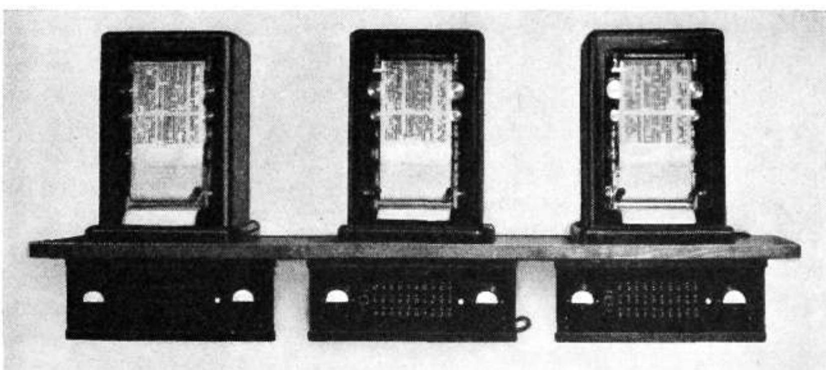


Fig. 3 X 5393
Centralograph equipment
for the supervision of 90 machines

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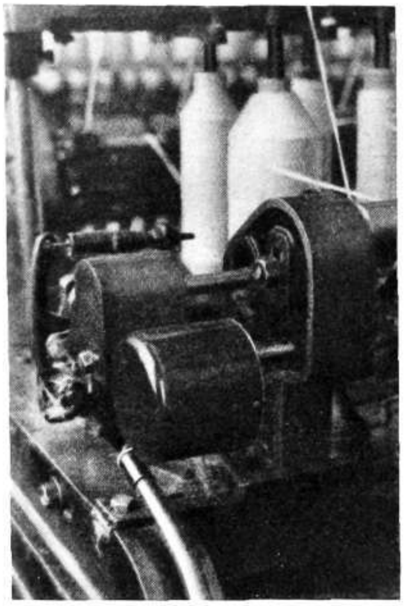


Fig. 4 X 3747
Centralograph contact
fitted on the front roller of a ring-spinning frame

of all stoppages, except for doffing, is marked by lines in the columns of the respective machines, and the reason for each stop is indicated by the corresponding reference letter. The centralograph diagrams are checked daily by comparing them with the entries by the foremen on the report forms; the figures thus obtained are tabulated according to machines or machine groups and reasons for stops. The tabulated summaries are then used for further check of time losses, thus giving a picture of the extent of the stoppages in a certain period (week or month) for each machine or machine group, as well as for each particular kind of stoppages.

Speed Losses

To check the stoppages occasioned by slowing down of machines with variable speed motors, the number of markings per centimetre is noted for each machine where the markings are most infrequent. It can thus be determined whether the machines have been working at the prescribed speed.

Stoppage Losses

Stoppages for doffing, cleaning etc. are regulary recurrent and the extent of the normal loss should therefore be ascertained with exactness by time studies. Where a doffing gang is used, their earnings should be calculated according to a bonus calculated on the basis of average doffing time, see Fig. 7. Surprisingly good results are often obtained with a bonus system of this kind.

The average times for change of yarn, draft, travellers etc. should also be ascertained by time study. The relation between actual and calculated times for these operations can be illustrated graphically per week and shift on the basis of the figures obtained through time studies as compared with those found in the diagram; this relation gives a good illustration of the average efficiency of foremen and operators.

The calculated duration of stops for repairs, lack of material etc. cannot be fixed by time study and must therefore be ascertained in graphical or tabulated form, divided over individual causes. The result will indicate to the mill manager any defects in the organisation.

Only when an exact picture of the development, nature and extent of the various stops is obtained through daily analyses of the tabulated information is it possible to reduce these to a minimum and increase the profits of the business. The means to attaining this end is the centralograph diagram and the application of time studies.

Control of Rotary Printing Machines

Exact control of printing machines constitutes one of the most difficult problems in a cotton mill. It has, however, been entirely solved by applying the centralograph system. The working time of printing machines is divided into running or printing time and fitting or stopping time. In most printing departments one must reckon with a total stopping time of 20 to 40 % of the total working time, or up to 50—60 % if multicolour printing is used; it is thus evident that a decrease of this percentage is of great importance. To bring about such a decrease it is, however, necessary to possess exact knowledge of the progress of the work, such as is obtained through the centralograph.

On printing machines the contact devices are fitted on the feed rollers, which rotate only when material passes through the machine. No centralograph registration will therefore be made, should the machine be running empty.

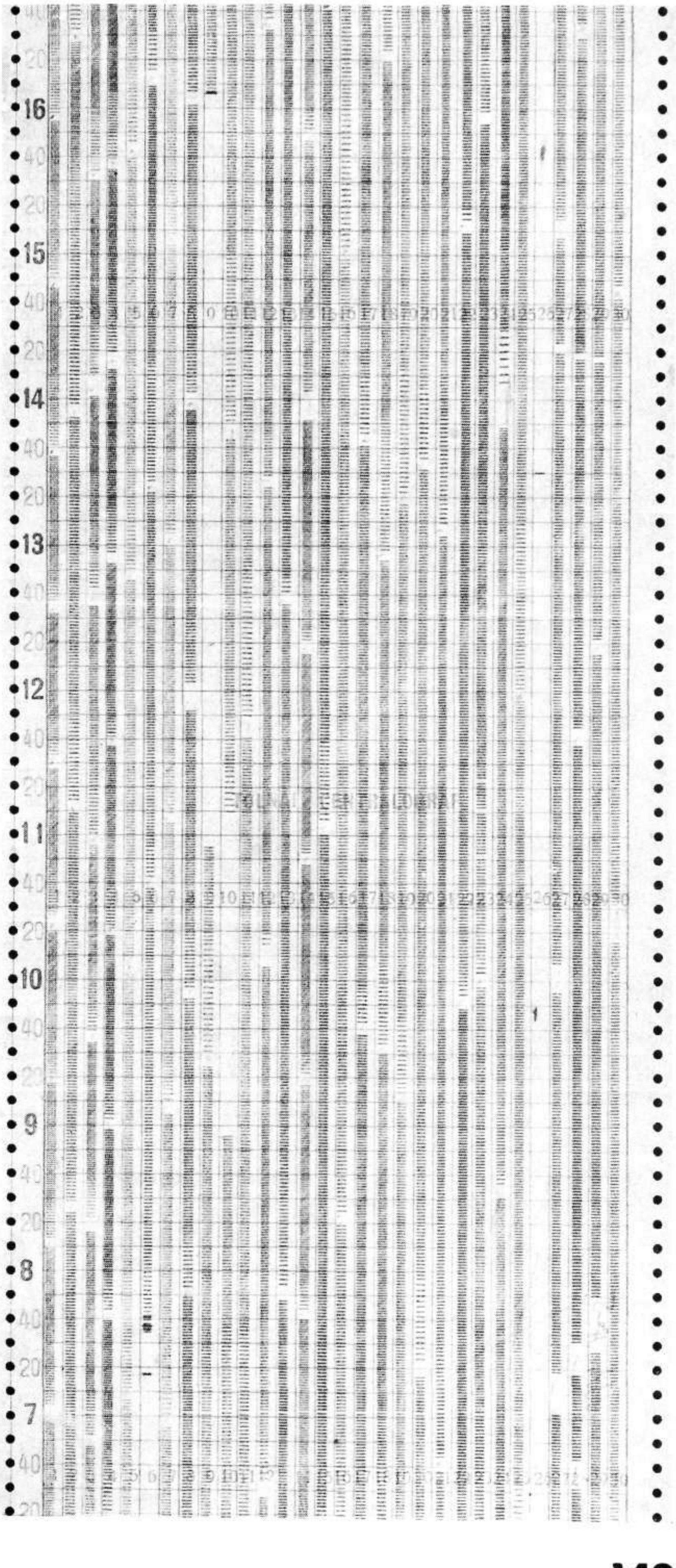


Fig. 5 X 5395
Centralograph diagram
showing the working of ring-spinning frames

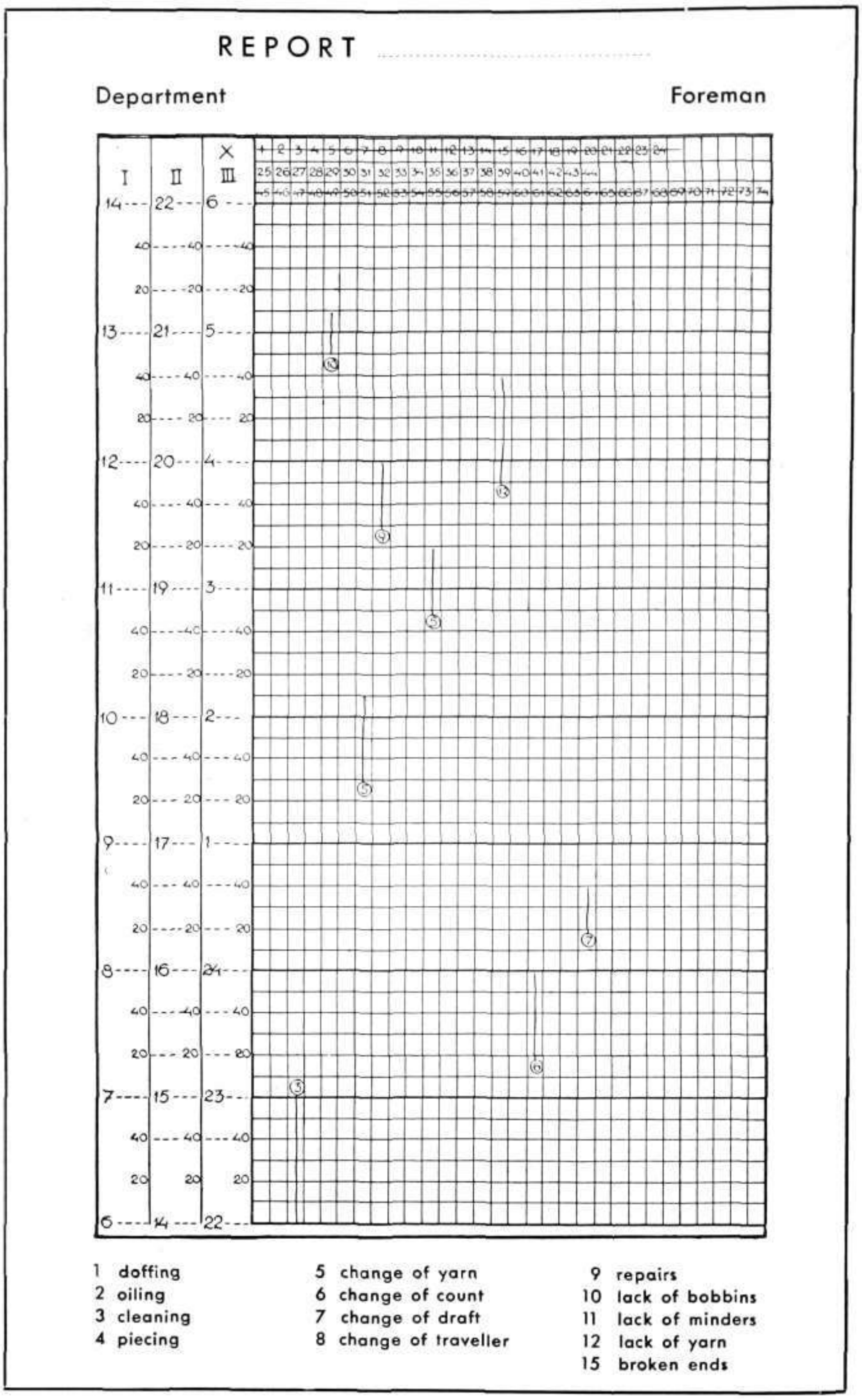


Fig. 6 X 5394

Report forms

stoppages of the different machines are marked in the columns of the respective machines, the reason for each stop being indicated by a reference letter

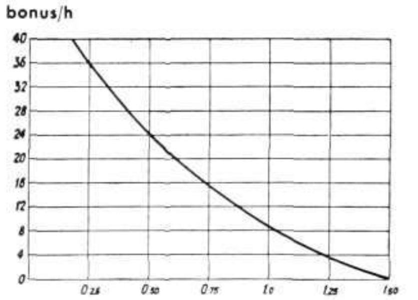


Fig. 7 X 3757

Bonus for the doffing gang

as function of the ratio real time to average time

Running Control

The density of the diagram gives an indication of the running speed of the machines, whereby it can be ascertained if they have been working at the prescribed speed.

Stoppage Control

The stoppages which occur on printing machines can be detailed as change of one or several colours, change of one or several rollers, insertion of new material, change of the printing order of the different colours, change of the colour scraper, etc. To ascertain these times it is necessary to calculate their normal duration, which is a somewhat complicated matter. In an eight-colour machine, *e. g.*, the material first printed with five rollers, and afterwards the pattern printed with seven rollers. The number

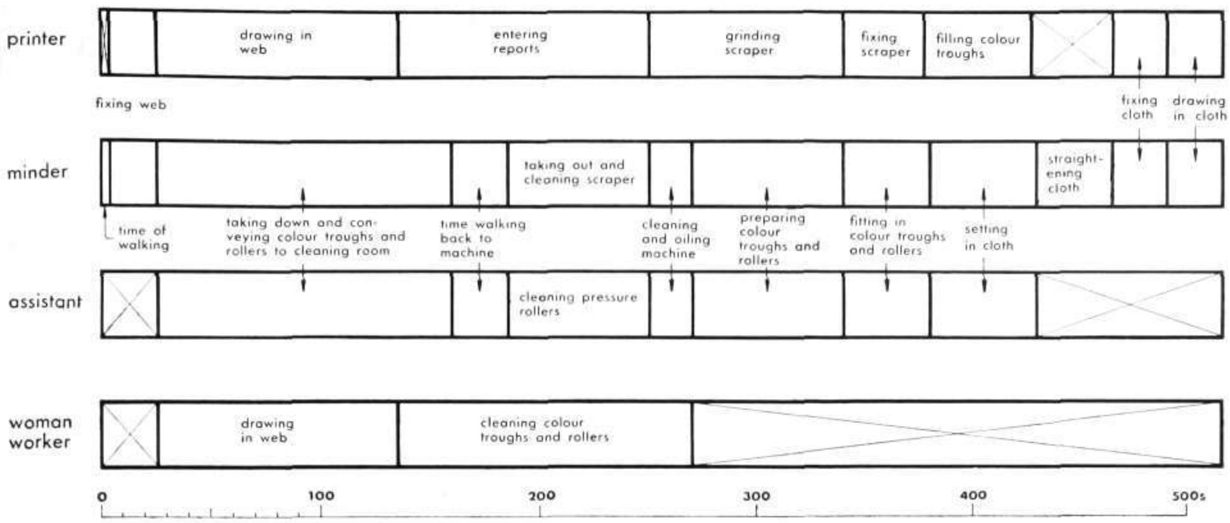


Fig. 8 X 7143

Graphic illustration of the average time

of changing from one colour to another

of combinations is therefore the square of the number of colours; in a twelve-colour machine, *e. g.*, 144 normal times for colour change and 144 for roller change would have to be calculated to cover all possibilities. This work appears at first to be rather formidable, but once these normal figures are established they provide for the future a very valuable aid.

A further complication in connection with the determination of the normal times for these operations is that they are carried out simultaneously by several persons (printers and assistants). The most practical method is therefore to ascertain all normal times graphically, see Fig. 8. After fixing the normal times for all combinations, a bonus system on the basis of the relation between actual time and normal time can be introduced for the printers and their assistants. The printers should fill in report forms on the same lines as those used in the spinning department, giving the duration of stoppages and the reasons.

The further reasons occurring for stoppages on printing machines, such as waiting for material, colours and rollers, repairs to rollers etc. should be classified and arranged graphically or in tabulated form as described in connection with the ring-spinning frames. By means of this control, made possible by the centralograph, the efficiency of the printing machines can be increased to a surprising degree.

Use of the Duration Meter at a Small Electricity Plant

A. DROUGGE, TELEFONAKTIEBOLAGET L. M. ERICSSON, STOCKHOLM

A consumer of electrical energy who buys his power according to an excess-supply tariff has in the duration meter an excellent means of determining the most favourable subscription limit. The following article gives the experience obtained by a small municipal electricity plant after one and a half years' use of a duration meter for this purpose.

The electricity plant in question distributes energy to subscribers living in a town in the neighbourhood of Stockholm, but it does not produce any energy of its own, all energy being bought from the network of the State over its substation. From there 50 c/s three phase energy is transmitted at 3 300 V to twenty-two transformer stations where the voltage is transformed to 220 V, the energy being afterwards distributed through an overhead line of 220/127 V. The high-tension line has a total length of about 18 km which is quite considerable compared with the low number of subscribers, not quite 200, but it is explained to a certain extent by the unfavourable position of the town on both sides of a lake. Most of the subscribers are cottage owners but there are also a few industrial enterprises, a flour mill and a few retail tradesman. There are further a dozen electrified farms and quite a number of the many gardeners of the town have electrically driven irrigation. Electric cooking has not yet been introduced to any great extent, but the subscribers show a distinct tendency to utilize the comparatively low prices of the current, viz: 0.09 Kr./kWh during the eight winter months and 0.045 kr./kWh during the summer (May—August), for household purposes.

On account of the character of the consumption the electricity plant has purchased the energy according to what is known as the »rural tariff», *i. e.*, an excess-supply tariff, to which comes a fixed charge of kr. 2:— per tariff unit. From January 1, 1936, the charges were:

for base power	175 Kr./kW/year
for excess power	
during the period January 1—April 30 and	
September 1—December 31	
below 10 kWh, per tariff unit	0.07 Kr./kWh
above 10 kWh, per tariff unit	0.05 Kr./kWh
during the time May 1—August 31	0.035 Kr./kWh

By tariff unit is understood in the case of agricultural subscribers the number of hectares of soil under cultivation and in the case of purely residential subscribers the number of rooms including kitchen. The number of tariff units for which the electricity plant pays a fixed price is about 2 000; as the total overconsumption during the eight winter months is considerably above 20 000 kWh, one may reckon with a charge for the current of 0.05 Kr. during the winter and transfer the additional price of 0.02 Kr./kWh for the above-mentioned 20 000 kWh to the fixed charge which is then increased to Kr. 2.20 per tariff unit. Thus, the base power will cost 175 Kr./kW/year, while the excess power costs 0.05 Kr./kWh during the winter and 0.035 Kr./kWh during the summer. The problem of the electricity plant is then to find the subscription limit for the base power which gives the lowest possible cost for the electrical energy purchased.

A problem of this kind is solved in the easiest and most correct way by studying the *duration curve* of the installation. By the duration of a load is understood the total time during which the load in question has been equalled or exceeded;

Fig. 1 X 3759

Duration-metering installation

from left to right: above duration meter, maximum impulse counter; below impulse transmitter, rectifier and programme clock if a graphical compilation of the durations of all loads occurring in a certain plant is made and the charges are arranged according to their magnitude without taking into consideration the actual chronological succession a duration curve is obtained which gives a very clear and easily interpretable form and image of the magnitude and variation of the load during a certain period, e. g., a month, a half-year or a year. The management of the electricity plant decided therefore to obtain information as to the duration curve of the plant for which purpose they procured an installation for duration metering; this installation consists of a duration meter, a maximum impulse counter, a programme clock, a rectifier and a master electricity meter with impulse contacts, all fitted on the front of a black polished oak panel, Fig. 1. The terminal blocks are at the back of the panel and are easily accessible when this latter is swung out.

In October 1935 this installation was mounted in the substation and connected to the current and voltage transformers of the power supply, see diagram, Fig. 2. In series with the demand limit meter *6* of the power supplier which is used as an accounting meter for the consumer there is connected an Ericsson three-phase meter *5*, Type T2, for 3 300/110 V, 3 × 30/5 A, 50 c/s, containing impulse contacts which transmit the load values to the duration meter and the maximum impulse counter. The impulse contacts could, of course, have been incorporated in the existing demand-limit meter, but this method has been avoided partly because it would then have been necessary to take down the meter and send it to the works for reconstruction — a comparatively long and quite expensive procedure — partly because the meter would after this alteration have required a careful re-adjustment and calibration. By using as master meter the Ericsson meter, Type T2, originally designed to include impulse contacts there is saving of work, time and money and moreover the advantage is gained that the error of the existing meter once adjusted is not altered. The installation contains also a rectifier *4* for feeding the operating magnets of the duration meter, which are made for DC. The rectifier can without inconvenience be connected to an existing voltage transformer, and this was done in the present case.

Duration Meter

The Ericsson duration meter, Type VM1, Fig. 3, consists of twelve counters, driven by a quite complicated mechanism which will be described here only

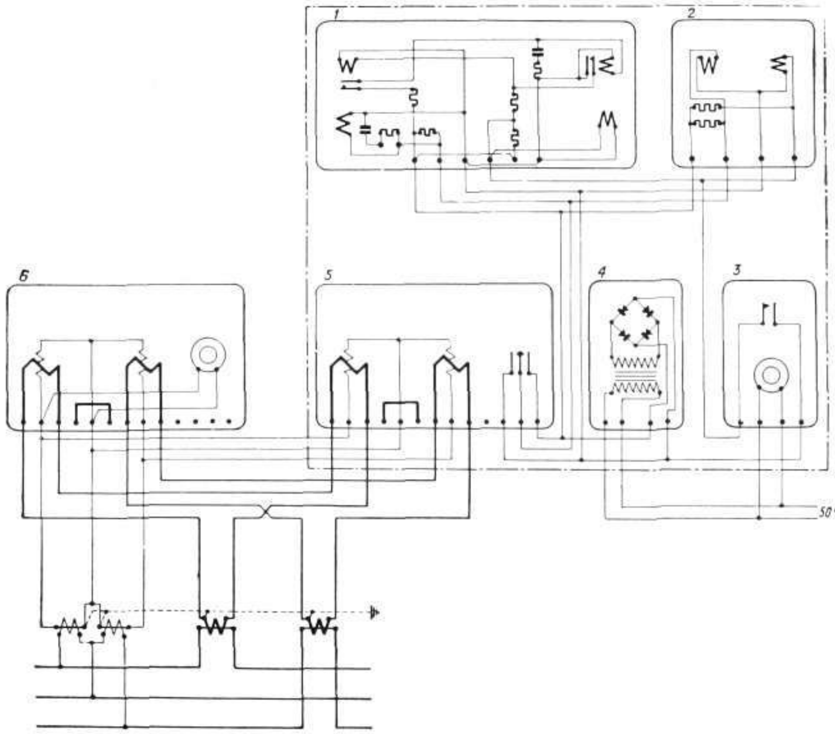


Fig. 2 X 5397

Diagram of duration-metering installation

1 duration meter
2 maximum impulse counter
3 programme clock
4 rectifier
5 impulse transmitter (three-phase kWh meter)
6 accounting meter (limit-demand meter)

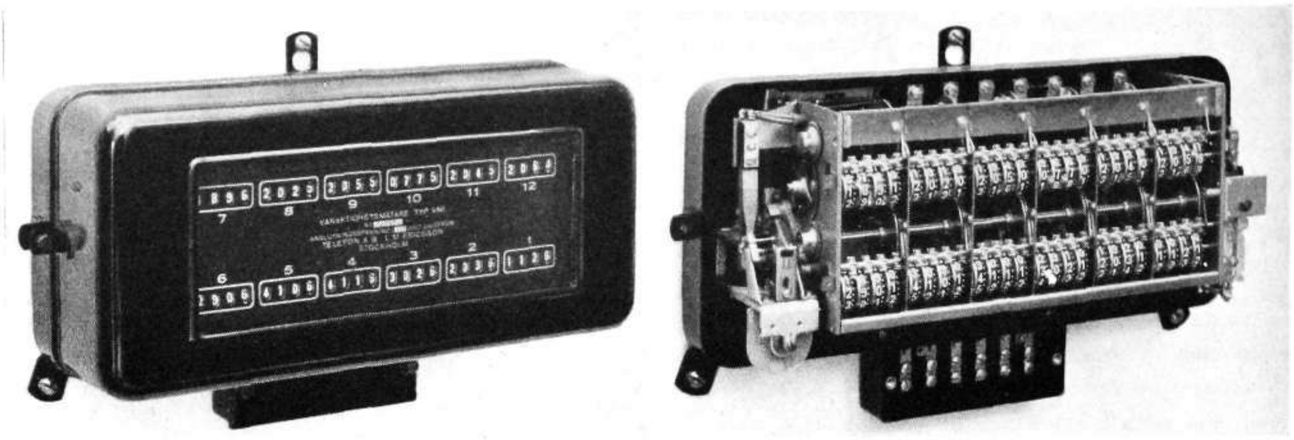


Fig. 3 X 7119
Duration meter
left with cover, right without

in so far as is necessary for a correct comprehension of the metering process. One of the counter shafts of the master meter *5* supports an impulse contact driven by the meter in the way shown diagramatically, Fig. 4. During the progress of the meter the impulse contact emits impulses to the duration meter, each impulse corresponding to a certain number of kWh, determined by the number of revolutions of the counter shaft per kWh and by the number of teeth on the gear-wheel of the impulse contact. These impulses, or primary impulses, are collected and stored by a mechanism in the duration meter, called the impulse collector. After this latter has received a certain number of impulses, which may be adjusted to suit different service conditions, it emits in its turn a secondary impulse which is registered by counter No 1 of the duration meter. The next secondary impulse actuates the counter No 2, the next counter No 3 and so on. After a certain time, or registering period, the contacts of the programme clock *3* are closed, and the impulse collector returns to home position. The next secondary impulse emitted by the impulse collector will thus actuate counter No 1 anew. The number of counters actuated during a registering period thus depends on the speed with which the secondary impulses are emitted, *i. e.* the magnitude of the load in kW.

In the above case the master meter was emitting a primary impulse for each 0.4 kWh metered energy; a secondary impulse corresponded to four primary impulses and the registering period was 15 min. If the duration meter has during a registering period emitted only one secondary impulse, the energy consumed in the same time in the installation has been $4.0 \cdot 4 = 1.6$ kWh. The mean load during the same time has thus been $\frac{60}{15} \cdot 1.6 = 6.4$ kW. On the other hand, if, *e. g.*, 5 secondary impulses have been sent out during the registering period, this would signify that $5 \cdot 1.6 = 8$ kWh have been consumed during the period at a mean load of $5 \cdot 6.4 = 32$ kW.

It has been mentioned before that a counter cannot be actuated more than once during the same 15 min. period and that the higher the load the more counters move one step forward. The relation between the number of counters actuated and the magnitude of the load is the following, *viz.*, that counter No 1 registers at 6.4 kW mean load, counter No 5 at $5 \cdot 6.4$ kW etc. Thus if counter No 5 is read after, *e. g.*, one month, it will be found during how many quarter hours the mean load has been equal to or greater than 32 kW. Counter No n thus indicates how long, expressed in registering periods, the load has been at least $nab \frac{60}{t}$ kW where a is the number of primary impulses per secondary impulse, b the number of kWh per primary impulse and t the duration of the registering period in min.

Fig. 4 X 3760
Contact device of the duration meter

In other words the twelve counters of the meter indicate the duration of their respective loads, the load corresponding to each counter being equal to the load of the first counter, multiplied by the sequence number of the counter. The 12 readings of the duration meter make it possible to draw a duration curve. In the present case there are evidently obtained the durations for the

12 loads, *viz.*, 6.4, 12.8, 19.2 .... 64.0, 70.4 and 76.8 kW. A thirteenth value which can always be obtained, *viz.*, for the load zero, is the total time covered by the investigation, and a fourteenth value, corresponding to the maximum load having the duration 15 min, are obtained by means of the above-mentioned maximum impulse counter *2*. This latter registers all the primary impulses emitted during a quarter of an hour, in such a way that the counter stops at the highest numerical value attained during the quarter of an hour in question. Thus, if the counter has during a certain quarter of an hour received 49 impulses, the figures will not be altered if the next quarter of an hour only gives, *e. g.*, 45 impulses; but if at a later moment the load should attain a value corresponding to 56 impulses, the counter will move forward seven steps, corresponding to the new maximum value. The counter thus only replaces a maximum-demand indicator and should be used when such an indicator is not included in the normal equipment of the installation.

Calculation of the Subscription Limit

As mentioned before, the installation was put in service in October, 1935, and the duration meter was at the beginning read off each fortnight. However, it was soon found sufficient to take a reading each month. In this case it was agreed that the power supplier should simultaneously with the monthly reading of the accounting meter also read the duration meter and communicate the result to the electricity plant. Along with each reading the following data were also furnished: the serial number of the duration meter; day and hour for the reading; positions of the 12 counters; position of the master meter; registering of the maximum meter; duration of the registering period. The values read were subsequently arranged in a table, *e. g.*, according to Fig. 5. The table is made up from the bottom to facilitate the subtraction between two successive counter values.

Thereafter a curve was drawn for each reading on the basis of the values obtained from the table, see Fig. 6 a which shows the duration curve for June 1936. The curve shows among other things that the constant load (no-load losses and base consumption) was about 7.5 kW, that the maximum load was 77.5 kW and that the load curve has fallen quite rapidly so that, *e. g.*, the load during half of the period, 350 h, did not exceed 26 kW. The total energy consumed during the period investigated may be obtained by planimetering the area bounded by the axes and the duration curve; the value obtained in this manner conforms very well, if the curve is accurately drawn, with the value shown by the master meter. Fig. 6 b shows the duration curve of the same electricity plant for December, 1936, and it is evident how much more ample

Fig. 5
Table of the duration-meter readings

counters			*1*			*2*			*3*		
kW			6.4			12.8			19.2		
date	time	period h	position	quarter hours	hours	position	quarter hours	hours	position	quarter hours	hours
28/12	11.00	674	2 398	2 688	672	7 069	2 342	585.50	1 432	2 098	524.50
30/11	9.00	767.75	9 710	3 057	764.25	4 727	2 472	618	9 334	2 307	576.75
29/10	9.15	720.50	6 653	3 839	709.75	2 255	2 161	540.25	7 027	1 946	486.50
29/9	8.45	768.50	3 814	3 074	768.50	94	2 393	598.25	5 081	2 031	507.75
28/8	8.15	669.75	740	2 020	505	7 703	1 735	433.75	3 050	1 449	362.25
31/7	10.30	817.50	8 720	3 269	817.25	5 968	2 591	647.75	1 601	2 232	558
27/6	9.00	696.50	5 451	2 780	695	3 377	2 262	565.50	9 369	1 892	473
29/5	8.30	744	2 671	2 974	743.50	1 115	2 497	624.25	7 477	2 032	508
28/4	8.30	697	9 697	2 788	697	8 618	2 300	575	5 445	1 902	475.50
30/3	7.30	712.50	6 909	2 828	707	6 318	2 347	586.75	3 543	2 022	505.50
29/2	15.00	—	4 081	—	—	3 971	—	—	1 521	—	—

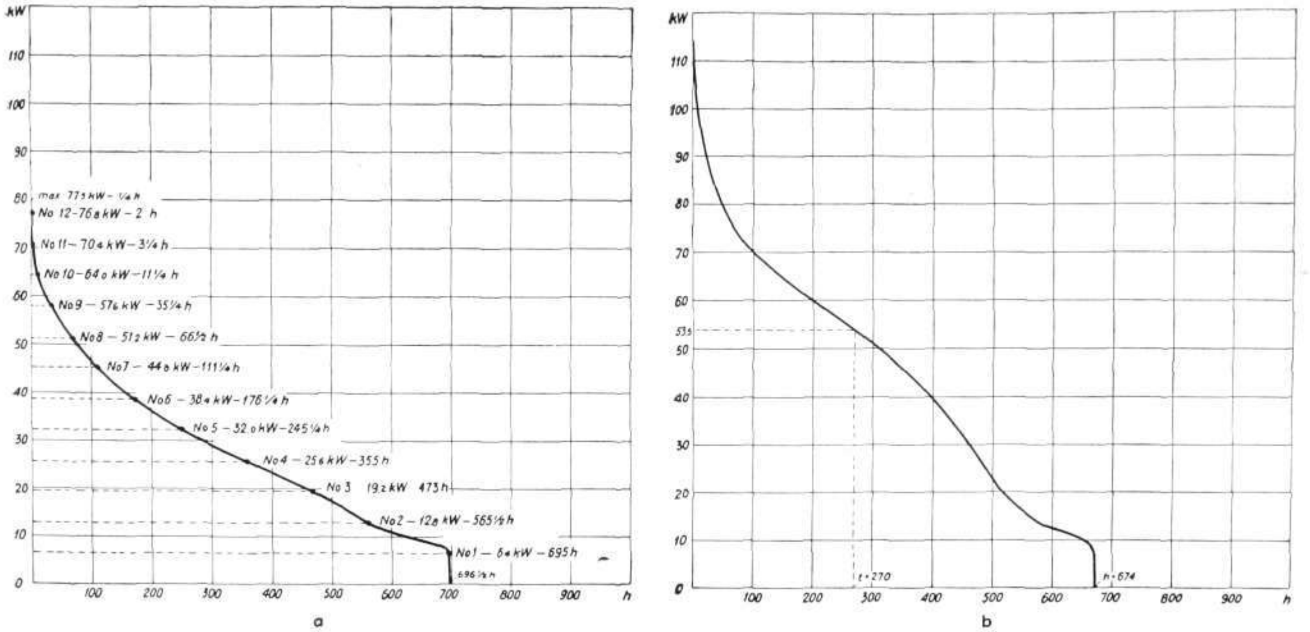


Fig. 6
Duration curves
a June 1936
b December 1936

X 1566
X 1567

this curve is in comparison with the curve from June. During half the time this load amounted to 47 kW. While the constant load has been nearly constant, a peak of 115 kW has arisen and the load has during not less than 60 h been higher than the highest load occurring in June.

For the calculation of the subscription limit giving minimum cost we introduce the following designations:

P = total cost of the power during the period investigated, in S. Kr.,
P_1 = cost of base power in Kr./kW/year,
p_2 = charge for excess power in Kr./kWh,
A_2 = excess consumption in kWh,
T = duration of the period investigated in h,
y = subscribed input in kW,
t = duration of this input in h.

If the duration of the period investigated is one year and P thus represents the yearly cost of the power, we obtain

$$P = P_1 y + p_2 A_2$$

If the period investigated only comprises part of the year, *i. e.*, T h, we obtain instead the equation, considering that one year has 8 760 h

$$P = P_1 \cdot y \cdot \frac{T}{8760} + p_2 A_2$$

Derivating this equation we obtain, see Fig. 7

$$\frac{dP}{dy} = \frac{P_1 T}{8760} + p_2 \frac{dA_2}{dy}$$

The condition for P giving minimum cost is $\frac{dP}{dy} = 0$

thus
$$\frac{P_1 T}{8760} = - p_2 \frac{dA_2}{dy}$$

but
$$t\,dy = - dA_2$$

then
$$\frac{P_1 T}{8760} = p_2 t$$

or
$$t = \frac{P_1 T}{8760\, p_2}.$$

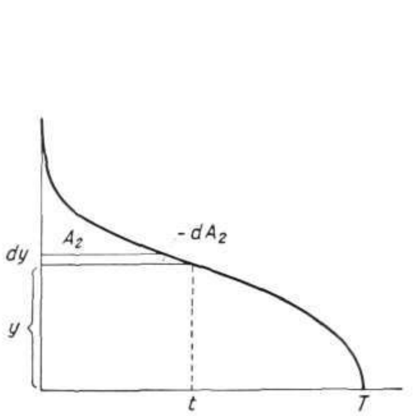


Fig. 7
Deduction of the formula $t = 0.4\ T$

X 3761

If the actual values for the winter season are inserted in this equation we obtain

$$t = \frac{175\ T}{8760 \cdot 0.05}$$

or

$$t = 0.4\ T$$

Applying this result to the curve, Fig. 6 b, which comprises 674 h, we obtain $t = 270$ h. The curve shows that the input the duration of which is 270 h amounts to 53.5 kW. If the subscription had only comprised December, 1936, the subscription limit could have conveniently been placed at 53.5 kW. However, subscriptions are generally entered per half year, beginning on January 1 or July 1 and it is therefore necessary to evaluate the probable optimum subscription limit for the next half year on the basis of the duration curve of the preceding half year. A difficulty then arises, *viz.*, that p_2 has one value 0.05 Kr. for four months and another, *viz.*, 0.035 Kr. for the other two months.

We will first investigate this question theoretically and then insert the actual figures in the formula obtained. We suppose that a duration curve has been drawn for the four winter months and another for all the six months, see Fig. 8. The area enclosed between the curves evidently represents the consumption during the summer months. Put

p_2 = winter charge in Kr./kWh,
p_3 = summer charge in Kr./kWh,
A_2 = excess consumption during the winter in kWh,
A_3 = excess consumption during the summer in kWh,

obtaining

$$P = \frac{P_1 T}{8760} y + p_2 A_2 + P_3 A_3$$

which gives by derivation

$$\frac{dP}{dy} = \frac{P_1 T}{8760} + p_2 \frac{dA_2}{dy} + p_3 \frac{dA_3}{dy}$$

At minimum costs we have $\frac{dP}{dy} = 0$ and then

$$\frac{P_1 T}{8760} = - p_2 \frac{dA_2}{dy} - p_3 \frac{dA_3}{dy}$$

From Fig. 8 is evident that

$$- dA_2 = t_2\, dy$$

and

$$- dA_3 - t_3\, dy$$

where t_2 and t_3 are the durations of the optimal subscription limit for a half year during the four winter months and the two summer months respectively. We further obtain

$$\frac{P_1 T}{8760} = p_2 t_2 + p_3 t_3$$

Inserting the actual figures we obtain

$$\frac{175\ T}{8760} = 0.05\ t_2 + 0.035\ t_3 \tag{5}$$

or

$$0.4\ T - t_2 + 0.7\ t_3 \tag{6}$$

This shows that the subscription limit required is situated at the load having a duration of 0.4 T h in a corrected duration curve, where the duration of each load corresponds to the total duration of this load during the four winter months augmented by 70 % of its duration for the two summer months.

X 3762

Fig. 8
Deduction of the formula
$t_2 + 0.7\ t_3 = 0.4\ T$

Such a corrected duration curve has been designed for the first half of 1937, assembling first the values of the table, Fig. 5, in the way shown Fig. 9. Subsequently the duration curves for the periods January—April and January—

June were drawn, which gave an image of the actual distribution of the load, see Fig. 10. As T was 4 366.25 h in this case, 0.4 T had the value 1 746.5 and this time coordinate was drawn in the diagram. It is then evident that the limit required must be situated somewhere between the fifth and sixth counters and it is then only necessary to calculate the »reduced» values for counters No 5 and No 6, adding also No 4 and No 7 to obtain the correct form of the curve. From the table, Fig. 9, the following values are obtained

duration	counters			
	4	5	6	7
t_3	764.25	551.75	374.5	232
0.7 t_3	535	386.25	262.25	162.5
t_2	1 819.5	1 617.25	1 380.5	1 072.25
$t_2 + 0.7\ t_3$	2 354.5	2 003.5	1 642.75	1 234.75

On the basis of these values part of the reduced curve was introduced in the diagram and was found to bisect the time coordinate 1 746.5 at an input value of 37 kW. Thus, the power charge would have been a minimum for the electricity plant, had this latter subscribed to a base power of 37 kW during the first part of 1936. Of course, it could not be predicted with certainty how the consumption would fluctuate during the latter part of the year but as the circumstances indicated in this special case that the both halves of the year would have about the same duration curve the electricity plant subscribed to the value found, *i. e.*, 37 kW. It was also found at the end of the year that the limit had been correctly chosen, see Fig. 10 b. In this assembly curve for the last half of 1936 the duration curve for the summer months has been drawn in first and the curve for the winter months added later. The reduced curve is drawn as before on the basis of the last equation, which is divided by 0.7, and may thus be written

$$\frac{4}{7} T = t_3 + \frac{10}{7} t_2$$

As T in this case was 4 418.25 h and $\frac{4}{7}\ T$ was thus 2 525 h the optimum subscription limit passes through the intersection between the time coordinate 2 525 h and a duration curve where all values of the actual half-year curve have been increased by $\frac{3}{7}$ of the actual winter values. The result conforms very well as may be seen with the limit valid for the first half of the year.

Fig. 9
Compilation of the duration-meter readings

counter		1	2	3	4	5	6	7	8	9	10	11	12
kW		6.4	12.8	19.2	25.6	32	38.4	44.8	51.2	57.6	64	70.4	76.8
month	total time h	readings h											
January	670	654.25	563	507.25	467.25	424	379.50	319	248.25	164.25	99.50	56	32.75
February	846.25	831.75	630.25	528	482.25	432.50	360	279.75	192.25	124.50	64	35.50	18
March	712.50	707	586.75	505.50	449	393.75	333.25	258.25	137.75	59	31.75	17.75	12
April	697	697	575	475.50	421	367	307.75	215.25	122	59.75	31	14.25	5.50
January—April	2 925.75	2 890	2 355	2 016.25	1 819.50	1 617.25	1 380.50	1 072.25	700.25	407.50	226.25	123.50	68.25
May	744	743.50	624.25	508	409.25	306.50	198.25	120.75	77.25	45.50	20.25	9.75	3.75
June	696.50	695	565.50	473	355	245.25	176.25	111.25	66.50	35.25	11.25	3.25	0.50
May—June	1 440.50	1 438.50	1 189.75	981	764.25	551.75	374.50	232	143.75	80.75	31.50	13	4.25
January—June	4 366.25	4 328.50	3 544.75	2 997.25	2 583.75	2 169	1 755	1 304.25	844	488.25	257.25	136.50	72.50

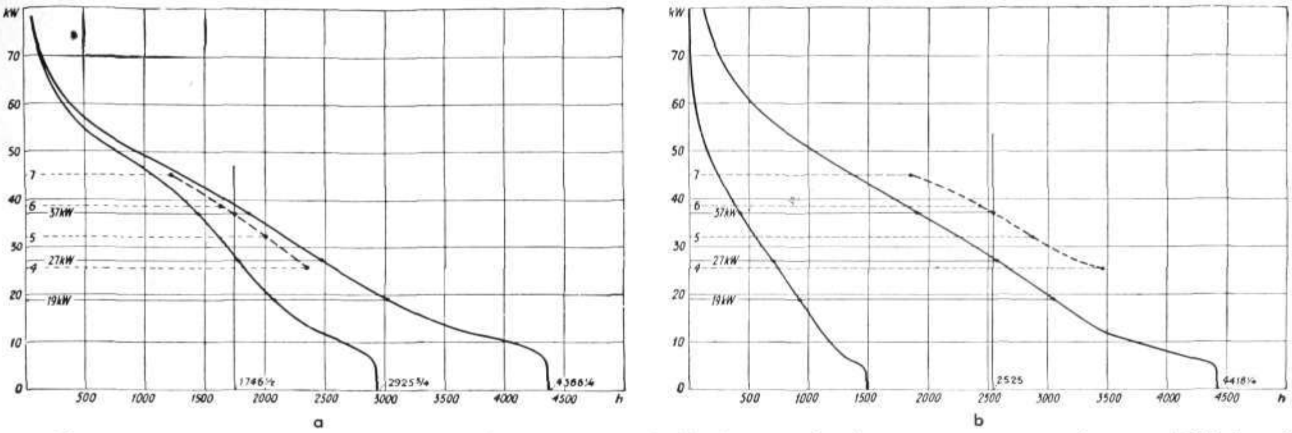


Fig. 10

Duration curves

a January—April and January—July
b July—August and July—December
--- reduced duration curve

X 1569
X 1568

During the latter half of 1935 the base power amounted to 19 kW, but it seems that this was far too low a subscription limit, considering the curves obtained for the months October—December. However, as the influence of the summer months could not be evaluated, it was decided that the subscription should not be increased beyond 27 kW for the first half of 1936. Eventually, for the next half-year this figure was increased to 37 kW.

Calculation of the Profit

On basis of the diagrams, Fig. 10, it is possible to calculate with a quite considerable accuracy the profit made by the electricity plant by altering the subscription limit. With the scale chosen for drawing both half-year diagrams 1 mm² corresponded to 10 kWh, and it was then only necessary to calculate the area comprised between the different output zones. Considering the curve for the first half-year 1936, Fig. 10 a, it is evident that if the subscription limit had remained at 19 kW the entire part of the power consumption comprised between 19 and 27 kW would have been registered on the surplus counter of the demand-limit meter. This consumption, counted in area according to the diagram and without claiming absolute precision, amounted during the winter months to 1 536 mm² and during the summer months to 656 mm². The cost of the excess power would thus have been increased by

$$1536 \cdot 10 \cdot 0.05 + 656 \cdot 10 \cdot 0.035 \cong 1\,000 \text{ Kr.}$$

By increasing the limit by 8 kW from 19 to 27 kW the electricity plant has thus saved 1 000 Kr. in excess power, but had to pay instead an increased charge for the base power, with $\frac{1}{2} \cdot 8 \cdot 175 = 700$ Kr. The net gain is thus 300 Kr. for the first half-year. If the limit had immediately been increased to 37 kW there would have been realized a further gain of

$$1\,620 \cdot 10 \cdot 0.05 + 570 \cdot 10 \cdot 0.035 - \frac{1}{2} \cdot 10 \times 175 \cong 130 \text{ Kr.}$$

In the same manner it is found from the curve, Fig. 10 b, that the gain during the second half of the year through increase of the subscription limit to 37 kW instead of 27 or 19 kW amounted to 160 and 495 Kr. respectively. The total gain for the electricity works during the whole year would thus have been 925 Kr. if the limit had been at 37 kW right from the beginning instead of at 19 kW.

However, it has to be admitted that the whole of this gain cannot be attributed to the duration meter, as there are approximate methods which allow an experienced and attentive observer of load conditions to evaluate whereabouts the subscription limit should be situated and it is therefore probable that the limit would have been increased even without the duration meter. However, the advantage with the duration meter is that it permits its user to obtain knowledge about the actual duration curve, which renders him independent of schematic standard curves which can only give approximate average values. It also eliminates all suspicion on the part of the customer, who is generally not very experienced in these questions, that the power seller is not judging the problem in a sufficiently unbiassed manner. The duration meter thus facilitates co-operation between seller and buyer and in this way serves both parties.

Mining Telephones

R. C. WOODS, ERICSSON TELEPHONES LTD, LONDON—BEESTON

In Great Britain the use of telephones in coal mines is governed by the statutory orders and regulations made by the Mines Department under the Coal Mines Act of 1911. By these regulations telephone communication is compulsory between the end of the haulage road and the pit bottom and the surface where the distance of the main haulage from the shaft exceeds 1 000 yards. The telephone is however an essential to efficient working in the modern pit and most pits have a complete system. The range of efficient yet safe equipment available to-day encourages the industry to obtain the ful advantages of telephony, rather than to restrict to the statutory obligations.

Principle

There are two distinct systems of mine communication, the flameproof, usually designated »FLP» and the intrinsically safe, generally referred to in the industry as »certified». Instruments and apparatus of a type certified by the Mines Department as safe are marked in a distinctive manner. Flameproof instruments bear on the case the letters »FLP» enclosed in a crown, with the certificate number underneath. Intrinsically safe apparatus bears a label with the name and type number followed by the words »certified by the Mines Department» and the date of the certificate. Where the apparatus is approved for use on either system, both methods of marking are employed.

The two systems are quite distinct in the means of preventing sparks from causing ignitions of firedamp. The *flameproof* method is so to enclose the places where sparking may occur that any flame which may result from ignition of the enclosed gas mixture — methane and air — either cannot pass to the outside atmosphere or is so cooled on its passage to the exterior that it cannot produce ignition of the most sensitive surrounding methane atmosphere. The usual means are to provide wide machined flanges for cooling, to limit unoccupied internal space and to attend specially to strength of materials and construction. All apparatus must be flameproof and the lines fully insulated armoured cable led into the apparatus via sealing glands. Good maintenance is an essential, as damage to casework, incorrect re-fitting of flanged joints or a line fault immediately introduces the element of risk. Flameproof enclosure of instruments does not preclude incendive sparking elsewhere and is useless, therefore, as a safeguard on bare-wire circuits.

The *intrinsically safe* method is to incorporate a safety device in each instrument and so provide an alternative path for part of the energy that otherwise would be concentrated in the spark. If necessary a limitation is also placed on the amount of current that can pass. Thus if an electrical spark occurs, inside or outside the apparatus, whether in normal working or as a result of any fault in the wiring system then ignition cannot occur. Bare-wire signalling is common in pits and, where signalling and telephones are associated, the intrinsically safe system is indicated. Automatic and other central-battery systems are not available in the intrinsically safe class. Battery power is limited to a maximum of 25 V and for intrinsic safety to the 3-pint Leclenché cell or its certified equivalent, and the precautions against incendive sparking make reliable service impracticable. Where such systems exist on the surface and it is desired to extend them into the mine for direct operation, then flameproof instruments and armoured cable must be used.

Design

The Ericsson flameproof instruments follow the principle of placing each contact or switch point in its own flameproof enclosure. These individual enclosures allow the volume of gas enclosed to be so low that the effects of ignition can be made very small. When apparatus is surrounded by an atmosphere of explosives gas for any length of time, this gas gradually replaces the air in the internal spaces. Slow gas diffusion and movement due to temperature changes are the two means by which the dangerous gas enters the apparatus. Also when gas is present it would enter if the cover were removed for inspection. Should a spark occur within the apparatus to ignite the explosive mixture, the pressure produced is released by the passage of the burning gases through the cooling flanges. These are so designed that the heat is absorbed before the outer atmosphere is reached and there is no possibility therefore of the ignition being communicated. The efficiency of the enclosure depends to a great extent on the ratio of cooling surface to total heat generated. The small volumes of space obtained by the individual enclosures of the Ericsson instruments result in correspondingly low heat generation and explosive pressure. In addition, the total mass of cooling metal is proportionately high to the volume of possible explosive mixture.

CB and Automatic Telephones

The central-battery mining telephone, Type N 1470, and the automatic mining telephone, Type N 1087, Fig. 1, are similar in appearance, but the inner door of the CB-instrument is plain. The terminal chamber is arranged for armoured cable as standard, the sealing gland being both simple and effective. Fittings are available for screwed conduit for industrial use where that system of wiring is preferred. With this system the conduit must be taken to a sealing box outside the danger zone and sealed also at each instrument terminal chamber, to eliminate risk of flame propagation along the conduit.

The terminal chamber connections are taken directly into an isolating switch enclosure, so arranged that opening the inner door for examination of the interior disconnects the lines from the internal wiring. This is essential where the lines are always under tension. The receiver switch on the inner door has its own flanged flameproof enclosure, the bearing itself having an ade-

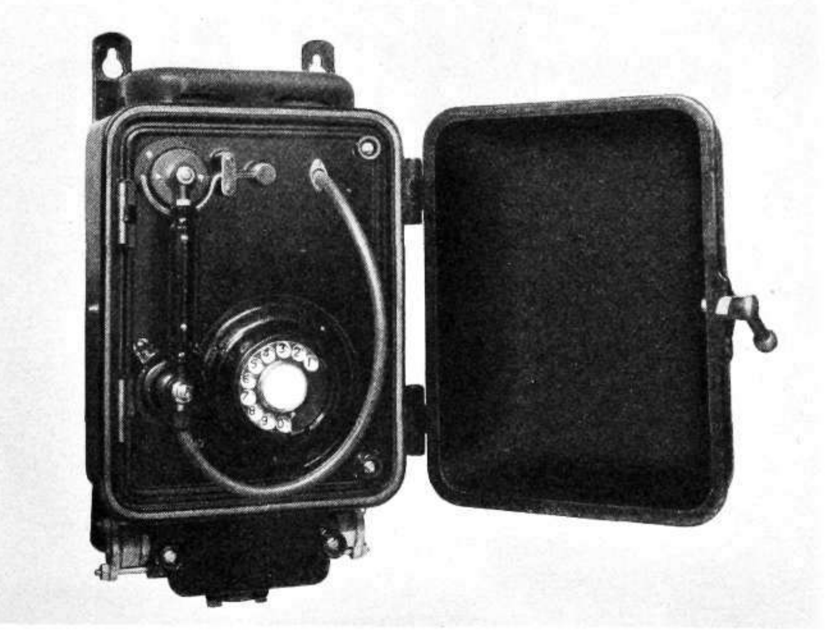


Fig. 1 X 5382
Automatic mining telephone, Type N 1087

quate flame-path. The atmosphere content of isolating and receiver switch enclosures is respectively 95 and 102 cm^3, which with the generous design affords a high factor of safety.

The dial assembly of the automatic mining telephone has the fingerplate independent of the dialling mechanism. Thus the safety of the enclosure does not depend on the light bearing shaft, but the movement is transmitted from finger-plate to mechanism by a clutch-shaft of generous proportions, coupled with a locking device which prevents damage to the dial mechanism by over-rapid dialling. Between the mechanism and the front casting carrying the flameproof bearing a gauze is inserted as a diffuser to prevent a cone of pressure being exerted upon the bearing in the event of ignition. This, while not an essential, provides an additional factor of safety of particular value where hydrogen mixtures and similar vapours are encountered. The back cover is of massive proportions and forms a spigot joint on the front housing.

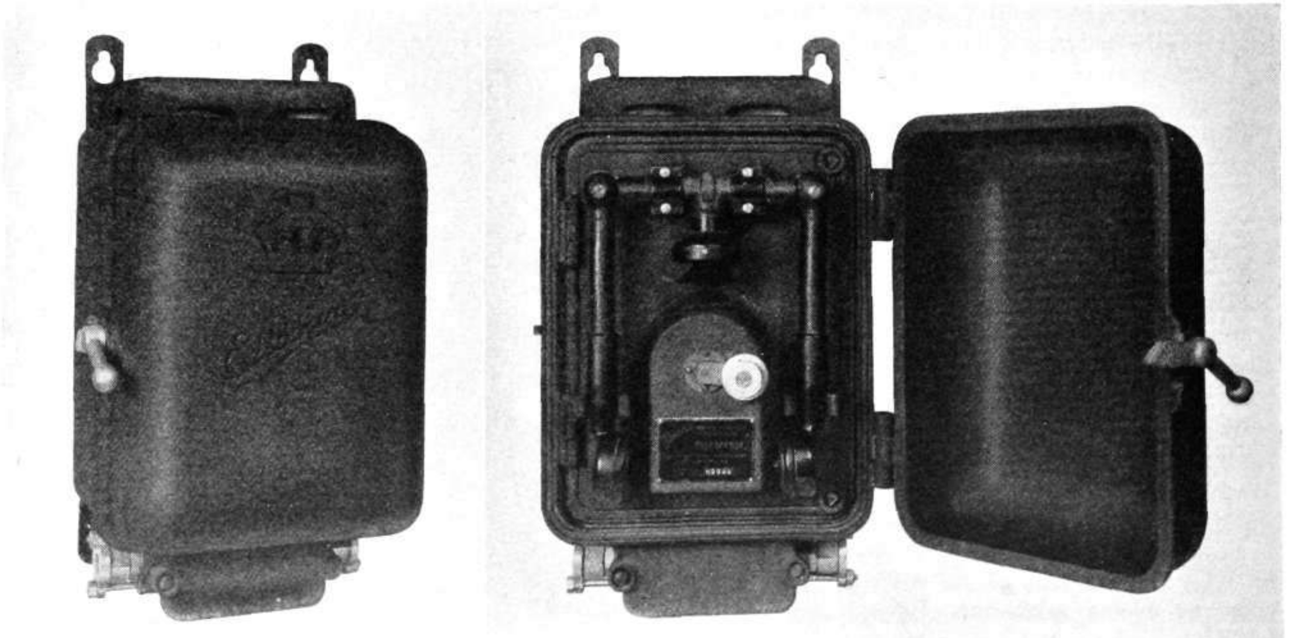
Magneto Telephones

The magneto mining telephones, Type N 2974 with handmicrotelephone and Type N 2984 with receiver-arm, Fig. 2 and 3, are the original Ericsson flameproof design. The switch enclosure of the first type is the same as that of the preceding instruments, but in that of the other type the atmosphere volume has been reduced to 39 cm^3. The other point of possible incendive sparking is the hand generator cut-out, which has a special end-bearing plate and flanged cover. Here again the atmosphere content is kept low at 95 cm^3. The terminal chamber is the same as that of the previously described instruments. These two magneto instruments are certified for use on both flameproof and intrinsically safe systems, so that for a colliery group or a pit where both systems are already in use, or where a possible change-over of system is to be anticipated, the dual purpose instrument is an advantage from a stock point of view.

It might be mentioned that all four above-mentioned flameproof telephones are approved by the Mines Department for use in firedamp (methane) as well as in petrol and acetone atmosphere.

For the magneto telephone system the Ericsson intrinsically safe apparatus is throughout of the high-impedance type, so that the effects of line resistance

Fig. 2 X 7118
Magneto mining telephone, Type N 2984
with receiver-arm



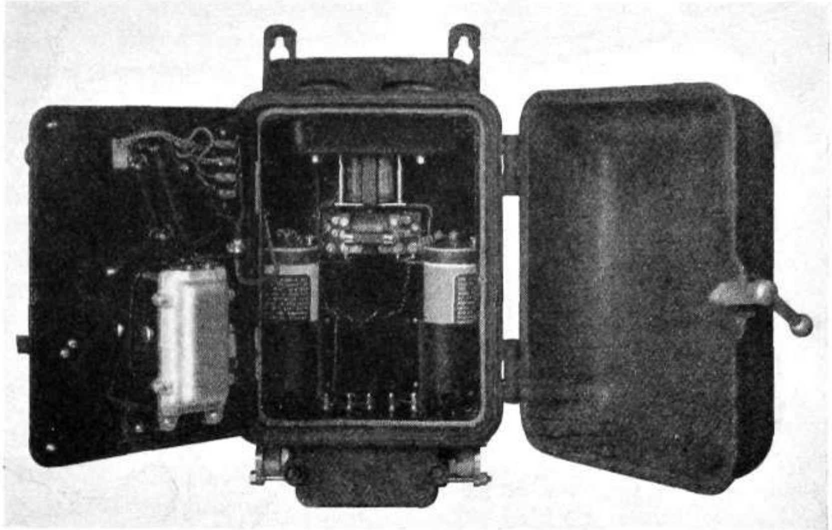


Fig. 3 X 5383

Interior of magneto mining telephone

on inner door receiver switch and magneto, inside the instrument bell with safety condenser and batteries

on the working of instruments in parallel is at a minimum and the general efficiency under adverse conditions is high. The specially designed hand generator used in the switchboards and instruments is wound strictly to turns and the two powerful magnets conform to strict limits of flux. The safety device consists of a resistance winding of 1 000 ohms superimposed on and directly connected in parallel with the nominal 300 ohm active winding. This generator has a particularly good output characteristic on varying resistance loads and compares very favourably with the lower impedance types of mining generator. Development tests have shown that this generator, even when machine driven at double speed in synchronism with and connected in parallel to a similar generator, will not ignite the most sensitive methane-air mixture, so that there is a sure margin of safety under all service conditions. This generator is used in all cases except the table telephone, where a generator of similar electrical characteristics but modified dimensions is fitted. The calling bells have 2 000 ohms DC resistance, with an impedance of the order of 7 200 ohms at 50 V, 16.6 c/s. The Mines Department devoted considerable research to the possibility of rendering various makes of apparatus safely interconnectable and found that by placing a condenser of approx. 0.01 μF across each calling bell etc., the desired object could be obtained. The condenser is of special manufacture to ensure permanence in service. All instruments are now fitted with such a safety condenser across the magneto bell, so that they can be used with any other certified types, of whatever manufacture, providing these are similarly fitted. The introduction of this small condenser has no appreciable effect on performance yet permits safe mixing of all certified types.

In manager's and officials' offices a table telephone may be preferable and there are also positions in surface offices or engines houses where the usual ironclad instrument is not essential. For such cases the table instrument, Type N 2155 D or the wall instrument, Type N 2504, certified for surface use under cover, provide a suitable alternative.

Switchboards

The most suitable type of switchboard for use in a mine is the *cordless switchboard,* which can be constructed to withstand adverse climatic conditions, dust and heavy usage. The normal working conditions of coal mines tend to much heavier and less considerate use than is generally accorded telephone equipment. The majority of switchboards in mines are only required to connect a few lines and for this purpose the small pyramid board, Type N 510, Fig. 4, is particularly suitable. The robust hardwood case has a

Fig. 4 X 3742
Mining switchboard, Type N 510
for 4 lines

sloping top reinforced by a heavy-gauge steel plate to protect from falling roof material and water. The front plate is of steel and carries the indicators under a waterproof cover furnished with a resetting knob. Beneath these, arranged in the pyramid formation from which the board takes its name, are the stout metal »push and pull» plunger keys for interconnecting the circuits.

For operating, a telephone such as Type N 2974 or N 2984 is required to be fitted alongside the switchboard. Where more lines have to be accommodated the switchboard, Type N 550, Fig. 5, is indicated; this can be arranged for from 10 to 30 lines. The connecting keys are in horizontal rows, the indicators are totally enclosed units, individually reset by push button. A calling generator and handmicrotelephone for operating are incorporated in these boards, which are usually under constant supervision and not exposed to unauthorised interference.

Where more than thirty lines are required a floor pattern *cord switchboard*, Type N 570, may be used, or if specially desired another cordless section could be placed at the side of the board, Type N 550. The cord board has enclosed, push-restored indicators for both calling and clearing and the connections are made by means of plugs, cords and keys. It accommodates equipment up to 100 lines. In practice, however, large mining switchboards are rare, and the tendency will be for them to become rarer. Mining conditions in most pits are best catered for by small switchboards, interconnected when necessary.

Coupling Unit

Where the administrative office telephone network was required to have free interconnection with the underground system, for safety all telephones had to be of certified type, and a certified switchboard at the surface was necessary. The number of tie lines to the pit might be very low compared with the surface lines connected.

By the recent introduction of the Ericsson mining telephone coupling unit a considerable advance has been made in mine communication. Hitherto

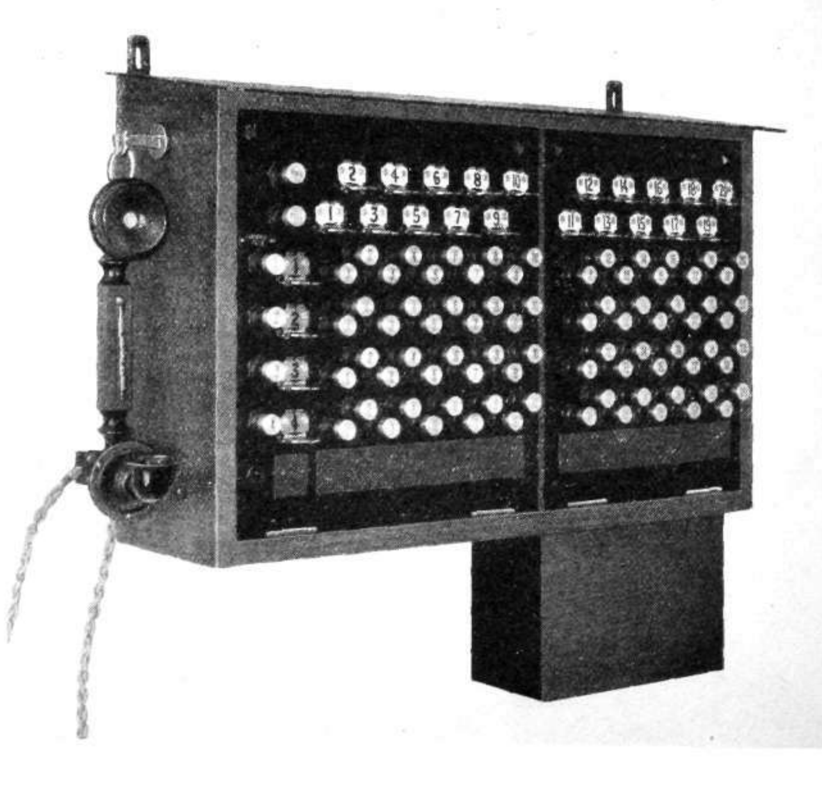


Fig. 5 X 5421
Mining switchboard, Type N 550
for 20 lines

Fig. 6 N 3744
Battery-call mining telephone, Type N 1150

intrinsically safe magneto systems could not be connected to ordinary surface systems because of the risk of dangerous energy being injected into the circuit. By a combination of series impedances with a shunt resistance composed of dry rectifier units, a protective device is obtained which has very little effect upon speech current, a small absorbtion from weak ringing currents, yet progressively absorbs energy as the danger rises. To do this, advantage is taken of the curved voltage-resistance characteristic in the forward direction of dry-plate rectifier units which are placed back to back. For low voltages of speech magnitude the shunt is of the order of a few megohms, for minimum ringing voltages the shunt becomes say 2 000—3 000 ohms or more, dropping in resistance steeply as the voltage across the pair rises. As the resistance drops the proportion of voltage drop over the series resistance increases, so that the device is to a large extent self compensating.

Calling Devices for Magneto Signalling

The extension bell, Type N 3109 D, is of the large-gong oscillating-coil type used by the British Post Office, but specially wound. The impedance is of the order of 5 000 ohms at 50 V, 16.6 c/s. A bell of similar design, Type N 3109 H, is adapted for AC working with a certified transformer from the supply mains. This is used on signalling systems in the same manner as the battery bells, but obviates the maintenance of batteries.

The indicator relay, Type N 8652, is the standard push-button restored indicator of the certified switchboard in a wood case. It is provided with a local bell contact. The relay, Type N 7236, is noteworthy as operating on the split-phase principle. The split-phase power is applied via a lever-arm and materially assists in producing a sensitive relay, suitable for use as an intermediate relay when it is wished to operate audible or visual signal, etc.

All this apparatus is of robust construction, those for use in the pit being specially finished to meet atmospheric conditions and provided with shrouded triangular tamper-proof screws to discourage unauthorised interference with working parts.

Battery-Call Telephones

All battery-call telephones, signalling bells and relays are necessarily of the intrinsically safe type, as they are primarily for use with bare-wire signalling. A flameproof bell signal system would be unduly expensive, difficult to maintain and would have no advantage over the normal system. The Mines Department only grant intrinsically safe certificates for apparatus of this class. Battery voltage is limited to a maximum of 25 V and the battery must be a standard 3-pint Leclanché cell or of a type specifically certified by the Mines Department; only one such battery per electrical circuit is permissible. This restricts the energy available within known limits. The safety devices on Ericsson instruments and switchboards consist of shunts of appropriate resistance across the active windings of bells, relays and indicators.

The speech circuits in both magneto and battery-call systems are normal LB-circuits and the amount of energy that can become available under worst fault conditions is definitely below that necessary for ignition, so that the safety devices are found associated solely with the calling apparatus. The battery-call telephone, Type N 1150, Fig. 6, is of simple and robust construction, with inset transmitter and loudspeaking type receiver associated with external flexible listening tube.

An external certified bell, Type N 3030, with a resistance of 20 or 30 ohms, or relay and bell is used for signalling. The battery-call switchboard, Type N 530, is of the same general design and mechanical construction as the magneto board, Type N 550, previously

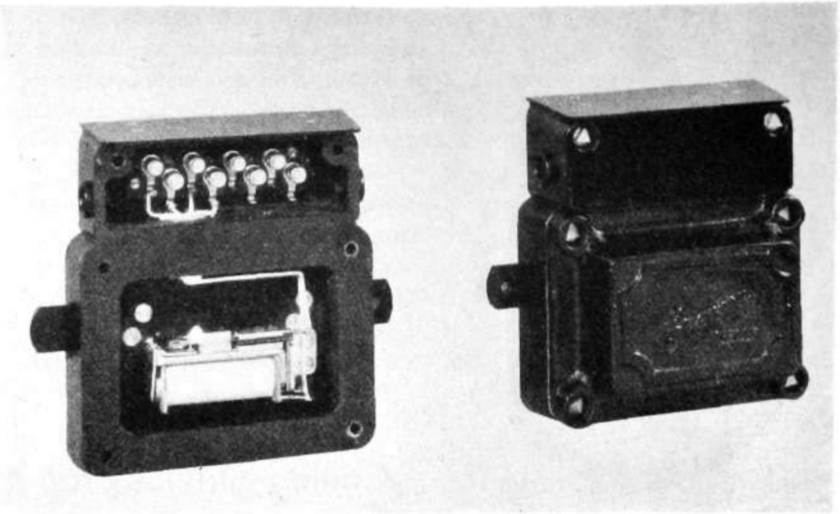


Fig. 7 X 5429
Battery-call mining telephone relay, Type N 7240

described, the electrical circuit and the indicators and relays being suitably proportioned and the generator replaced by the common signalling battery.

The relay, Type N 7240, consists of the latest type of telephone relay with integral safety resistance, mounted in a stout iron case having a watertight joint between wide machined flanges. A separate terminal chamber is provided with substantial connectors and a drip proof cover. Provision is made for from one to three sets of contacts. The same design of housing is used for the magneto-telephone relay also.

Use

The principal division of mines apparatus on the score of suitability for the service required is magneto telephone system for all general telephone communication and battery-call system for all haulage road signalling and the transmission of instructions by code rings. In small undertakings the addition of battery-call telephones to the existing bell system may be favoured, and local circumstances may make them preferable. Generally, however, the magneto system is distinctly preferable for its flexibility, reliability and high efficiency under adverse conditions of service. The range of equipment available is evidence of the popularity of the system. It may perhaps be noted that the same type of switchboard is used for both intrinsically safe and flameproof systems, but in the latter case the board must be placed out of the danger zone and provision made for terminating the armoured cable via sealing glands well outside the danger zone, and preferably at or near the board. The cost of a flameproof switchboard would in most cases be considered prohibitive and the demand negligible, while with the exception perhaps of the smallest boards it is rare that they cannot be placed in a position free from risk of gas.

The Latest British Post Office Telephone Instrument

F. ENGBLOM, ERICSSON TELEPHONES LTD, LONDON-BEESTON

The normal Ericsson telephone instrument in bakelite which was described in Ericsson Review No 1, 1933, has received a flattering recognition from the telephone administrations as well as from private enterprises of several countries on account of its attractive appearance and excellent electrical and mechanical qualities.

It was awarded a new and honourable distinction when the British Post Office adopted the table instrument as one of its standard types for automatic and manual CB systems.

The new British instruments have been designed by Ericsson Telephones Ltd in co-operation with technical departments of the British Post Office. The English instrument has the same form as the normal Ericsson instrument but is somewhat wider on account of the requirements of the British Post Office which stipulated that certain standard parts as induction coil, condenser, bell and cord connection block should be used in the new instrument, as these parts should be interchangeable with similar parts which were already stocked by the British Post Office.

The size of the instrument has also been increased on account of a telephone register or pad having been inserted in the base plate of the instrument. Access to the register is obtained by pulling out a sliding tray with a moulded knob at the front. The pad may be used as a directory for several hundred numbers and should prove a great boon to the telephone user at home or at the office for calling friends or business relations. The pad consists of a booklet with alphabetical index which may be renewed in a few seconds simply by opening a locking device. The pad is protected by a hinged metal flap on which are chemically engraved instructions for using the telephone for trunk calls etc. Between the flap and the pad there is further inserted a hinged pocket of transparent sheet material which may be used as a holder for a printed card with suitable text, *e. g.*, special numbers, long-distance rates etc.

The British Post Office has this year ordered over 350 000 instruments of this type, of which Ericsson Telephones Ltd secured the order for nearly 100 000 instruments.

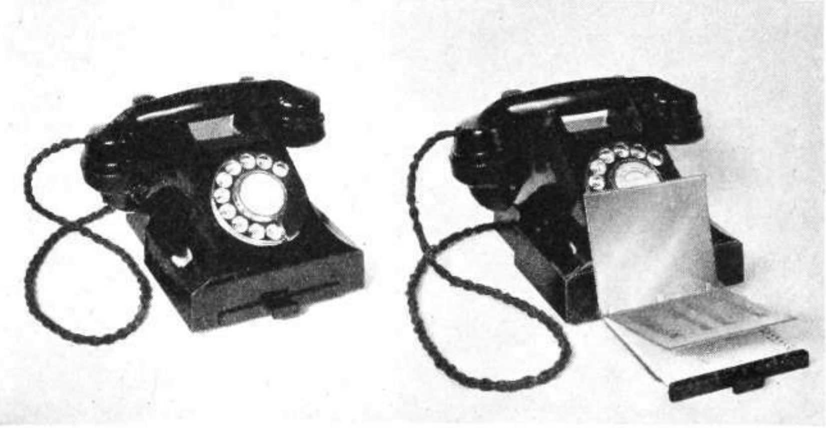


Fig. 1 X 5423
British Post Office telephone instrument
right with the register pulled out for use

New Ericsson Wireless Sets

B. ARVIDSON & C. FREDIN, SVENSKA RADIOAKTIEBOLAGET, STOCKHOLM

The construction program of Svenska Radioaktiebolaget for 1937—1938 comprises, compared with the preceding year, a greater number of types in the lower price class and a corresponding reduction in the higher one. The table models Ericsson 373 and Ericsson 375 are superheterodyne receivers of normal design while Ericsson 376 is a more developed type at a somewhat higher price. Ericsson 372 is essentially intended for local reception. One console model only, Ericsson 379, fitted with automatic record changer is manufactured. All these models are made for connection to the main AC or universal current. Ericsson 374, a long-distance receiver with short-wave band, is made for battery feed.

The development of wireless receivers is characterized this year chiefly by a general adoption of short-wave reception. During the 15 years or so which have elapsed since the favorable propagation properties of short-waves were discovered, the name short-wave has nearly always been associated with the activities of wireless transmitting amateurs. In the last three years the public also has begun to take interest in short-wave reception due partly to the steadily growing number of broadcasting transmitters in the short-wave band, partly to the sensational results attained under favourable receiving conditions. Most wireless receivers intended for long distance reception are now equipped for the short-wave band, 17—50 m, which has proved most suitable for broadcasting and in which certain bands have been allocated to this kind of transmission through international agreement. In spite of the fact that as regards frequency these bands are comparatively wide and allow ample place for many transmitters, yet they constitute an insignificant part of the whole wave-length band and the stations are actually compressed into four or five hardly more than one millimeter large zones on the dial of the wireless receivers.

It is thus not very easy to tune the receiver for a short-wave transmitter or to find a station on the dial in case no special devices are provided for it. The tuning may be considerably facilitated by a gearing between the driving knob and the tuning device and such a vernier is found nowadays on most receivers; the larger Ericsson Receiver this year has a planet gear which may be connected in when desired. However, a device which indicates in a reliable and precise manner the position of a station on the tuning dial has not ordinarily been used. A few American manufacturers and recently also European manufacturers have used for this purpose a vernier indicator which is driven from the tuning condenser shaft over a gear. Most devices of this kind have, however, the inconvenience that the indicator does not follow closely the movement of the condenser so that there is quite an appreciable play. This is of course due to the difficulty in obtaining a sufficiently good mechanical gearing at moderate cost. A solution of the problem where the moment of the tuning condenser is magnified optically is ideal as regards elimination of play.

Fig. 1
Ericsson 379

X 3785

Two of the Ericsson receivers of this year, *viz.*, Ericsson 379 and Ericsson 376, have an optical short-wave dial designed on to this principle. The movement is magnified ten times, which signifies that the apparent total length of the dial is 1.3 m. These devices makes the tuning very simple and it is further facilitated by the orthoscope which in Ericsson 379 and Ericsson 376 consists of a cathode-ray tube which gives a very distinct and extraordinarily sensitive indication of correct tuning of the broadcasting station desired.

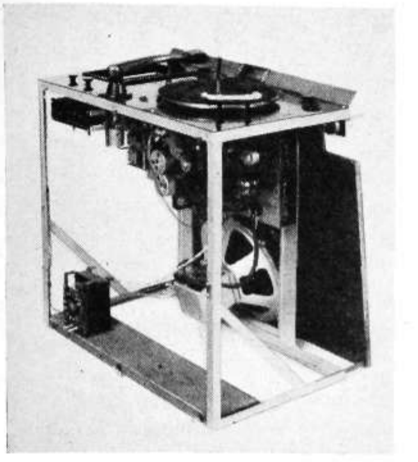


Fig. 2 X 3786
Chassis for Ericsson 379

European valves of new type with lower filament input than has hitherto been possible are used in all main-connected receivers. The input and thus also the operation cost are lower than was previously the case.

Ericsson 379

This receiver, Fig. 1, is the largest of the six new models. The entire set with loud-speaker and radio grammophone with automatic record changer is mounted on a welded frame, Fig. 2, and thus entirely independent of the cabinet. The chassis is supplied in this state also for building into furniture. This design has great advantages, as all parts are fully accessible for testing and adjustment during final inspection. The acoustic disadvantages of the cabinet have been eliminated in a very simple manner. Instead of reducing the resonant frequencies of the cabinet by means of acoustic chambers or the like, these have been entirely suppressed by replacing the sides of the cabinets by plaited cane. The sloping front of the cabinet composes in this way an ideal acoustic baffle.

The DC receiver has eight valves with the following functions: HF-amplifier MEF 5, frequency shifter MEK 2, IF-amplifier MEF 5, IF-rectifier MEB 4, LF-amplifier MEF 6, output valve MEL 5, orthoscope MEM 1 and rectifier MEZ 4. The universal receiver has the same valves, excepting that the rectification of the intermediate frequency and the LF-amplification are done in a combined valve MEBC 3 and that the output stage has two valves MCL 4 in push-pull connection. With 220 V mains voltage, both receivers give an output of 8 V, they have both the same sensibility, *viz.*, 2 μV at 50 mW output and the same selectivity.

As may be seen from the diagram, Fig. 3, the receiver is based on the superheterodyne principle. The arrangement of the aerial circuit is an increase of from three to eight times the voltage of the aerial signals as received. The HF-valve together with a tuned intermediate circuit augments the voltage thirty times more, at which it is fed to the control grid of the frequency shifter. The main anode of this last is connected to the input side of a four-circuit band-pass filter which is tuned to the frequency range 109 000—117 000 c/s. The signal voltage over the anode circuit which is now transformed to intermediate frequency has been multiplied thirty times by the amplification in the frequency shifter. The IF-valve, which is fed from the band-pass filter, terminates the total HF and IF-amplification by amplifying the signals 150 times. The rectification is made in the IF-rectifier and the LF-composant goes through a resistance condenser filter through the volume control on the grid of the LF-valve. The DC tension and the DC output of the IF-rectifier, which is negative in relation to the cathode, is transmitted through resistances to the grid circuits of the three first valves to be used as control tension for the automatic volume control. The total LF-gain is 1 000. The final stage gives 8 W output at 10 % distortion.

The tone control is continuously variable for the upper as well as the lower half of the register and regulated by means of two separate devices operating similarly to the bass and treble keys on an organ.

Fig. 3 X 7128
Diagram of superheterodyne receiver, Type 379 V
for AC, 8 valves incl. rectifier, 7 tuned circuits and oscillator circuit, wave-length range 17—50, 200—570 and 725—2 000 m, intermediate frequency 115 000 c/s, output 8 W

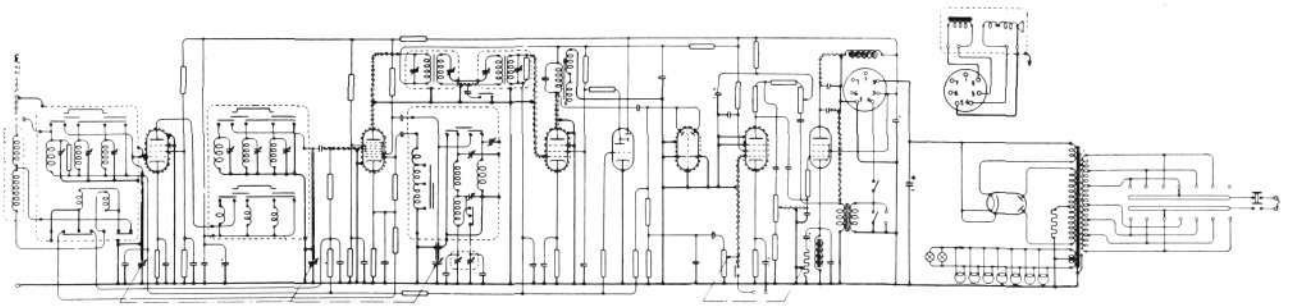


Fig. 4 X 3787
Ericsson 376

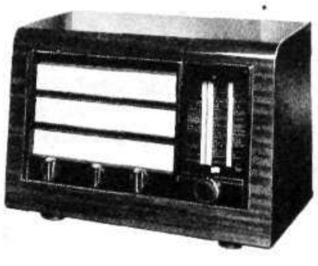


Fig. 5 X 3790
Ericsson 373

The orthoscope consists of a miniature cathode-ray tube with incorporated amplifier triode valve. The gauge of the cathode ray bundles and thus the extent of the luminous angles on the screen of the tube are determined by the potential of the control electrode, which depends in its turn on the operating tensions of the triode valve. The grid voltage of this latter is taken from the IF-rectifier and the anode tension from the auxiliary grid of the IF-valve, the potential of which is increased by the volume of the incoming signal. Thus the regulating range of the orthoscope is increased so that it gives a deflection for tensions between 0.5—30 V without the luminous angle exceeding 90°; the orthoscope therefore gives equally distinct deflection for both of the stations which induce in the aerial tensions between 2 μV and 6 V.

The grammophone has an automatic record changer of new type for eight 25 cm or eight 30 cm records. The record changer is very simple and reliable in operation. The records are threaded on a bent steel spindle which is fixed to the centre of the turntable. A knee on the spindle and a holder at the rim of the records serve as support. When the motor is started, the holder pushes the first record against the centre of the turntable; the record then loses its support on the knee of the spindle and falls down on the turntable. Meanwhile the pick-up which rested in its starting position outside the rim of the record has been turned to the correct starting position for play. When the record has been played, the pick-up is returned to its initial position, and the whole process is repeated until the last record has been played, when the grammophone motor is automatically cut off.

Ericsson 376

This receiver, an eight-valve superheterodyne with eight tuned circuits, has the same chassis as Ericsson 379. It is a table model, built in a cabinet of horizontal type, see Fig. 4. The lower part of the bakelite frame at the front of the cabinet is extended in a plate which protects the cabinet from being scratched or soiled when the dials are operated.

Ericsson 375

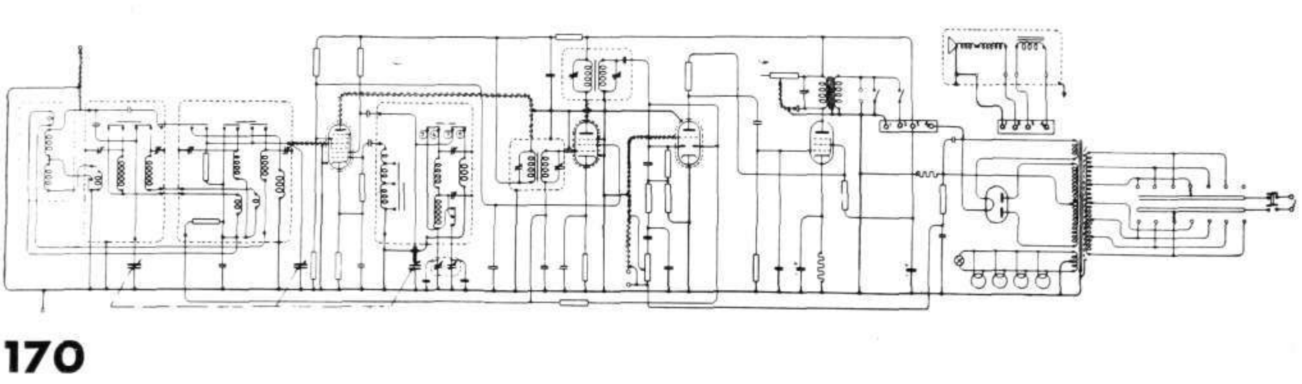
This receiver is an improvement on last year's model, Ericsson 365. It is a five-valve superheterodyne with eight circuits, made as a table model. The AC receiver has the following valves: MEK 2, MEF 5, MEBC 3 MEL 3 and MAZ 1, and the universal receiver MEK 2, MEF 5, MEBC 3, MCL 4 and MCL 2. The wave length ranges are: 17—50, 200—570 and 725—2 000 m. Special care has been taken regarding the quality of the sound and the short-wave reception, the efficiency of which has been increased quite considerably.

Ericsson 373

This model is the smallest in size of the superheterodyne receivers this year and is similar as regards exterior, Fig. 5, to Ericsson 376. Ericsson 373 is a five-valve superheterodyne with seven circuits including the oscillator

Fig. 6 X 7129
Diagram of superheterodyne receiver, Type 373 V

for AC, 5 valves incl. rectifier, 6 tuned circuits and oscillator circuit, wave-length range 17—50, 200—570 and 725—2 000 m, intermediate frequency 115 000 c/s, output 3 W



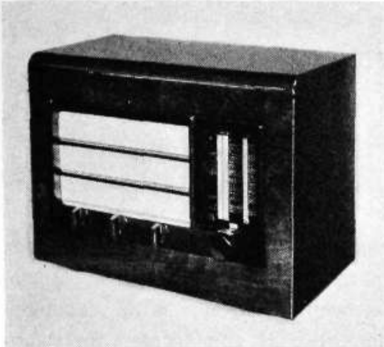


Fig. 7 X 3788
Ericsson 374

circuit, see diagram, Fig. 6. It has the same valves as Ericsson 376 and its receiving qualities are nearly as perfect as those of this latter receiver. Despite this the price is low enough to correspond to what has previously been the price for a two-circuit receiver. For low main voltages it is supplied in a special design with the final stage in push-pull connection.

Ericsson 374

This receiver is a three-valve two-circuit battery receiver with short-wave range. The batteries, a 2 V accumulator and a 150 V anode battery are mounted in the cabinet, Fig. 7. At an output of 50 mW the sensibility is 40 μV. The receiver has three wave ranges: 17—52, 190—575 and 700—1 970 m. The principle used for the diagram, Fig. 8, one stage HF-amplification, screen-grid detector and final penthode gives, with the new current-saving valves, two VS 24 m with output valve PT 2, a very good sensibility and selectivity.

Ericsson 372

This three-valve single-circuit receiver is mounted on the same chassis and in the same cabinet as Ericsson 373. The AC-receiver has the following valves: MEF 6, MEL 3 and MAZ 1, and the universal receiver MEF 6, MCL 4 and MCY 2. The detector is a penthode in feed-back connection which controls directly a 9 W final penthode. The wave-length ranges are: 190—575 and 700—1 970 m. The sensibility at an output of 50 mV is 2 000 μV. The arrangement of the aerial circuit is such that the tuning is independent of the size of the aerial.

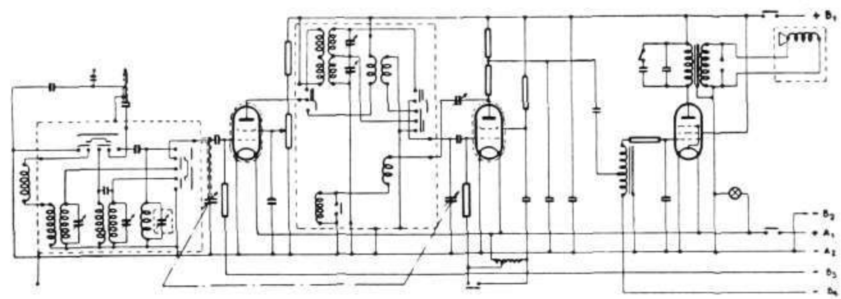


Fig. 8 X 5422
Diagram of two-circuit receiver, Type 374
for battery feed, wave-length range 17—52, 190—575 and 700—1 970 m, output 25 W

New Catalogues

Catalogue 603: Manual Switchboards for Magneto System

Following a complete standardization of manual telephone switchboards for magneto system and the corresponding parts, a special catalogue of the new improved types of switchboards has been published. This catalogue includes wall switches as well as switchboards. Of the former there are cordless switches for up to 6 lines, non extensible cord switches for up to 15 lines and finally switches which are extensible with detachable units, which may be very easily built into the switches. These units are line units for 10 lines as well as units comprising cord circuits, keys and other parts for one call. Different types of extensible wall switches are to be found for 30 and 50 lines max. All wall switches have drop indicators as calling signals. There are different types of switchboards with drop indicators, combined drop indicators and jacks, indicator jacks and visual indicators as calling signals. They are extensible in the same manner as the larger wall switches and made for 19 simultaneous cords and 160 lines, with the exception of the indicator jack switches which may be made for up to 200 lines. The switchboards have a multiple capacity of 800 lines with four-panel multiplication and 400 lines with two-panel multiplication. The switches with multiple are made only with lower portion of wood, but the switchboards without multiple may also be obtained with open lower portion of iron, enamelled in wood colour.

Supplement 5 to the General Catalogue

This supplement contains some new apparatus designed since Supplement 4 to the General Catalogue was published. Nearly all these apparatus have already been described in Ericsson Review and we may restrict ourselves to an enumeration of them. Thus the supplement contains the home telephone, which has been described in Ericsson Review No 3, 1935, as well as instructions for its connection for different purposes. Further there are described a wall telephone instrument with magneto, mounted in the same bakelit case as used for the Ericsson normal wall telephone instrument, see Ericsson Review No 3, 1936, as well as a watertight telephone instrument for use outdoors, see Ericsson Review No 1, 1937. Further there are dealt with watertight AC bells, see Ericsson Review No 1, 1937, for which there is a table indicating voltage and resistance for the different bells designed by Ericsson. One page describes frequency-control equipments for mounting in power stations in order to regulate the AC frequency, see Ericsson Review No 3, 1936, and No 2, 1937. Finally, this catalogue contains some new, modificated constructions of later apparatus (redesigned apparatus), *e. g.*, a new head-phone for program distribution system etc. and new thermo-contacts for fire-alarm installations.

Ericsson Technics

Ericsson Technics No 3, 1937

T. Laurent: Calcul des processus non stationnaires à l'aide des transformations fréquentielles

In the present work it is first shown how the theories which are valid for phenomena arising when sinusoidal alternating tensions are introduced in linear passive quadripoles may be considered as a superstructure of the theory of stationary alternating tensions. To this effect a quadripole of special composition is used, which is better adapted to the constructive mind of the engineer than purely mathematical abstractions.

The properties of this quadripole are characterized by a propagation time function which is easier to handle for practical computations of oscillation process than the well-known formula valid for the properties of quadripoles. The *Heaviside* expansion theorem and the limitation of it shown by *Wagner* are deduced. Finally the influence of frequency transformations on the expansion theorem is shown as well as the new possibilities this opens for practical work.

The different problems arising when quadripoles are composed are treated and the formulæ deduced are illustrated by sixteen examples. The theoretical treatment of filtered quadripoles shows also an interesting phenomenon, *i. e.*, that a band-pass filter attenuation having an arbitrary number of attenuation peaks may be obtained through successive frequency transformations of a simple cross-filter link and that minimum attenuations comprised between the attenuation peaks may obtain the desired values directly without preliminary approximative computations.

Finally a universal method for the computation of transients in linear passive quadripoles is presented. This method is certainly better adapted to practical needs of telephone and telegraph engineers than the methods hitherto used as it is based essentially on the knowledge that these engineers must have in order to solve the problems meeting them in their daily work.

Ericsson Technics No 4, 1937

T. Laurent: Calcul général des affaiblissements de filtres à l'aide des transformations fréquentielles

The general filter-attenuation problem, *i. e.*, the computation of the attenuation curve of a band-pass filter, situated outside the passing band and over a minimum attenuation curve giving at the same time the least possible surplus of attenuation has not yet been solved. Reference has therefore been limited to the tentative composition of simple attenuation curves, excepting a few special cases where *W. Cauer* has established a collection of curves on the basis of approximative computation.

In the present article it is shown how frequency transformations allow for a systematic solution of the general filter attenuation problem. *Cauer's* special problem then receives a particularly simple solution and may be treated without approximation in the majority of cases.

On this account, the frequency transformations have given a new proof of their ability to disentangle complicated problems which arise in telecommunication and it seems that they will soon be considered as an indispensable theoretical tool to the technicians in this domain. The word »frequency transformation» has generally a larger scope than that meant in the present work and the particular signification of »*bdmn* transformations» in comparison with analogous transformation methods is therefore emphasised.

Finally it is shown how it is possible to solve the filter attenuation problems by introducing by transformation the desired attenuation curve in the imaginary negative frequency range. This curve is subsequently used as a model for the composition of a technically attainable attenuation curve. This curve is in turn introduced by transformation in the physical frequency range, using a method the reverse of that used for the first transformation.

Ericsson Technics No 5 & 6, 1937

S. Ekelöf: The Transient of an Inductively Shunted Electric Transmission Line — with Special Reference to the Impulse Transmission in Selective-Calling Telephone Systems

The aim of the present work is to investigate the transients obtained on impulse transmission in selective-calling telephone systems. In the first part the problem is set forth and discussed; it is shown how it can be reduced to the calculation of the transients of an ordinary transmission line possessing a uniformly distributed inductive leakage. Beside this uniform smooth line the uniform lumped line, *i. e.*, a transmission line furnished with equally spaced leakage coils, is also given some consideration.

The *Heaviside* operational calculus gives us a suitable mathematical tool for solving our problem and an attempt has been made to give an exposition of this method, which should be at the same time mathematically acceptable and simple enough to be useful to the engineer. After these preliminaries we formulate and solve the problem mathematically, treating first different types of infinite lines in their response to a suddenly impressed constant EMF. The results obtained allow for a simply study of the finite line as well as of the response to an EMF of arbitrary form.

In the second part of the work a series of numerical computations have been carried out; their results are discussed and presented graphically. Finally an account is given of some measurements, the purpose of which was to confirm the practical applicability of the theoretical results.

In preparing this presentation of his investigation, the writer has had in view that it should be easily accessible to different classes of readers. Thus the purely mathematical parts are essentially concentrated to Part I. Those who are mainly interested in the practical results will therefore do best by proceeding directly to Part II, first reading, however, the exposition of the problem in Chapter 1.

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