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On cover: Inside view of a workshop department at LM Ericsson's factory at Midsommarkransen, Stockholm: assembling of 500-line selectors

L M Ericsson's Automatic Telephone System with 500-line Selectors in the Past 25 Years

C BERGLUND, TELEFONAKTIEBOLAGET LM ERICSSON, STOCKHOLM

U.D.C. 621.395.343(091)

The 60th birthday of Knut Kåell, head of L M Ericsson's Telephone Department, is taken reason for developments in the 500-line selector system, with which Knut Kåell has been associated ever since the initial experimental stage. The article furnishes some historical particulars of the system and gives an account of the most significant modifications in it since its inception.

The first automatic exchanges of the LM Ericsson type with 500-line selectors were opened for traffic in 1923. The system will therefore soon be celebrating its 25 years. During that time the design of the system has undergone considerable development aimed at increasing its perfection. The approaching 25th anniversary may be made the occasion for a review of the progress of the system throughout the years. Ever since 1918, when trials began to be made in earnest the development of this automatic system has been directed by the present head of LM Ericsson's Telephone Department, Knut Kåell. The credit for the introduction of the system and its further progress is chiefly due to him. Mr. Kåell has just celebrated his 60th birthday, which furnishes a special reason for this article giving a brief account of results with this the most noteworthy of Knut Kåell's engineering achievements.

X 4512

Knut Kåell

has directed the progress of the 500-line selector telephone system since 1918

The First Exchanges

LM Ericsson's automatic telephone system with 500-line selectors is based on ideas of Axel Hultman, Telephone Director in the Swedish Telegraph Administration, who in collaboration with LM Ericsson tried out various selector designs before the Swedish Telegraph Administration in April 1921, when ordering Stockholm's first automatic exchange, decided on LM Ericsson's system with 500-line selectors.

Nevertheless the first exchange on this system to be opened for traffic was one in Rotterdam, see Fig. 1. Operation of this exchange began in May 1923 and in August and December of the same year automatic exchanges were opened in the Norwegian towns of Hamar and Kristiansund. In January 1924 the exchange ordered for Stockholm was put into service, being enlarged from 5000 to 10000 numbers in November the next year. Before that time, however, a further exchange had been added at Rotterdam and exchanges had also been opened in South Africa, at Shanghai in China, at Dieppe in France and at Verona in Italy. During 1926 exchanges came into service at Ankara, Turkey, and San Sebastian, Spain, and in the same year a start was made with the comprehensive automatisation of Mexico City.

The plant at San Sebastian consisted of one head exchange and four sub-exchanges. In view of the low internal traffic in these sub-exchanges they were constructed as satellites, *i. e.*, these exchanges were provided with line finders and final selectors only and even their internal traffic was routed over the connecting devices of the head exchange. This was the first time 2-wire junction circuits were employed between the automatic exchanges. To give the register time to stop the selector, the system had hitherto been constructed with the revertive impulses transmitted from the selector in a time equivalent to 1½ steps before the selector should come to a stop. In conjunction with the working out of the revertive impulse repeater for the plant at San Sebastian, arrangements were devised that made it possible to employ a revertive impulse shift of 1 step only. This increased the operating reliability of the system and the improvement was incorporated in exchanges built later. The system was also prepared in Mexico City for the employment of satellites to a considerable extent.

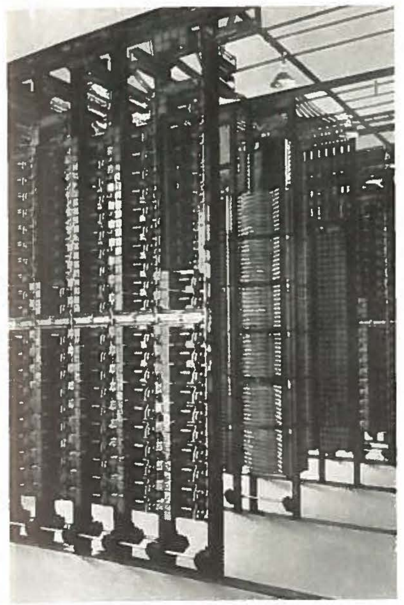


Fig. 1 X 4513

Inside view of the telephone exchange at Rotterdam West, Holland

The first automatic exchange on L M Ericsson's system with 500-line selectors, built 1923

With the above automatic exchanges the system had been introduced to several countries both inside and outside Europe. As experience in operation was everywhere extremely good the demand for the system became exceedingly keen. The introduction of the system in the large cities of Stockholm and Rotterdam proved particularly valuable. Close cooperation with the Telephone Administration experts of those cities has provided many useful impulses that have contributed in high degree to the development of the system.

Register Finders are Dispensed with

Experience with the first exchanges led to certain improvements in respect of mechanical construction and lay-out, these being introduced in subsequent years when increased production set in. *Sequence switches* are used as auxiliaries to the selectors to ensure the necessary contact combinations. For connection of a register to a connecting circuit, the same design is applied as *connecting circuit finder* with 36 switching positions. Owing to the relatively small capacity of this finder the register group had to be small and a rather large number of registers was required to give good accessibility. This design therefore was replaced by the more economical cylindrical selector, the bare wire multiple of which was connected to the register, the selector being connected to the connecting circuit as a *register finder* which could reach 20 registers. During the years 1927 and 1928 new Swedish exchanges with this form of construction were put into service at Stockholm and Gothenburg, several exchanges in Northern Italy and the first Polish exchange at Cracow.

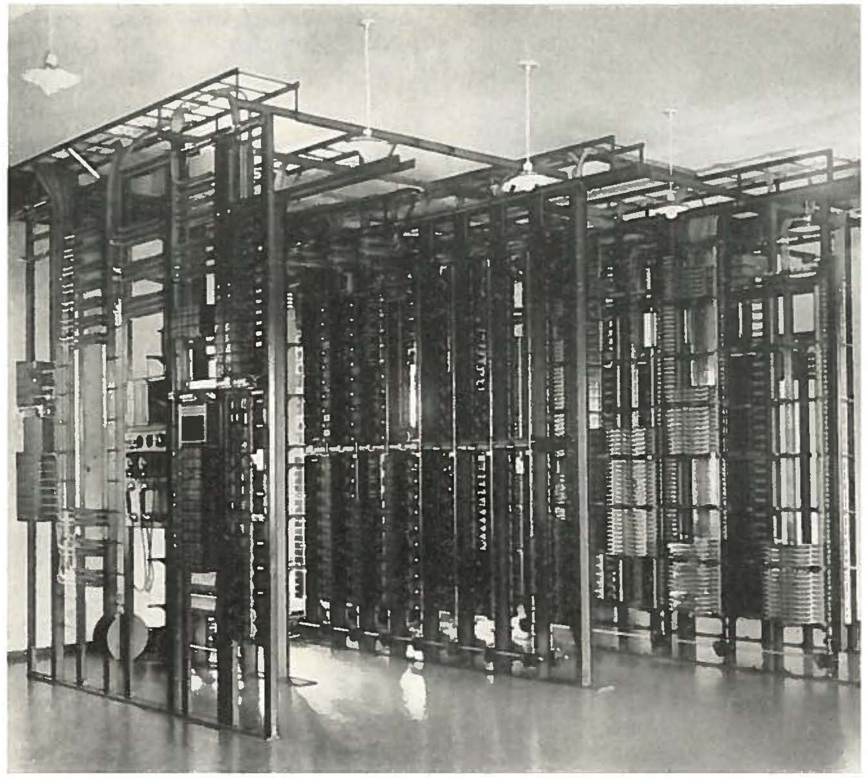
In the running of these exchanges it was observed that the register finders were only in motion very seldom. This was owing to the register finder, due to the pure chance occupation of the connecting circuits, being almost always set at an unoccupied register. It was then considered whether the register finder could not be dispensed with and replaced by fixed connection of a number of connecting circuits to the same register. Theoretical and practical investigation confirmed that such a connection could be introduced with advantage, with an arrangement that the call could only be connected to a free connecting circuit that had connection with a free register, while other connecting circuit finders were temporary barred from hunting the calling line. Experience of operation has since confirmed the suitability of this form of connection. Apprehensions that it might unfavourably affect accessibility and overload capacity were without grounds provided the number of registers was not made too small. The adoption of this connection provided appreciable simplification of the system, and in particular traffic supervision and fault location were much facilitated.

This system came into use during the period 1929—1931, for the completion of automatising in Rotterdam, for Stockholm and Gothenburg, for new exchanges in the Polish cities of Warsaw and Lodz, for Naples and other Italian towns, for extensions made in Mexico City and for other Mexican towns. The system was also applied in several exchanges in Argentine, at Tallinn, capital of Esthonia, Juiz de Fora, LM Ericsson's first automatic exchange in Brazil and at Larvik in Norway, see Fig. 2. Just prior to that, an agreement respecting deliveries and licences was concluded with the Russian authorities which included the supply of an exchange to Rostov. Later several

Fig. 2 X 6282

Inside view of the automatic exchange at Larvik, Norway

built 1930



exchanges were constructed in the Russian state factories for Moscow and other towns of Russia, during the first six years with the help of experts from LM Ericsson both for manufacture and fitting.

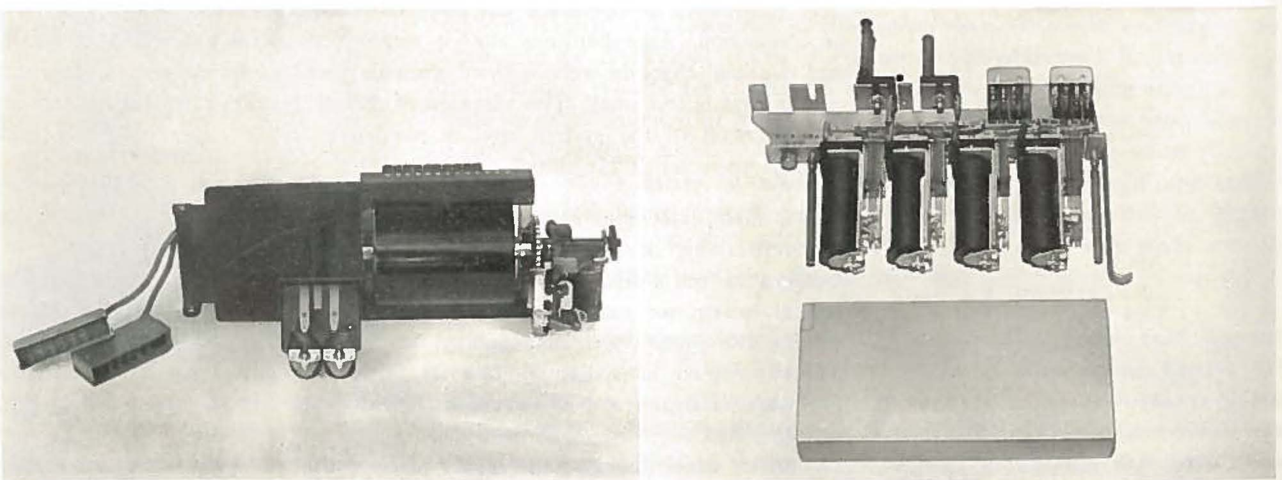
System OS 1029

By October 1929 a new form of execution of the system had been tried out, and it was given the designation OS 1029. It had been found that relatively more trouble occurred in the sequence switches than in the relays and that the sequence switches required more inspection and maintenance. Also it was considered desirable for operation that the control devices for the selectors should be near to the selectors which was difficult to arrange with sequence switches. The system was therefore re-designed to replace the sequence switches by auxiliary devices for the selectors, consisting entirely of relays, see Fig. 3. The selector's connecting cord and plug could now be replaced by a jack fitted on the selector plate, while the relay set was furnished with two plugs to connect it to the selector and to the fixed cabling of the rack, see Fig. 4, right. The *allotter* (or pre-selector) used up to then, the purpose of which on call was to set going a limited number of finders, could

Fig. 3 X 7447

Sequence switch and on the right relay set

In the present-day 500-line system a sequence switch has been replaced by a relay set.



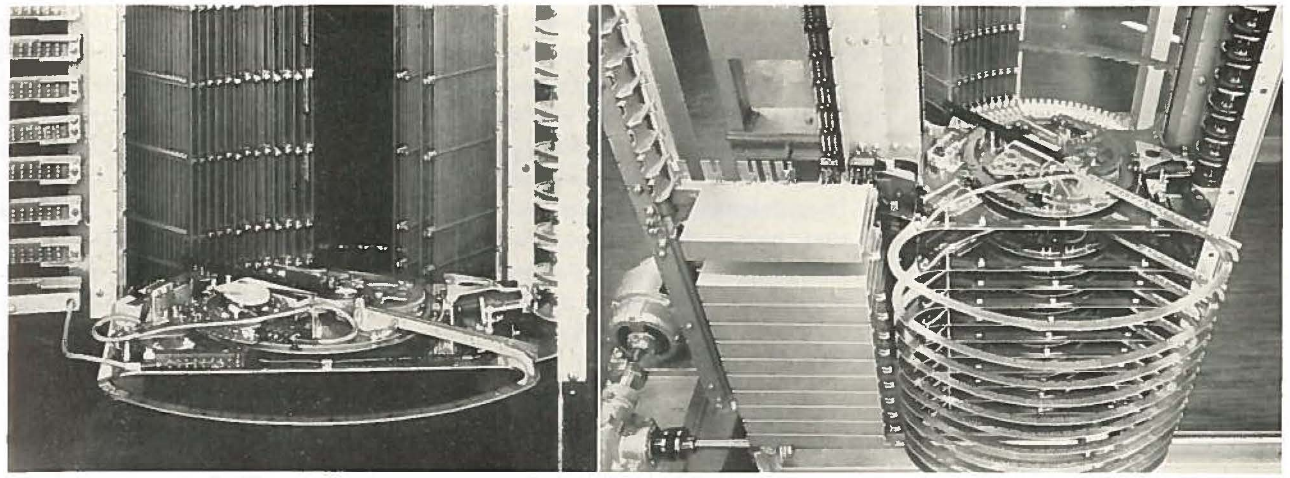


Fig. 4 X 7448

500-line selectors fitted in racks

left, old construction for working with sequence switch; right, present construction with relay set

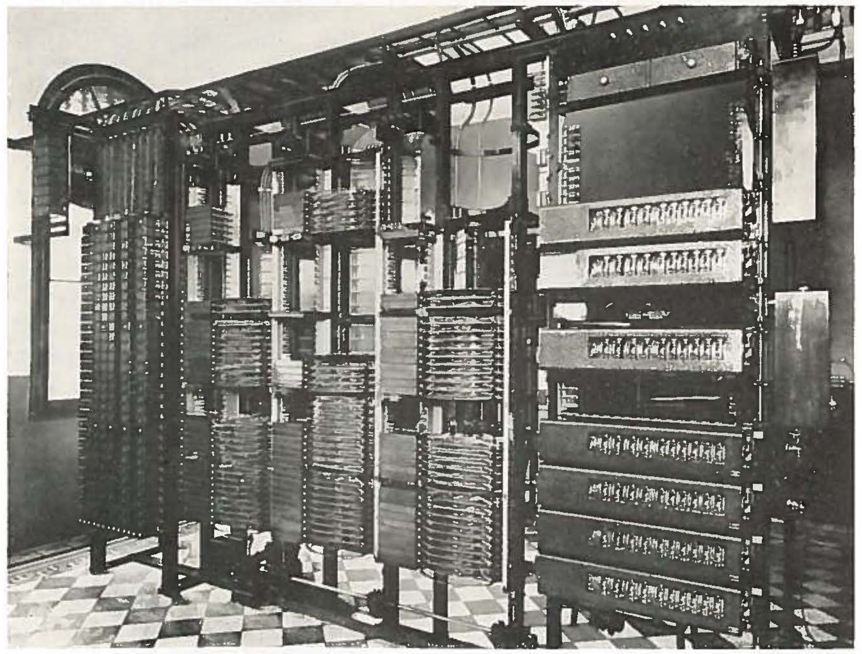
be taken away as the system was now arranged with only one finder for each free register starting for a call. The rack motor common to a bay of racks was made as combined motor and signalling machine. Whereas earlier exchanges were made with continually rotating shafts, there was now brought in a device which kept the motor running only as long as connecting or a conversation were proceeding in the bay of racks.

The aim with the new system was in the first place to produce a simple standardised system for employment in a large number of exchanges in Argentine where automatisation was to be put through on a large scale. It was then found desirable to build up the system in complete units of 500 numbers, see Fig. 5. Such a unit could constitute an independent exchange, but it could also be combined with other units to form larger exchanges. In this way large lots could be made for stock, it being determined later in the course of erection and fitting how the units should be combined into exchanges. However, the system proved so convenient that its general design was applied also to large exchanges, but then it became the practice to join up two 500-number units to form a 1000-number unit, or other rack groupings were made to suit individual cases. A somewhat modified construction was utilised for the extension of existing exchanges having sequence switches.

Fig. 5 X 6283

500-line group in the automatic exchange at Lido, Italy

built 1933



The new system immediately found widespread employment. In 1931 alone some thirty new exchanges were opened for traffic, mostly in Argentine and Italy. Between then and 1934 new exchanges were opened at Venice and Padua in Italy, several exchanges in Finland including Tammerfors, two exchanges in New Zealand, at Marton and Whangerei, the first exchanges in Colombia, at Honda, Ibagué and Armenia, and an exchange in Tripoli. In collaboration with the Norwegian Elektrisk Bureau, several exchanges were built including those at Haugesund, Kristiansand and Fredrikstad, as well as one at Iceland's capital, Reykjavik. In these years also the automatisations of the centre of Gothenburg, of Warsaw and of Mexico City were completed. In 1933 the first exchange in the extensive suburban area of Stockholm was opened.

The System is Made More Rapid

By the removal of the connecting circuit finder, the delay in hearing dialling tone after the subscriber had lifted the handset had been decreased. The delay now consisted solely of the time taken up by the finder's hunting the calling line. As many of the selectors start from rotary movement position to hunt the mat from which the call comes, the time for the rotary movement is relatively short and the radial movement of the finder takes up the greater part of the time. There was now added an extra cog-wheel to the finder, thereby doubling the speed of the radial movement. Since this modification the time between the subscriber lifting the handset and hearing dialling tone amounts on the average to about one second. Still it may be advisable, especially at exchanges where connection is made over several group selector stages, to increase the speed of the group selectors as well. In such cases it is possible with advantage also to make the group selectors for double speed of movement. As the selectors are moved progressively while the number is being dialled, the time of waiting from the completion of dialling until the subscriber is rung normally consists solely of the time taken by the final selector's radial movement, or on the average slightly more than a second. The system in its present execution is therefore quick operating and the brief waiting times normally occurring are insignificant.

Naturally the above applies solely if the number of connecting devices is sufficient, so that only in very exceptional cases are free devices for establishing the connection lacking. Unfortunately shortage of material during and since the war has led to insufficiency of connecting devices at many exchanges. If no free connecting device is available, the connection is held up until a device becomes free. With some other systems, the subscriber receives busy tone if connecting devices are not immediately available and must replace the handset, to dial the number again later. Obviously it is more convenient for the subscriber not to have to go through the whole process again, but in heavily overloaded exchanges the time of waiting may occasionally be long causing much inconvenience. This drawback is often looked upon by subscribers as evidence of technical imperfection in the automatic system, which is of course unfair. The exchanges are constructed for a given amount of traffic and if this amount is appreciably exceeded rapid accessibility cannot be expected. Nevertheless, it is to be hoped that telephone administrations may find it possible to increase the traffic capacity of the exchanges. LM Ericsson's system enjoys particularly great properties of adaptation in this respect, owing to all connecting devices being provided with plug and jack. Thus the traffic capacity can easily be augmented by putting new connecting devices into overloaded groups or by transferring devices from the groups with smaller load.

The System is Adapted to Most Recent Traffic Conditions

In the sequence switch system supplied for Rotterdam, there was introduced an improved connecting for group numbers. This meant that, on calling the group number, an unoccupied line to the subscriber is hunted automatically. If, however, an individual number of the group is called (night connecting

number) this line only is hunted. For automatic traffic from trunk operator to group number the final selector first hunts for an unoccupied line. If there is not one, the direction of the selector movement is reversed and connection is made to a locally busy line. The trunk operator may also make individual call to a definite line. This arrangement for group numbers as also many other up-to-date connecting facilities, such as to coin-box instruments, special lines and party lines, has been developed for the latest execution of the system. Whereas formerly special final selectors were employed for trunk traffic, the system is now made with final selectors that serve both local and trunk traffic.

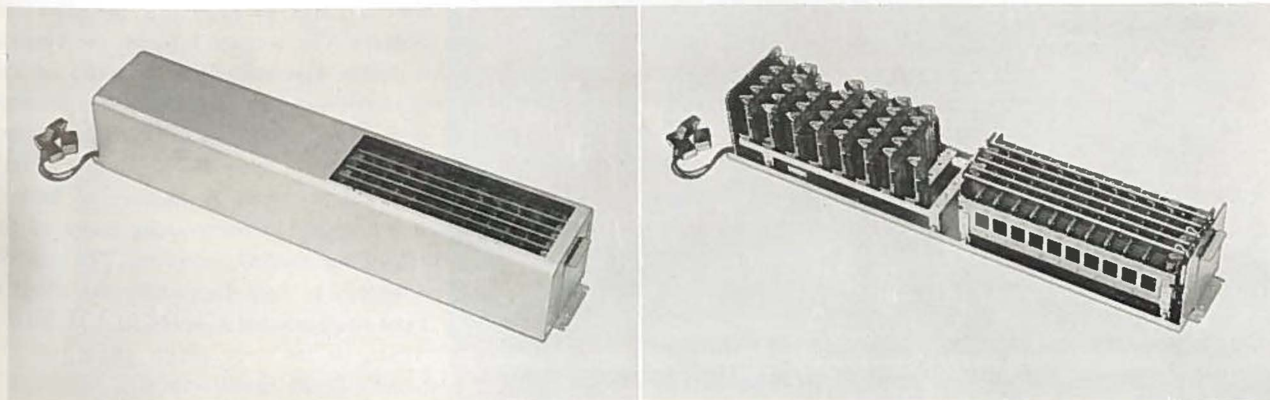
In the early years of the system the automatisation applied solely to the local traffic of a community. In many quarters it was considered that the system could without alteration be incorporated in a complete automatisation not only of the local but also of the trunk traffic. This required that the registers should be made capable of registering number series belonging to the automatised trunk network and that the system could work in conjunction with rural exchanges on other automatic systems. The exchanges should therefore be adapted for automatic debiting of trunk calls also. To avoid reconstruction of exchanges for rural and trunk automatisation a number of new features were introduced to be put in when such automatisation was to be introduced either immediately or in the future. Though naturally the fixing of details must be adapted to the numbering and charge systems to be applied, those features in principles are very similar. Here will be described the arrangements employed in Sweden, but these have with small modifications also been applied to exchanges in other countries.

Sweden is divided up into a large number of network groups. The parent exchange in such a network group is often an automatic exchange with 500-line selectors, while the other automatic exchanges of the group are usually constructed according to a direct-driven crossbar selector system. Numbers in a uniform subscriber number series are employed in the network group. For automatic connections between subscribers in one and the same group the subscriber number only is dialled. For traffic with another network group, however, there is first dialled a network group number and then the subscriber number. For a local call the call meter moves forward a step for each call, no matter what its duration, but for calls between different local networks the call meter is moved by a current impulse each time a certain period of time is started during the conversation. The length of the period may be varied according to the distance between the local exchanges concerned in the call.

The local exchange registers are so constructed that they can receive both the network group number and the subscriber number. If the call concerns a subscriber belonging to the same exchange, the register works on the usual principles, but for call to a rural exchange on the crossbar selector system or to another network group there is route hunting in the group selection in the usual way, after which there is repetition of the dial impulses with the aid of the register. The register is said to be made also for *decimal translation.*

Fig. 6 X 7451

Present-day register with crossbar selector left, with cover removed



Formerly contact arm of the finders had only three contact springs, two for the line wires and one for the test wire. Over the last-named wire there was transmitted an impulse to the call meter at the close of the call. To facilitate the emission of time-zone-metering impulses to the call meter at any time during the conversation, the call meter is now connected in over a fourth contact spring in the finder and the group selector is often also to furnish with a fourth contact spring. As in this way there is obtained a separate connection to the junction line from the call meter, it is possible to insert suitable devices for transmitting time-zone impulses in the outgoing end of the junction circuit. No interference with the existing automatic system, however, is necessitated by the introduction of time-zone impulsing. It is also clear that these modification in the principle of the system ensure full freedom to employ any system whatever at the local exchanges with which collaboration has to take place, and that the system can work with any time-zone-metering system whatever.

The registers used in the new Swedish exchanges are crossbar selector registers, *i. e.*, the impulse recording devices consist entirely of relays and a relay-like combination group represented by the crossbar selector, see Fig. 6. For exchanges in other countries registers of the former design have been employed, supplemented by circuits for decimal translation. Nowadays, particularly in places where complicated numbering systems may come into question, the crossbar selector is commanding increased employment. The modern Swedish system is described in Ericsson Review No 2 a/1946.

In one essential particular the Swedish system differs from the system normally prescribed by LM Ericsson for rural automatisation. The registers in the Swedish exchanges not only direct the connection in their own network group, but also connections to adjacent network groups, whereas in the normal LM Ericsson's system the registers direct the traffic in their own network group, but transfer the number to a trunk register for traffic to other network groups. The trunk register then deals with connection to other network groups. The Swedish administration's registers are thus more complicated. It is therefore of importance that their numbers should be kept down to the greatest extent possible. This would seem to be the chief reason why registers in the Swedish exchanges are connected to the connecting circuit over a connecting circuit finder consisting of a crossbar selector. In LM Ericsson's normal system there is required fixed connection between registers and connecting circuits, which means the provision of rather more registers, however. The crossbar registers, besides their unsurpassed reliability and their quietness of operation, have the advantage of immediate restoration. This ensures short occupation time for the registers. In the LM Ericsson present-day system for large exchanges, where each register has fixed connection to connecting circuits belonging to different 500 groups, with more or less normal ratio between conversation time and connecting time, there is required not more than 1 register per 6 connecting circuits.

New Improvements in Design

Appreciably increased reliability has been achieved by providing the relay and selector spring assemblies with *twin contacts*. The contact between the vertical bronze wires of the multiple and the double German silver contacts of the selector has proved very dependable. As in addition the machine-driven selector is quiet in movement, with smooth connection and no shocks to be spread through the rack, the 500-line selector proved right from the beginning a very successful design in respect of contact reliability. One is inclined to believe that the designer in his time succeeded intuitively in overcoming many of the troubles that still confront the designers of mechanical selectors. The contact problem in those days had not been subjected to such thoroughgoing investigation as is nowadays the case. The very comprehensive study at LM Ericsson's of this very important question has so far only given rise to slight alterations in respect of material and methods of manufacture.

Throughout the whole existence of the system LM Ericsson's experts have been constantly on the look-out for improvements. Here we can only give a few isolated examples of improvements in detail that have been produced. Thus new designs have been made for the selector's cords so that these are now practically everlasting. New and more efficient protectors for the connecting devices have also been devised. Recently the selector has also been re-designed to allow of the employment of revertive impulsing in loop, without repeater on the junction circuits.

Nowadays the junction circuits between exchanges are normally made two-wire, and in the Swedish exchanges where the distance between head exchange and sub-exchanges is large, revertive impulsing has also been done by A.C. to allow of phantoming of the junction circuits. In present-day exchanges all normal traffic demands are fulfilled and arrangements to satisfy all known traffic requirements are available.

Formerly exchanges were constructed with black-enamelled racks and green mottled covers. To lighten the weight of racks and for other aesthetic reasons a change has been made to light-grey enamelling of racks and covers.

Pre-war

In view of the wide distribution LM Ericsson's system has attained it is not possible in the scope of this article to give anything like a complete account of the exchanges built. We will therefore content ourselves with giving below some essential particulars.

In the years 1935—1939 the first exchanges were opened in Hungary at Miskolc and Munkács, in Czecho-Slovakia at Nitra and Poprad, in Morocco at Tanger, in the Netherlands colonies at Willemstad on Curaçao. More exchanges were built in Poland at Lwów and Budgoszcz, in Finland including Oulu (Uleåborg) and Vaasa, as well as at many towns of Brazil and Argentine. In Sweden the automatisation of the central parts of Stockholm was completed in 1938 with an exchange capacity of 180000 numbers, while the automatisation of the Stockholm suburbs is proceeding at a rapid rate still. Automatic exchanges were constructed at many other towns of Sweden including Borås, Örebro and Norrköping. The first fully automatic rural automatisation on a large scale in Sweden comprised some 100 exchanges in three

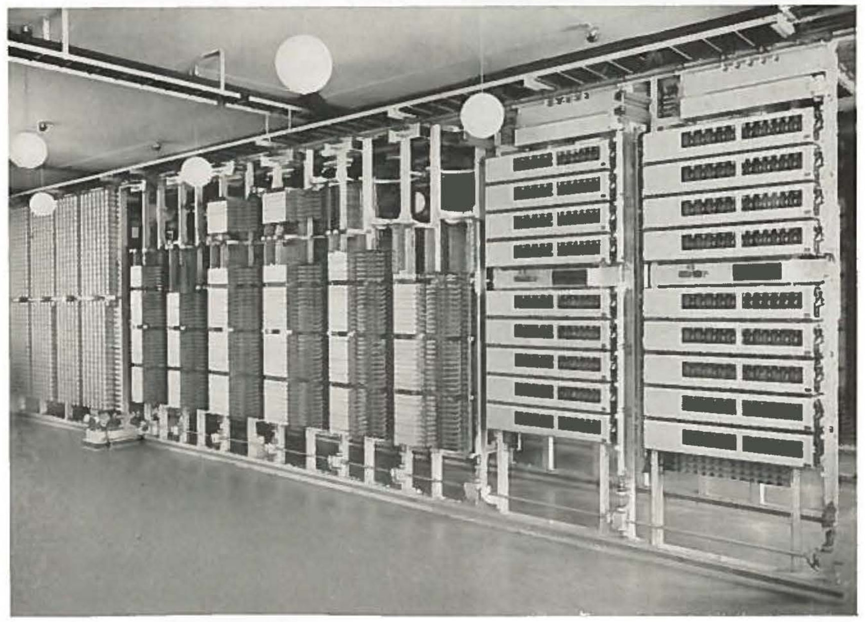


Fig. 7 X 6284
1000-line group in the automatic exchange at Djursholm, Sweden
built 1940

network groups with 500-line exchanges in two of the network group centres, Borås and Kinna. Particular interest was aroused in an exchange at Istanbul, constructed for direct collaboration with already existing exchanges on Standard's Rotary system. LM Ericsson's system with 500-line selectors was modified to conform to the grouping of the existing exchanges. A similar exchange has recently been opened at Bahia in Brazil and another is being made for Bello Horizonte in the same country.

War Years

During the war a number of exchanges were opened in Sweden, including Helsingborg, Västerås, Eskilstuna and Upsala, as well as several exchanges in the suburbs of Stockholm and Gothenburg, Fig. 7. Despite the trade blockade and other difficulties, it was possible to complete many exchanges abroad. A new exchange in the southern part of Rotterdam was opened a couple of days after the bombing of that city. In replacement of the burnt-down head exchange a new exchange was built and the other exchanges extended.

During these years exchanges were opened in Norway, at Stavanger and Trondheim and other places, several exchanges in Argentine and Brazil, the first exchange in Bolivia at the capital La Paz, an exchange at Medellin, Colombia, more exchanges in Finland, including Åbo. Unfortunately the exchange ordered for Viborg in Finland was not executed, owing to war operations. Enlargement of the exchange at Reykjavik on Iceland was made possible by air transport of material.

Post-war

Immediately after the close of the war considerable quantities of material held up by the trade blockade could be sent to the places of assembly, so that many exchanges could be completed and opened in the next few years. Many new exchanges have been ordered, these including one for Aarhus, the first large automatic exchange in Denmark, the material being manufactured partly at the Danish undertaking Telefon Fabrik Automatic A/S of Copenhagen, working in collaboration with LM Ericsson. Large extensions have been undertaken at Rotterdam, and at Bogotá, capital of Colombia, exchanges for 40000 numbers are in course of construction. New exchanges are to be erected in Guatemala, Panama, Ecuador and San Salvador. In Italy, the factory manufacturing LM Ericsson's system is in full operation with the reconstruction of telephone exchanges in the severely devastated towns, including Naples.

There are now in operation or under construction exchanges for something like 1½ million numbers on the LM Ericsson system with 500-line selectors. Throughout the world there is need for new exchanges and extensions to plants formerly delivered. LM Ericsson is therefore at present increasing manufacturing capacity both in Sweden and at factories in other countries, in the hope of being able to take an active part in the reconstruction and expansion of the world's telephone networks.

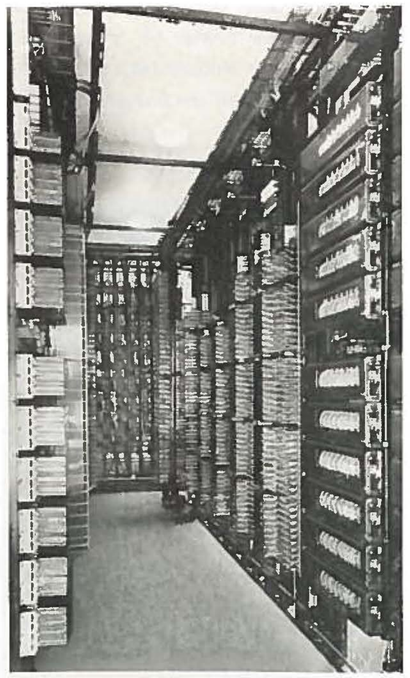


Fig. 8 X 4514
P.A.B.X. for Victorian Railways at Melbourne, Australia
built 1935

P.A.X. and P.A.B.X.

LM Ericsson's system with 500-line selectors found employment at an early stage in private telephone installations, particularly those with exchange lines, known as P.A.B.X. Even round about 1929 and 1930 large plants of this kind were installed in Italy, France, Austria, Norway, Poland, Holland and Turkey and for some giant state institutions in Russia. Nevertheless deliveries on a large scale did not start until switchboard types meeting all modern traffic conditions were standardised in 1934. A description of these will be found in Ericsson Review No 3/1937. Among the employments of the system may be mentioned the railway administrations for their service telephone networks, which are often of considerable size. In Sweden many railway exchanges have

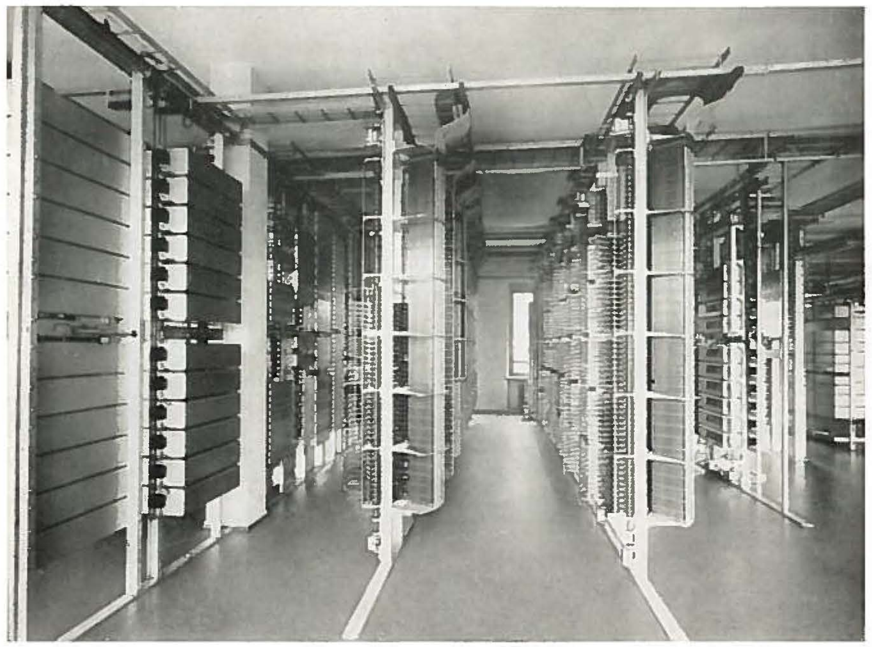


Fig. 9 X 6285
Apparatus room of Helsingfors' trunk exchange, Finland
built 1941

been built and the system is so arranged that fully automatic long distance traffic may be adopted later throughout the country's railway telephone system. Large railway exchanges have been built for the Victorian Railways in Australia, see Fig. 8, in Ancona and Bologna, Italy, and in Oslo. The total of numbers in operation for P.A.X. and P.A.B.X. in the system now approaches 100000.

An interesting new feature for P.A.B.X. plants is the centralized P.B.X. switchboard, described on page 109 in No 4/1947 of Ericsson Review, which has been put into service with good results at Rotterdam.

Other Employments

LM Ericsson's 500-line selector has also found employment for manual exchanges with automatic distribution, such as the big exchange at Odense, Denmark. In modern trunk exchanges, where the cords have been replaced by automatic switches, the 500-line selector has also been used. The new up-to-date Helsingfors trunk exchange is built on that system, see Fig. 9, and at present there is being built with 500-line selectors one of the biggest trunk exchanges in the world at Stockholm, for an initial capacity of 3000 trunk circuits.

Summary

LM Ericsson's system with 500-line selectors even when first brought out was a very reliable system and the first exchanges, constructed 25 years ago, are still operating and giving satisfactory operating results. Nevertheless, LM Ericsson never lose sight of the fact that even the best designs must require progressive development. It is only by continual improvement that a system can keep up-to-date and maintain its lead.

The Development of Automatic Telephony in Sweden

up to the Construction of the First Large Automatic Exchanges

N PALMGREN, TELEFONAKTIEBOLAGET LM ERICSSON, STOCKHOLM

U.D.C. 621.395.343(485)(091)

In 1910 consideration began to be given in Sweden to the automatisation of telephone plants in the cities of Stockholm and Gothenburg. As none of the foreign systems was suitable for Sweden it was believed that a system adapted to Swedish conditions could be worked out in the country. The following article gives a short description of the different telephone systems and selector constructions made at this time.

Around 1909 and 1910 serious consideration began to be given in Sweden to the automatisation of telephone plants in the larger cities of Stockholm and Gothenburg, in conjunction with a new building then being erected by the Telegraph Administration. Opinions were sharply divided regarding automatisation itself and as to whether semi or full automatisation was to be preferred. At that time Europe had only a few large automatic telephone plants, though automatisation had made more progress in America.

In conjunction with the Royal Board of Telegraphs' inquiries concerning automatisation for Sweden and the most suitable system, two officials of the Telegraph Administration were sent on a tour of inspection in America. They were Mr. *Axel Hultman* and Mr. *Herman Olsson*. On their return from the tour in the summer of 1910, both these officials were convinced that a fully automatic system was best suited to Swedish conditions and their view was eventually adopted by the Telegraph Administration.

They considered, however, that none of the systems employed in America was suitable for Sweden and that it should be possible to work out in the country one adapted to Swedish conditions. Both of them had come back well supplied with ideas and suggestions, which they were gradually able to realise. It was Mr. Hultman who produced the proposals and ideas and Mr. Olsson, the born designer, who worked out the proposals down to the smallest detail. The two men complemented one another in excellent fashion.

We in Sweden in those days were not entirely strangers to automatic telephone switchboards. Ever since the nineties Mr. *Pehrsson* at Malmö and Mr. *G A Betulander* at the Telegraph Administration workshop in Stockholm had been engaged on developing automatic telephone switchboards with up to 100 numbers. Mr. Betulander had already designed a couple of selectors, one for 10 numbers with contact bank of bright German silver wire laid in grooves in an ebonite plate, see Fig. 1. The selector wiper, Fig. 2, was stepped forward by

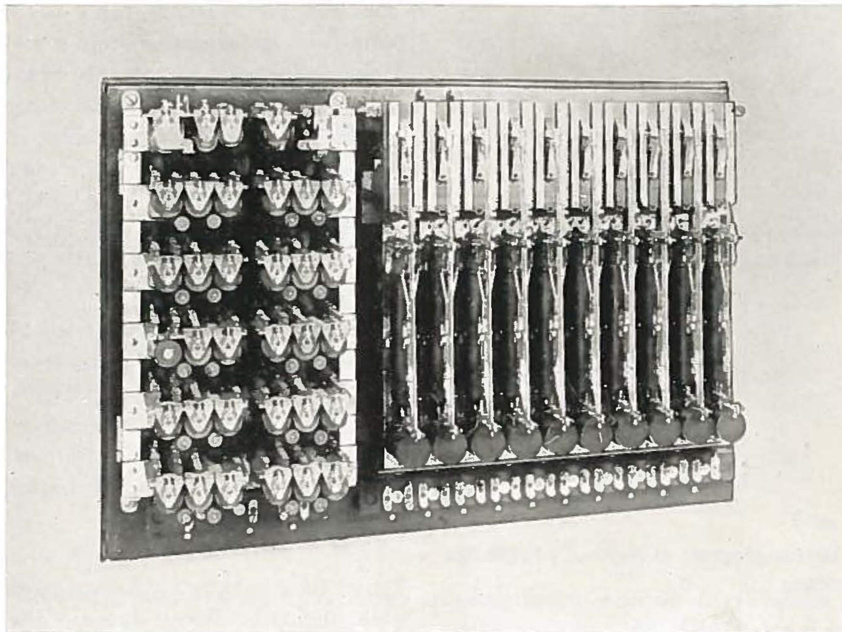


Fig. 1 X 6311

Switchboard with Betulander's 10-line selector

mounted on ebonite plate. Each selector is intended for 10 numbers and has contact bank of bright German silver wire, laid in grooves in the plate; left, the selector's operating relays.

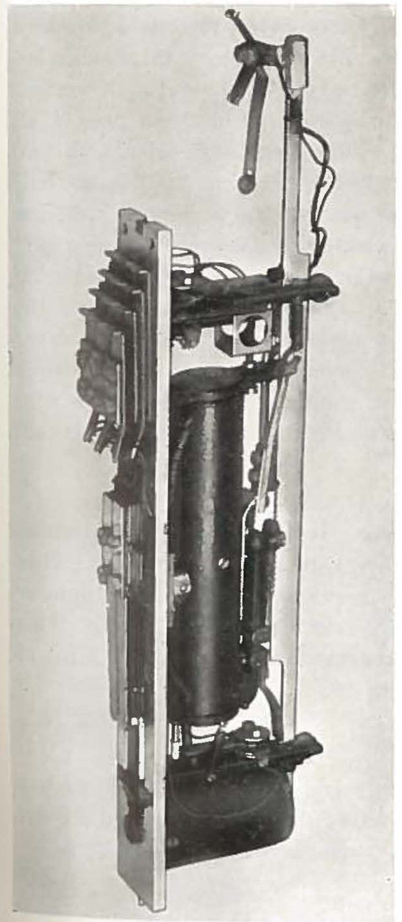


Fig. 2 X 4524

Betulander's 10 line selector

a magnet up to the wanted line, then falling down in the bank, thus providing contact between the wiper contacts and the line wires of the bank. The other type of selector was for 100 numbers, to some extent resembling the American Strowger selector. In 1910 Mr. Betulander was granted leave of absence from the Telegraph Administration to take up the post of technical head of the newly established firm of *Autotelefon Betulander,* in whose factory at Liljeholmen he continued work on his system aimed at making it cover even larger plants.

Mr. Hultman, after various trials, arrived at a machine-driven system with bare-wire multiple on an entirely new principle, see Fig. 3. The bare-wires of the multiple were held in place by flat sheets of insulating material with holes through which the wires were drawn. The designer had considered a capacity of 1000 to 10000 lines for this multiple. Thus a 10000 line multiple, if each line comprised three individual wires, would consist of $3 \times 10000 = 30000$ bare wires. The length of the multiple field was determined by the number of selectors belonging to it. The multiple field was fitted in an iron rack. A multiple field for 10000 numbers was divided into four sections, with 2500 numbers to a section. Each section consisted of 50 rows with 50 numbers in each. Each number comprised three separate wires, the two speaking wires and the testing wire.

The selector wiper ran on a guide-bar at right angles to the conductors in the multiple field, with two sections of the multiple field above the guide-bar and two sections below. The space between the sections was so large that the wiper could move freely in it. In home position the wiper stood in the middle of the field. The wiper could be pulled to right or left, up or down, by lines wound on drums coupled by electro-magnets to a continually rotating shaft. The contact wiper has four separate movements, left or right, up or down. Setting of the selector was done from registers, directed by revertive impulses. Both the models of selectors and testing of the system were executed by Telefonaktiebolaget LM Ericsson.

Mr. Olsson first designed 100-line selectors, with some resemblance to the Strowger selectors, but gradually went over to rotary step-by-step driven selectors for 30 and 10 numbers respectively. In the system he later arrived at the 30-line selectors served both as pre-selectors and final selectors, one part of the multiple being used for outgoing traffic from the subscriber and the

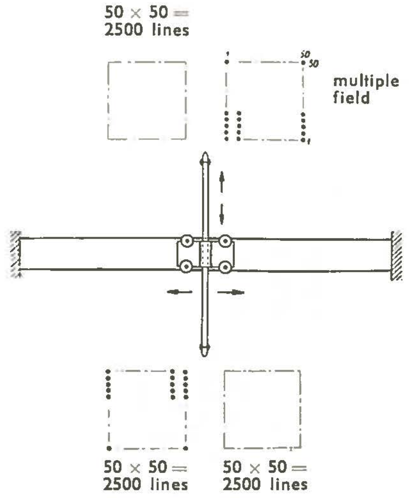


Fig. 3 X 4530

Skeleton diagram of Hultman's 10 000-line selector

other part for incoming traffic to the subscriber. Setting out in the latter case being done by indication from a marker. The 30-line selectors were also used in the group selector stage, the contact position in the multiple being indicated by a separate marker that also carried out testing for unoccupied line. By this system the multiple in a 30-line selector could be divided into any desired number of outgoing routes, the number of lines in a route varying according to the traffic. Registers were used for setting out the markers. All selectors were simple and worked only as finders to given marked positions.

As stated, Mr. Betulander started his factory at Liljeholmen in the beginning of 1911. Basing on the experience gained with his earlier switchboards he considered that the selector devices should be simple in mechanical respect and with little wear. So he began work on the 10-line selectors with bare-wire multiples referred to earlier. For these selectors to replace the 100-line selector of the Strowger system, 11 of them would be required for each 100-line selector.

Ten of these selectors are disposed one and one in each of the outgoing routes, while the 11th selector receives the incoming impulses from the subscriber, is set out accordingly and starts the selector belonging to the appropriate group. This latter selector then hunts a free line in the group. In the same way these 11 selectors act as final selectors, the first selector pointing out the 10s of the subscriber number and connecting to the selector belonging to this 10s, which is then set out to the line in question. A system with 10-line selectors of this kind will naturally be considerably dearer than a corresponding system with 100-line selectors only.

In the course of work for the simplification of this system there was produced in 1912 what is called the link circuit system. The principle of this connection is that a number of incoming lines, e. g., 10, may with the aid of a number of links, e. g., 10, obtain connection with $10 \times 10 = 100$ outgoing lines, *i. e.*, 10 lines in 10 outgoing routes, see Fig. 4. Each link is provided with two 10-line selectors, one for hunting the incoming lines and one for hunting outgoing lines. The multiples for outgoing lines are common to several incoming groups. The links exist solely to provide connection between incoming and outgoing lines. To obtain connection over free link there is required in addition per 10 incoming lines a marker, see Fig. 4, which on call from one of the incoming lines is connected by means of a finder to the line. The marker receives impulses from a register and then connects the incoming line over the link to free line in the wanted group of outgoing lines. When the connection is established the marker is disconnected, leaving it free for the next call.

By means of this principle 20 10-line selectors replace 10 100-line selectors. There is, however, the addition of a marker with finder devices etc. Thus where $11 \times 10 = 110$ 10-line selectors were previously required, the number has been reduced by link system to 20 10-line selectors plus one marker. This means the number of selectors has been brought down to about one fifth of the previous figure.

Very soon a change from 10-line selectors to relays as connecting devices was made, see Fig. 5. Instead of 20 10-line selectors there were required in this case $2 \times 100 = 200$ relays. There were also a number of auxiliary relays.

Thanks to the link circuit system it was now possible to construct even larger telephone plants solely of relays and at reasonable cost.

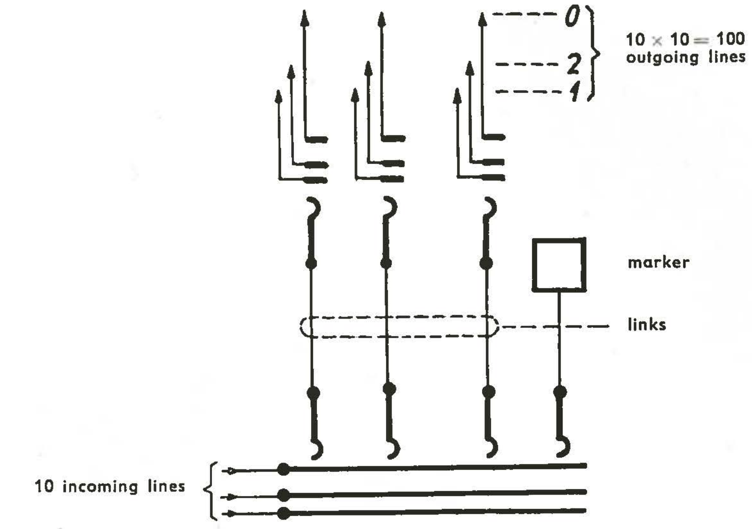


Fig. 4 X 6300

Skeleton diagram of link circuit system with 10-line selectors

Thus work was proceeding on three different fronts with the development of automatic telephony in Sweden. Trial plants were put up, these being carefully studied by the Telegraph Administration.

By 1915 progress was such that the Board of Telegraphs was in a position to place orders for large plants on the different systems for further trials. A plant on the Hultman system was ordered from Telefonaktiebolaget LM Ericsson. The exchange had a maximum capacity of 1000 numbers. Some 300 subscribers were immediately connected to it. The exchange was in service during the years 1918 to 1920. The selectors were of the type described above for a maximum of 10000 lines and were controlled by sequence switches and registers. Coupling in of the selectors was done by line finders, these consisting of an endless steel band made to rotate over a constantly turning shaft and in their movement actuating springs that were pressed against a multiple field of bare wires. Such a line finder was common to 100 subscribers. This plant and two others were for semi-automatic operation.

The Telegraph Administration's workshop made a trial plant for 200 lines on the Olsson system. This plant was erected in one of the Administration's buildings and was in operation from 1917 to 1920, serving some subscribers but mainly being used for service telephone instruments.

About the same time there was ordered from *Autotelefon Betulander* a plant working solely with relays on the link circuit system described above, this

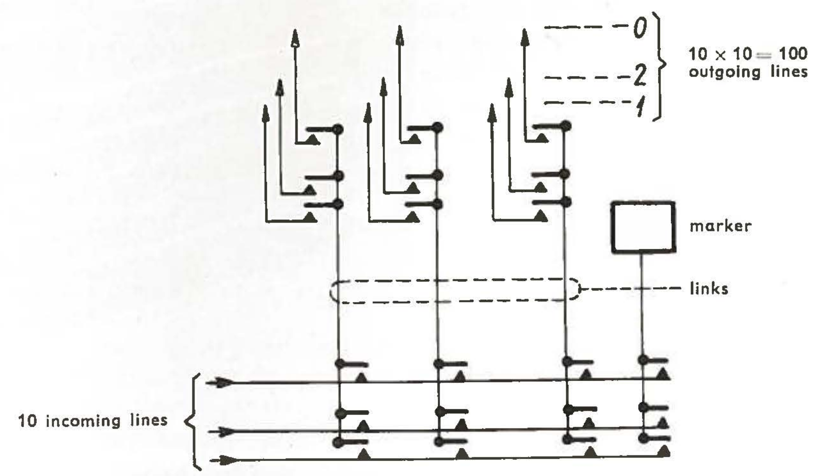


Fig. 5 X 6301

Skeleton diagram of link circuit system with relays. Each relay is shown as a make contact.

being put up in the same building. It was for up to 1000 numbers. Later about 400 subscribers were connected to it. The plant operated from 1917 to 1920 to general satisfaction.

In the course of work on this Betulander plant, efforts to develope the relay system were continued. The chief aim was to bring down the cost. Though a relay in itself is an inexpensive device a connecting group of $10 \times 10 = 100$ relays is relatively costly. There was therefore room in this respect to cheapen the relay system.

Gradually a new design, known as the crossbar selector, was arrived at. Before then, there had been designed at the Western Electric Co. in America what was called a crossbar switch. This selector consisted of 100 banks of contacts arranged in 10 rows one above the other. The contacts were actuated by 10 vertical and 10 horizontal rotary rods. The rotary movement of the rods was produced by electromagnets, one for each rod. The contact banks were placed at the points of intersection between the rods. The vertical rods were each furnished with 10 articulated arms, the horizontal rods with cams corresponding to these arms. In connection a vertical rod was first rotated, all its arms then being set under their own contact banks in a vertical row. Then a given horizontal rod was rotated. The arm of the vertical rod that was at the point of intersection between the two rods was lifted by the cam on the horizontal rod, this causing the bank of contacts at this point of intersection to be actuated and its contacts to make.

The crossbar selector, Fig. 6, designed by the Betulander company worked to some extent on the same principle, but the basis of its design was ordinary relay construction. Instead of the horizontal rods of the American selector and their contact banks, the Betulander consisted of 10 relays, each provided with 10 make groups and a long armature common to all 10 groups.

Nevertheless the groups were normally free from the armature, so that they were not actuated solely by the attraction of the armature. In front of these relays there were five bars, placed between alternate vertical rows of contact banks. The bars were rotatable to right and to left and they were governed by electromagnets, two for each bar. Each bar was provided with 10 assignment wires of piano-wire. Each such assignment wire at the point of attachment was in the shape of a spiral spring, to make the assignment wire easily

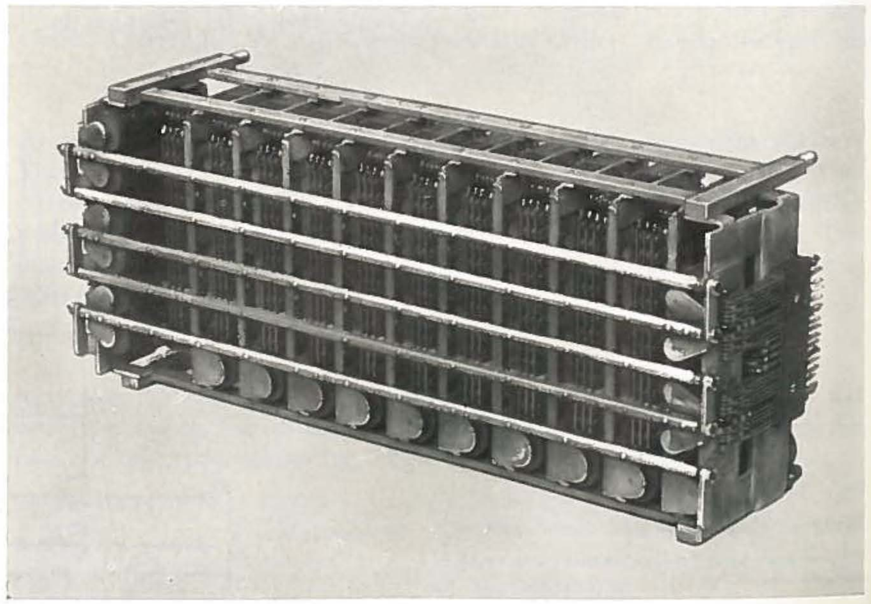


Fig. 6 X 6303
Betulander's crossbar selector

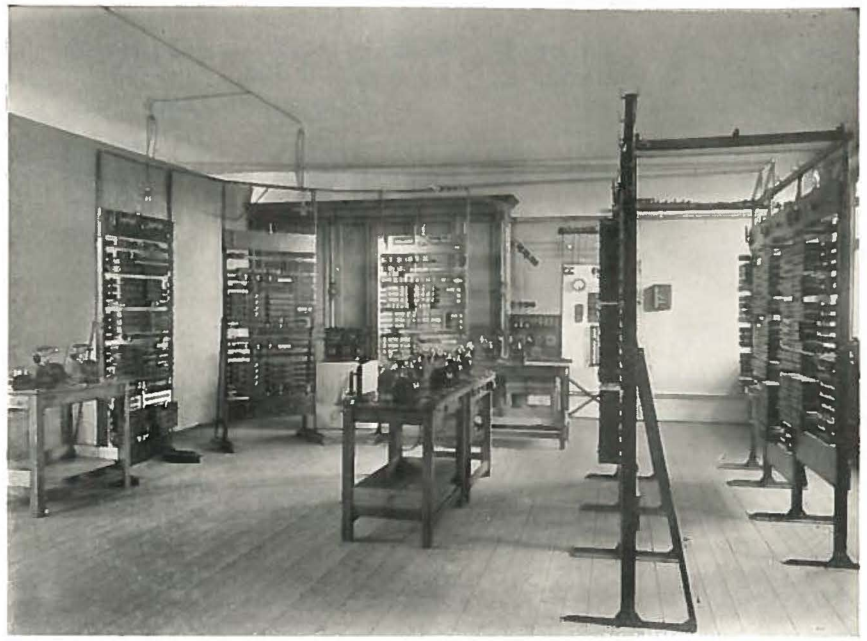


Fig. 7 X 6302
Inside view of the trial plant for the link circuit system of the Betulander company at Liljeholmen

articulated and permit of a certain bending. When one of the bars was rotated to left or to right the assignment wires for this bar would go between the armatures of the 10 relays and the vertical row of banks. Then, when one of the armatures attracted, the bank of contacts for this relay were actuated and made contact. The bar was released, but the armature remained attracted throughout the call and the assignment wire was held under the contact bank which therefore continued made. The same bar could be used immediately afterwards for another connection.

The number of contacts in such a crossbar selector would be the same as the corresponding number of contacts in the previous relay group consisting of $10 \times 10 = 100$ relays, but the number of coils had been brought down from 100 to 20. To this there were added in the crossbar selector 5 bars with their assignment wires. A further simplification obtained was the bringing down of the number of relay armatures from 100 to 10.

The crossbar selector had its first practical test in the Betulander trial exchange. In one of the rows of racks, equivalent to equipment for 100 subscribers, the individual relays in the connecting groups were replaced by crossbar selectors. These selectors were in service during the years 1918 to 1920 and were particularly satisfactory in operation.

The collaboration between Telefonaktiebolaget LM Ericsson and Mr. Hultman resulted in LM Ericsson taking over some of Hultman's ideas, such as the bare-wire multiple, machine-driven selectors etc. As regards the capacity of the selectors, Mr. Knut Kåell, who right from the beginning was in charge of this work of development, carried out an inquiry which showed that the most favourable capacity was about 500 numbers. Taking this capacity as basis, the work of designing was put in hand, this finally resulting in the present system with 500-line selectors.

The interest for LM Ericsson's system with 500-line selectors aroused in the Telegraph Administration was so great that further trials with Hultman's system were considered unnecessary.

By 1920 the Telegraph Administration had advanced so far in its study of the various trial plants that tenders were asked for two fully automatic telephone plants, one for 10000 subscribers and the other for 5000 numbers. Requests for tenders were sent to Telefonaktiebolaget LM Ericsson, Autotelefon Betulander and to two foreign manufacturers, Siemens-Halske and Western

Electric Company. A commission was appointed at the Telegraph Administration to consider the tenders that came in.

The Betulander Company, owing to its restricted resources, could not on its own account undertake the delivery of two such large plants, and the company therefore came to an agreement with Telefonaktiebolaget LM Ericsson that, in case Betulanders secured the order, the plants would be manufactured in the LM Ericsson factories. Under the agreement the Betulander Company tender was to be submitted through LM Ericsson. Thus LM Ericsson put in tenders for two systems, their own system with 500-line selectors and the Betulander relay system.

The Telegraph Administration commission very thoroughly considered the various tenders. Great interest was attracted by the new system with 500-line selectors, of which there was a small test plant installed at LM Ericsson's offices. After careful deliberation the Commission decided for the LM Ericsson system with 500-line selectors.

For various reasons, the Telegraph Administration did not order both the proposed plants, but only the smaller one, that for 5000 lines.

The contract for this plant bears the date of 23rd Arpil, 1921. By 1st August, 1923, the plant was ready for service. On that day 100 service telephones were connected in for trial traffic. The trials proved satisfactory and on 13th January, 1924, the exchange was opened for public service with some 300 subscribers connected. Week after week fresh subscribers were added and by the beginning of February 1924 over 2000 subscribers were being served.

In view of the good results attained with the crossbar selector in the trial plant constructed by the Betulander Company, the Telegraph Administration decided to continue work on this selector. It was considered, however, in the Telegraph Administration that the link circuit system was too complicated and that blocking might arise and cause lowered accessibility. Consequently in plants constructed by the Telegraph Administration the crossbar selector worked as 100-line selector in the group selector sections, *i. e.*, each of these selectors could only handle one call at a time. Obviously a plant on this system will be much more expensive than if it were made with link circuits in which each crossbar selector may be employed for ten call connections at one time. The first plant of this kind was opened at Sundsvall in 1926. Crossbar selector exchanges were later installed at a number of towns, including Malmö. Later small rural exchanges were developed for up to 200 or 300 lines. Recently link circuit systems have been constructed by the Telegraph Administration and enlargement of the Sundsvall exchange has been done on this system.

LM Ericsson has also developed a link circuit system, or as it is now called bypath system with crossbar selectors and has already received a considerable number of orders for the system, which is believed to have a great future.

Around 1930 the world's greatest telephone undertaking, the Western Electric Company of America, began to devote attention to the crossbar selector and the bypath system, to replace their panel system previously employed, with machine-driven 500-line selectors. In 1938 this concern opened at Brooklyn the first plant with crossbar selectors or crossbar switches and with the bypath system. The crossbar selectors in this plant were in the main of the same design as those earlier made by Autotelefon Betulander. The opening of the plant at Brooklyn was regarded in America as one of the greatest advances of automatic telephony.

It is a notable fact that the value of great inventions is often not realised until long after their inception. The bypath system with crossbar selectors, though a trial plant was in operation as early as 1918, has only in recent years enjoyed the appreciation it deserves.

New Table Instrument for Automatic Systems

V SÖDERSTRÖM, TELEFONAKTIEBOLAGET LM ERICSSON, STOCKHOLM

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In various domains of telephony great efforts have been devoted in recent years to improving the sound quality of telephone conversations. One feature of these efforts has been improvement in reproduction of the higher frequencies. The intensive work of development carried on by LM Ericsson in regard to telephone instruments has resulted in a new table telephone instrument for automatic telephony being put on the market.

Outwardly much resembling our previous type, internally this instrument constitutes an entirely new design, the aim in the first place having been to ensure good speech transmission, strength, great reliability, small maintenance cost and simple construction adapted to modern manufacturing methods.

In 1931 LM Ericsson introduced an up-to-date telephone instrument with case of press-moulded bakelite. This instrument proved to be a real success in respect of good transmission, solid construction and attractive appearance. After a few years it was adopted in slightly modified form by the British Post Office and is still the normal instrument of that administration. Since then the external form of LM Ericsson's table instrument has constituted the pattern for the latest telephones of almost all leading telephone manufacturers.

Nevertheless, LM Ericsson have by no means rested on their laurels from the good results of the 1931 instrument. Ever since its introduction energetic research in the domain of telephone instruments has been kept up and test results and experience in operation, both of this instrument and those of other makes from various parts of the world, have been carefully studied. On the basis of this work, extensive design activity has been going on which has resulted in LM Ericsson putting on the market a new type of table instrument for automatic systems, see Fig. 1.

Fig. 1 X 6290
The new telephone instrument

Case

On the new instrument, sharp lines have had to give way to more rounded forms, which makes the bakelite case less sensitive to blows and jars, besides being more in keeping with the soft lines of the handset. The die-press tool for the case consists of a steel block with the whole case shape cut out. Thus there are no joints or seams requiring polishing or grinding off, and the outside of the case receives its high finish direct from the moulding, this being a great advantage in resistance to wear and climatic action.

The case, which is rather lower than the previous type, is provided with two bakelite pins that actuate the switch hook when the handset is put down and with a number-frame of press-moulded material. The items in the frame are easily exchangeable from the front of the instrument, as attachment is by a spring holder. Fitting of the case to the baseplate of the instrument is done by screws directly threaded in the case.

Dial

The dial mechanically is of entirely new design and is provided with perforated disc of moulded plastic with figures cast in, also of plastic. It is countersunk in the front slope of the case and connected to the inset terminal block by a cord soldered on to the dial spring assembly. A description of the dial's construction will be found on page 82 of this issue.

Inset

Internally the design of the instrument is on entirely new lines. The internal devices are fitted well in view on the baseplate. The parts are easily accessible, see Fig. 2, and the cable drawing between the various parts and the terminal block especially simple and handy.

The condenser, fitted on the fixing bracket of the bell mechanism, has loose connection, that by loosening the two fixing screws and moving the condenser forward it is easy to get at the bell for adjustment or to provide it with a biasing spring, if required.

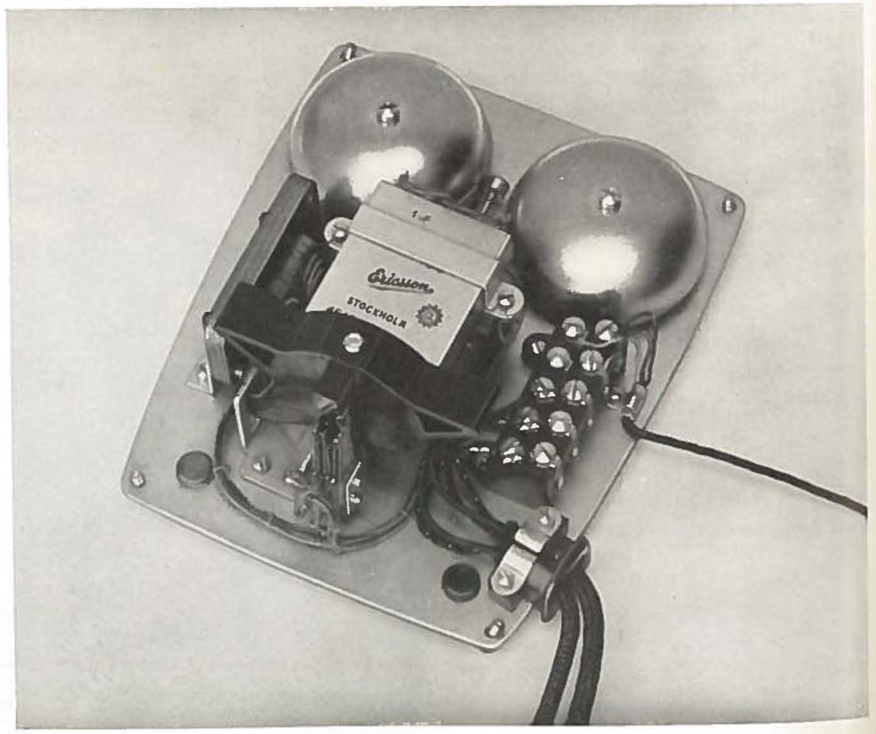

Fig. 2 X 6293

Inset

top: gongs; below them: induction coil, condenser, terminal block; bottom: switch hook and spring assembly

Fig. 3 X 4517

Wall terminal

The switch hook, acting on the spring assembly for connection of the instrument to the line, consists of a sheath of bakelite running on a pillar riveted to the baseplate. A projecting stud on the sheath goes down between two springs in the assembly when the handset is put down and pushes the sheath down by means of the two movable pins in the case. Up and down and sideways the sheath is guided by a projecting stud which runs in a groove in the bracket on which the spring assembly is mounted. This bracket may be shifted owing to the fixing screws going into oval holes, and thus the spring assembly may be adjusted in relation to the upper stud of the sheath. In the new design the movement friction has been much reduced. All the springs in the assembly are of phosphor-bronze and provided with twin contacts. Where required supporting springs are fitted. For special diagrams the spring assembly may be enlarged as to number of springs above the number given in LM Ericsson's normal diagram.

The *induction coil* frame is of press-moulded bakelite. At the ends pockets have been cast providing good protection for the soldering tabs fitted in them. Each soldering tab has two lugs, one for the wire from the induction coil winding and the other for soldering of the connecting cable. The iron core consists of 16 to 17 sheet-iron laminations 0.35 mm thick. These are riveted together after fitting in the coil frame by means of tubular rivets, through which the fixing screws for the induction coil pass.

The *A.C. bell* is polarized and has two coils with the magnet located between them. The resistance per coil is 500 ohms. The coils which are bakelite moulded have the same sort of soldering lug as the induction coil. The bell's air-gap is adjustable and as the gongs also may be adjusted good sound intensity is obtained. The iron bracket on which coils with armature and magnet are fitted is shaped as fixing for the bell mechanism on the baseplate and has two lugs on top for attachment of the condenser. The gongs are of special sheet brass, have different pitches and are mounted on pillars riveted to the baseplate, thus ensuring good sound intensity. There are sound apertures in the baseplate below the gongs.

The *terminal block*, moulded in bakelite, has ten terminal screws, five in each row, with the rows on different planes to facilitate connection of the cords. The screws, which also hold the soldering strips to which the cable is soldered, pass directly through threaded holes in the bakelite. Thus there are no cast-in lugs. The cable lead-in has space for the wall terminal cable and for the transmitter cord. These are each clamped here separately, by two clamps, so that any pull on the cords is taken up here and does not strain the terminal block. For connexion of extra receiver there is a closed slot in the case which can be broken open for a cord to be led in and terminated on the same clamps as the handset.

Cords

The wall terminal and handset cables are provided with cable lugs, ensuring rapid fitting and easy exchange of cables. As the cables have cable lugs an extra receiver can be connected without trouble under the same screws holding another cord.

Wall Terminal

The wall terminal consists of a circular bakelite block with a lid of black enamelled sheet metal. The block has space for three terminals, each with two screws, one for the wall terminal cabling the other for connection of the line. Mounting on the wall is done with one single screw, as the back of the block has sharp points penetrating the wall when the screw is tightened, thus hindering the wall terminal from shifting when drawing the cable or when

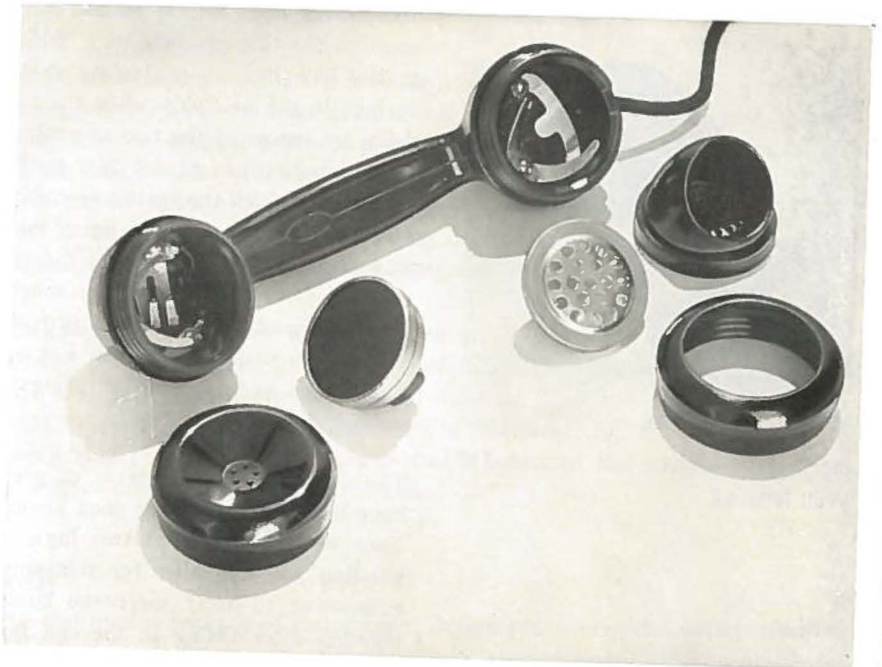

Fig. 4 X 6292

Handset

partly taken to pieces; left to right: receiver cap, receiver inset, transmitter inset, transmitter funnel with fixing ring below

knocked. In fixing, the two parts of the cable are laid around the raised centre piece, see Fig. 3. A pull on the cable is taken up by this fixing, so that no special arrangement for clamping the cable fast is required. The lid is provided with a screw and the lid's shape is such that the screw-head lies below the lid's plane.

Handset

The handset, Fig. 4, is of transfer moulded bakelite. There are no cast-in conductors or lugs and all terminal screws fit directly into threads in the bakelite. The screw-threads of the receiver cap and the transmitter ring are in bakelite. The handle is hollow so that the conductors connecting the receiver with the transmitter side may be laid in when assembling. These conductors are connected with the same screws that hold the springs which form the contacts between the receiver inset and the transmitter inset.

Receiver

The receiver, Fig. 5 and 6, is constructed in the form of an inset which when inserted in the handle rests against two supporting springs, being pressed against these when the lid is screwed on. The inset itself consists of a die-cast

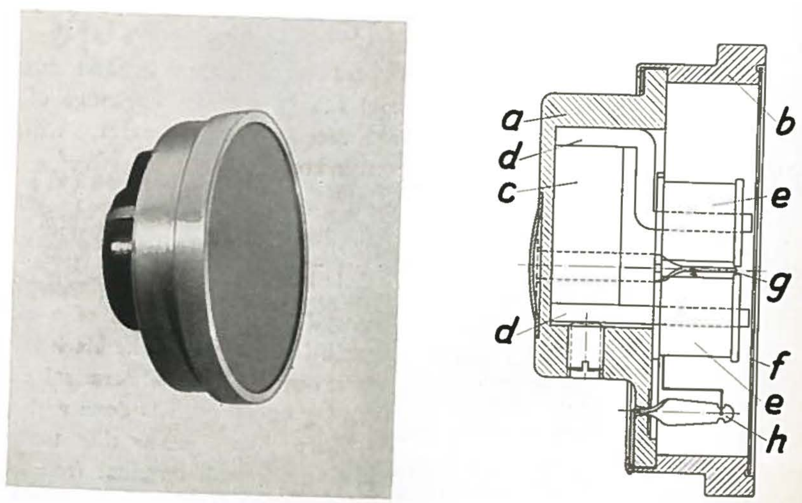

Fig. 5 and 6 X 4536 X 4532

Receiver inset, with cut section (at right)

a bakelite base
b brass case
c magnet
d iron bracket
e coil
f diaphragm
g soldering tab
h soldering tab

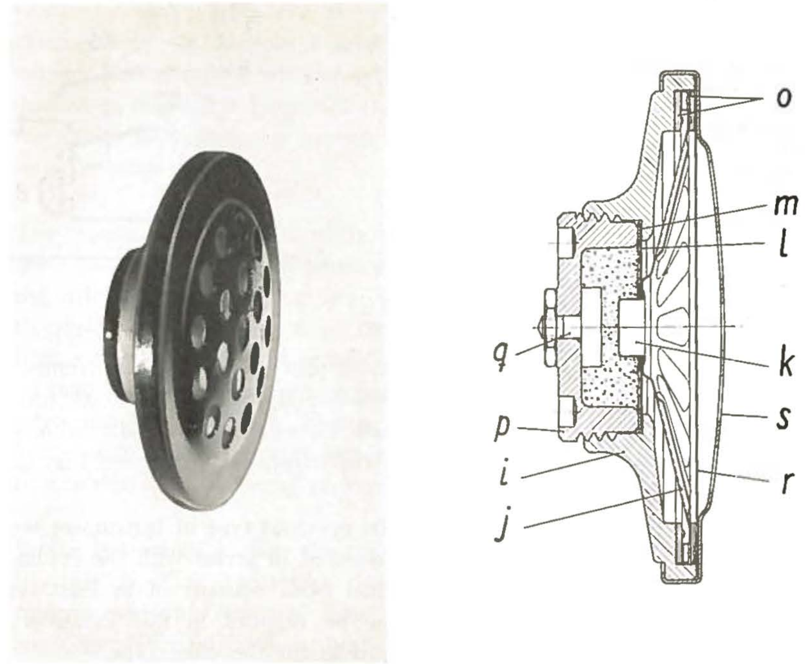

Fig. 7 X 4519 X 4531

Transmitter inset RLA 18, with cut section (at right)

i frame
j diaphragm
k electrode
l insulating sheet
m copper star
o papper ring
p cup
q electrode
r protective silk tissue
s protective cap

bakelite base *a* enclosed in a brass case *b* with rim for the diaphragm. In the bottom there is a cavity in which the cobalt steel magnet *c* is laid and screwed in, along with the two iron brackets *d* forming the cores for the coils *e*. The ohmic resistance is as previously 2×60 ohm. The diaphragm *f* is not stretched but lies loose in a rim, being held in position by the pull of the magnet. Thus it reacts easily for the current variations in the coils. The coils, connected in series, are connected to two soldering tabs *g* and *h*, of which *h* has metallic connection with the case on which the diaphragm lies and the *g* has metallic connection with a contact strip in the centre under the bakelite base.

Transmitter

The transmitter inset, Fig. 7, is of entirely new design, though similar in size to the previous one, so that it can also be employed in earlier handsets of bakelite type. The frame *i* is of brass and constitutes one connection to the carbon. The diaphragm *j* is in the form of a cone and is made of thin aluminium sheet to ensure mobility. There are moulded ribs on the cone to stiffen it and prevent self oscillation in the diaphragm. The upper electrode *k* is riveted on the diaphragm and also holds the insulating sheet *l* which constitutes one wall in the carbon chamber, besides a copper star *m* which forms the metallic link between the electrode and the frame. The whole of this system is movably pivoted in two layers of thin specially impregnated paper rings *o*. The carbon chamber consists of cup *p* screwed into the frame and made of melamine. The other electrode *q* to the carbon is screwed in the cup. The inset diaphragm is protected by an impregnated silk tissue *r* and by a protective cap *s*, bent over to hold the diaphragm and the paper rings in position. As the electrodes are immersed in the carbon, the inset will be free from interruptions and less dependent on its position during conversation.

Connection

In systems with 24 V feed tension and 2×400 ohm feeding coils the 200 ohm transmitter inset *RLA 1820* is employed. The connecting diagram is the same

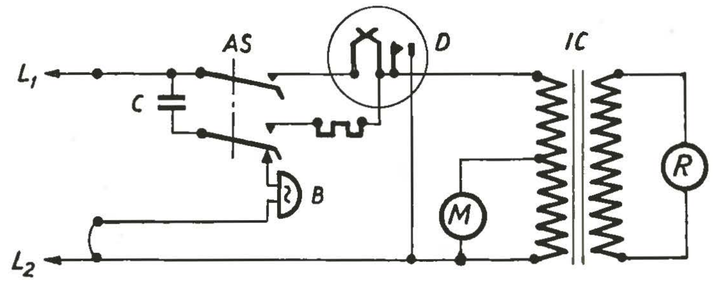

Fig. 8 X 6294

Diagram of connection with transmitter inset RLA 1820

- AS switch hook
- B bell
- C condenser
- D dial
- IC transformer
- M transmitter
- R receiver

as for previous types of instrument, see Fig. 8. For systems with 48 V feed tension and 2 × 400 feed coils the 100 ohm transmitter inset *RLA 1810* is used. To ensure better adaptation a condenser has in this case been inserted in the telephone circuit, see Fig. 9.

The previous type of instrument was so connected that an extra bell could be connected in series with the ordinary bell. For this connection the wall terminal cable consists of at least three conductors. The new instrument may also be supplied in this execution, the connecting diagram then being the same as for the older type.

As extra bells are not usually employed to any large extent, it has been considered less economical to provide all instruments with the above arrangement for extra bell. It has been suggested instead that the extra bell should be connected parallel with the line over its own condenser, this enabling two-conductor wall terminal cable to be employed. In order that the extra bell shall not ring during impulsing from the instrument, it is provided with a biasing spring, which prevents operation of the bell with intensified voltage of max. 30 V over the bell, and a series connected 1 μF condenser. In practically all cases the voltage over the bell during signal is always more than 30 V.

These instruments may also be employed in other feed systems that give the same maximum voltage over the transmitter.

On request, LM Ericsson supplies instruments also for connection to systems with other feeding conditions. For example, for connection to a system with 50 V feed tension and 2 × 200 ohm feeding coils the 60 ohm transmitter inset *RLA 1806* is used. The instrument is then connected in the same manner as for instruments with inset *RLA 1810*, but contains a transformer with other resistance values.

Transmission Properties

In recent years great efforts have been devoted in various quarters to improving the sound quality of conversation. In cable and repeater practice, designs have been sought that transmit even the high frequencies contained in speech.

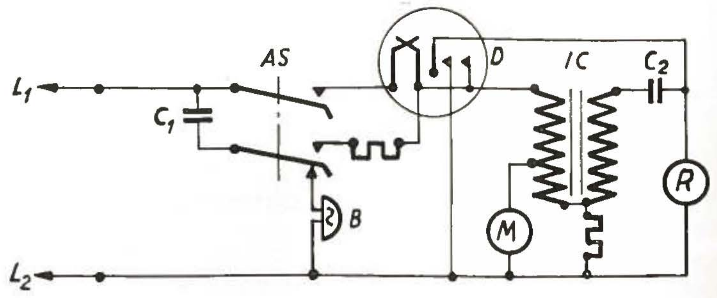

Fig. 9 X 6295

Diagram of connection with transmitter inset RLA 1810

- AS switch hook
- B bell
- C_1, C_2 condensers
- D dial
- IC transformer
- M transmitter
- R receiver

Obviously such efforts are of little account unless the telephone instruments connected in the network reproduce the higher frequencies in a satisfactory manner. Transmitters of older type were generally of such a kind that reproduction of the higher frequencies was weak and in the frequency band essential for cables they gave an uneven transmission, reproducing some frequencies stronger than others.

The transmitter inset previously employed by LM Ericsson, the »star inset», gave very good values for sending reference equivalent which is a measure of the efficiency of the transmitter. Though there were departures from the ideal frequency reproduction, yet in comparison with other designs the LM Ericsson transmitter gave favourable intelligibility values. While working on the development of a new transmitter it was found that an improvement of the sending reference equivalent was of less importance than the production of a transmitter with improved reproduction quality less affected by the position of the transmitter, thus ensuring higher stability and longer life.

In the last-named respect the new transmitter inset represents an appreciable advance on other transmitter designs tried by us. In comparison with older designs the new transmitter has considerably better frequency characteristic, less dependence on position, higher stability, lower noise level and longer life. In spite of these qualities the transmitter comes very near the star inset's outstanding values for sending reference equivalent.

Particular attention has been directed to producing a transmitter that retains good transmission properties even after prolonged operation in severe climatic conditions. It has therefore been a question of arriving at a transmitter with low noise level, with no possibility of interruption at different positions of the handset and to avoid absorption of humidity. Older types of transmitters far too often display a tendency to deteriorate. This may be attributed to a considerable extent to changes in the carbon and trouble has arisen, especially during the war when it was not possible to obtain the most suitable initial material for the carbon. Intensive work has been directed to arrive at the method of burning the carbon that ensures the desired inalterability.

The receiver is very sensitive, gives good speech transmission and has good stability.

The new telephone instrument constitutes throughout an outstanding design, ensuring good transmission even for the higher frequencies so important for the quality of speech, and tests made have given exceptionally good values for intelligibility. Of hardly less importance is the fact that the instrument may be expected to retain its good transmission properties even after long service under severe operating conditions.

New Telephone Dial

C O SOHLBERG. TELEFONAKTIEBOLAGET LM ERICSSON, STOCKHOLM

U.D.C. 621.395.636.1

In conjunction with the introduction of the new telephone instrument described on page 75 in this number of Ericsson Review, a new telephone dial has been designed, chiefly intended for the new instrument but also fitting the present L M Ericsson instrument of bakelite type.

In the designing of this dial, executed in collaboration with the Swedish Telegraph Administration, every attention has been paid to the experiences gathered in this field throughout the years, with the object of making the new dial reliable, resistible to inside and outside wear, easily manipulated, inexpensive to make and maintain and finally to make the visible parts aesthetically attractive and more in the style of the bakelite cases.

The new dial, carrying type designation *RGA 30—39,* differs as regards appearance, see Fig. 1, from the present LM Ericsson dial mainly in the finger plate, shaped more to suit the new telephone instrument, being made of plastic instead of sheet brass as previously.

A new feature is that the figures of the dial are directly moulded in the finger plate, forming a continuous surface without dust collecting hollows. This method also does away with the loose number plate. If desired the figures may also be placed on a fixed enamel ring lying beneath the finger plate and serving as »wear track» for finger ends.

As in the present LM Ericsson dial the mechanical construction of the new one is mostly built up on the inside of a dustproof sheet-brass frame, Fig. 3 c, thus ensuring that the components are well protected and easily accessible for inspection.

On the *frame,* provided with appropriate pressed slots which ensure good rigidity, there are riveted the bearing case for the mainshaft, see Fig. 3 a, the brake cup for the governor as also two pillars carrying a bearing plate, Fig. 2 a, for the intermediate shaft and the governor shaft.

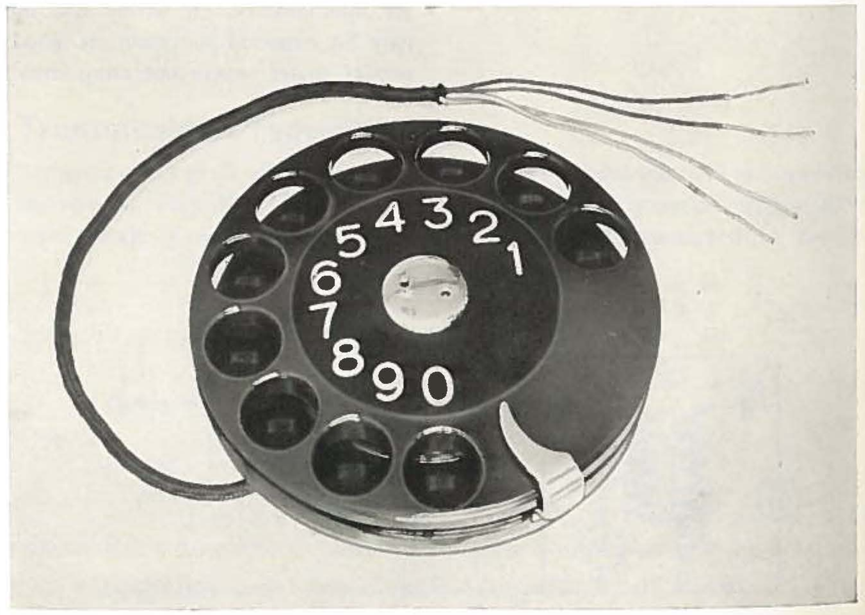

Fig. 1 X 6289
The new dial, type RGA 30—39

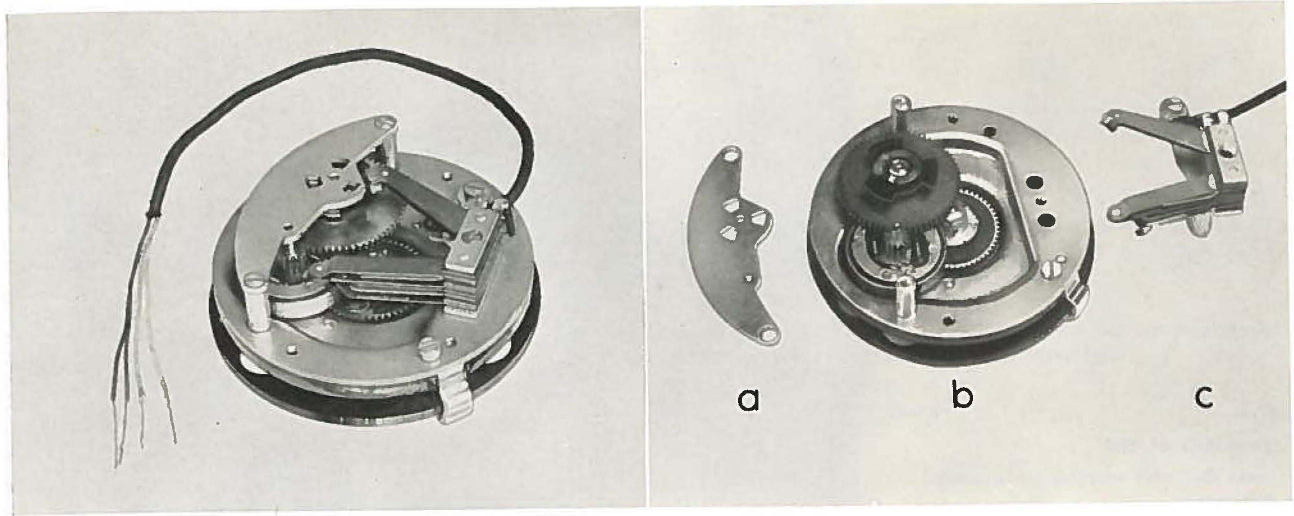

Fig. 2 X 7452
Dial
rear view, at the right, partly dismantled
a bearing plate
b mechanism
c spring assembly

The *mainshaft,* Fig. 3 a, which to minimise bearing friction has been given a comparatively small diameter, carries on its upper end the spring box, Fig. 3 b, and the finger plate.

The *spring box* containing the main spring, of clock type, has a rectangular centre hole fitting the outer end of the main shaft. On the upper side there are two lugs that engage in corresponding hollows at the rear of the finger plate and by means of which that plate, the spring box and the main shaft are firmly locked in the proper relative positions.

The *finger plate,* see Fig. 1, which as in the present LM Ericsson design, has 13 divisions, rests on the spring box and both parts are attached to the mainshaft by means of a visible special screw. Thus all arrangements for concealing this screw are unnecessary and it is made accessible.

On the inner end of the mainshaft there is a cog-wheel, Fig. 3 f, attached by a pin and nut, Fig. 3 a, the former passing through the hub of the cog-wheel, which transmits the rotary movement of the finger plate to the intermediate shaft, Fig. 3 d, has a stop-dog on the underside to limit the movement of the finger plate and above a lifting cam acting on the shunting contacts of the spring assembly when the dial is in home position.

The *impulsing mechanism* of the new dial is in the main built up on the same principles as in the present LM Ericsson dial. Thus it has a three-spaced impulse cam, blocked during the winding up, Fig. 3 e, fitted on the intermediate shaft, Fig. 3 d. It has been found that a three-spaced impulse cam, engaging between the impulse springs, provides very even and vibrationless impulses. When the impulse cam has the same spacing as the finger plate it is easy to understand that there is more difficulty in getting the impulses equal, with impulse cams having fewer divisions than three the gear ratio between the cog-wheels of the main and the intermediate shaft will be less appropriate and moreover the impulse springs will have a relatively great braking action.

There has also been retained in the new dial design the characteristic feature of the present LM Ericsson dial with a separate locking connection for the impulse cam and another rapid-acting connection for the governor.

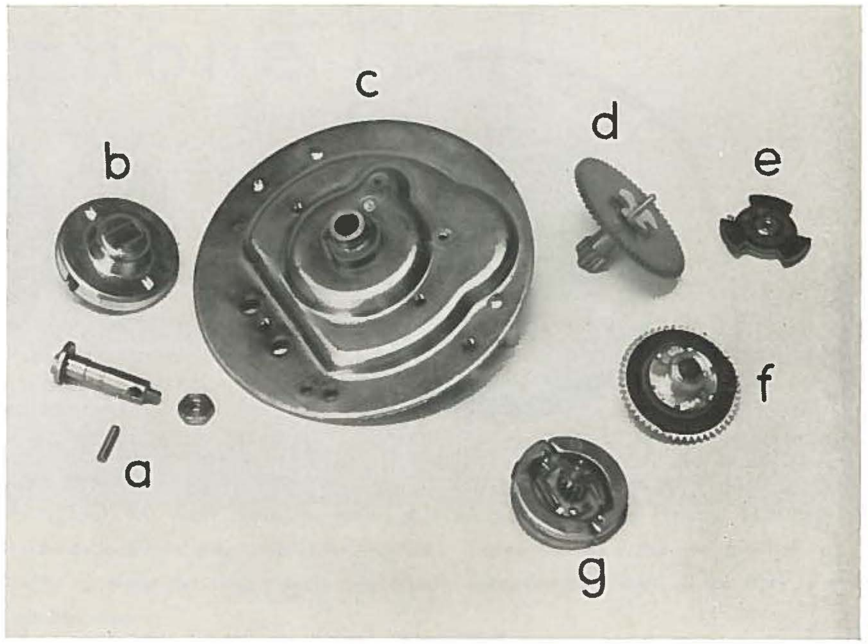

Fig. 3 X 6291

Components of dial

a main shaft with attaching pin and nut
b spring box
c frame
d intermediate shaft
e impulsing cam wheel
f main cog-wheel
g governor

If only one locking connection is employed, common to both the impulsing cam and the governor, the result will be that the finger plate each time it is released after being wound up will make a more or less big »jump», as of course the common coupling cannot have smaller division than the finger plate, so that the governor will not come into action until after a certain, though brief, interval.

The governor coupling employed in the new design, see Fig. 3 d, consisting of a spiral spring closely encircling the hubs of the two cog-wheels fitted to the intermediate shaft, releases the cog-wheels from each other when the dial is wound up but locks them immediately when it runs back, thus making it entirely smooth without interruption. Another advantage is that the governor has a smooth transition from full revolutions to stop.

The *governor,* see Fig. 4, is of an entirely new design, driven by a slow-moving cog-wheel. It consists of a cog-wheel pressed on a shaft, attached to the cog-wheel, a bridge with a pin riveted to each end, as well as the two governor balance weights. These weights which are provided with open bearing grooves are attached to their pins by small spiral springs, which also counteract the centrifugal force of the governor's rotary movement.

The adjustment of the dial speed is done very simply by using a screwdriver, or the like, to move in one direction or the other a spring disc lying between the cog-wheel and the bridge, to which disc the two spiral springs are attached. The brake studs are made of such a material that neither they nor the brake track require any lubrication.

All the *contact springs* have been assembled to form a detachable spring assembly, fixed by a screw. For reasons of circuit design the home position contact springs are so built up that they may be actuated in two steps. The thirteen-spaced dial causes the impulsing contact to give one extra impulse on the return of the dial and this last impulse must therefore be shortcircuited, which is done via the home position contact springs before the dial reaches home position. In addition, these contact springs shall break the shortcircuiting of the speaking set. In dials of older type this is done a little while before the last impulse is shortcircuited, which may at times cause circuit trouble.

Fig. 4 X 4516

Governor
with one brake section taken off

U.D.C. 621.395.344:519.2

JACOBÆUS, C: *Blocking Computations in Link Systems.* Ericsson Rev. *24* (1947) No 3 pp. 86—100.

To ensure economic utilisation the crossbar selector must be connected in link system divided into its parts, the vertical units. The article presents a method of blocking computation for these connections, which combines undeniable simplicity with an accuracy satisfactory for all practical purposes. The paper constitutes a section of an extensive inquiry into the subject now being worked out.

U.D.C. 621.395.636.1

SOHLBERG, C O: *New Telephone Dial.* Ericsson Rev. *24* (1947) No 3 pp. 82—85.

Description of a new telephone dial constructed in conjunction with the introduction of LM Ericsson's new table telephone instrument.

U.D.C. 621.395.343(091)

BERGLUND, C: *LM Ericsson's Automatic Telephone System with 500-line Selectors in the Past 25 Years.* Ericsson Rev. *24* (1947) No 3 pp. 58—67.

Some historical particulars of the 500-line system and an account of the most significant modifications in it since its inception.

U.D.C. 621.395.343(485)(091)

PALMGREN, N: *The Development of Automatic Telephony in Sweden up to the Construction of the First Large Automatic Exchanges.* Ericsson Rev. *24* (1947) No 3 pp. 68—74.

A short description of the different telephone systems and selector constructions made at the automatisation of telephone plants in the cities of Stockholm and Gothenburg during the years 1910—1920.

U.D.C. 621 395.721.4

SÖDERSTRÖM, V: *New Table Instrument for Automatic Systems.* Ericsson Rev. *24* (1947) No 3 pp. 75—81.

A description of Telefonaktiebolaget LM Ericsson's new table instrument for automatic telephony recently being put on the market.

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