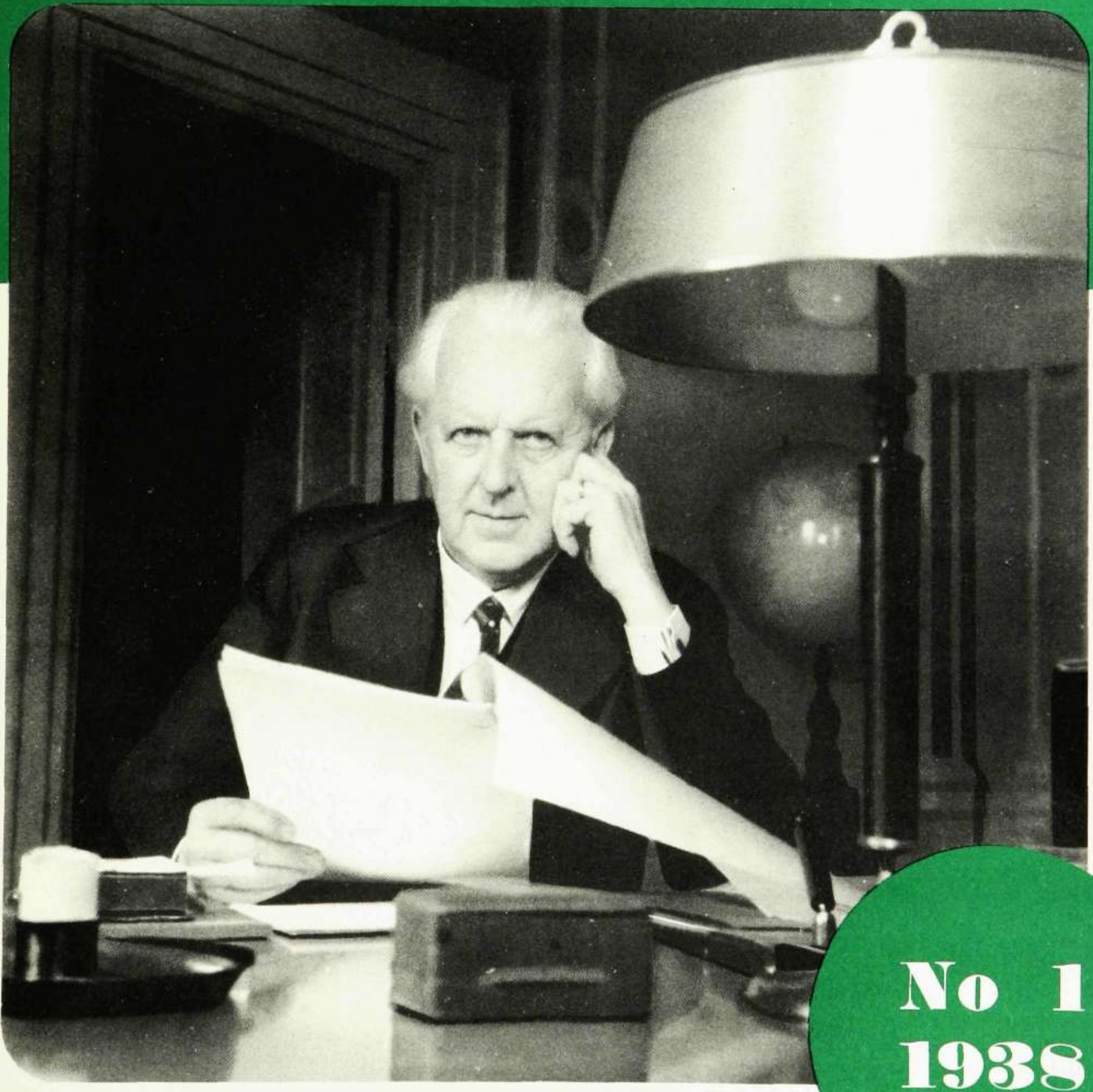
Ericsson Review



Count Adolf Hamilton, Director General of the Telegraph Administration, Stockholm

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CONTENTS

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Telephone Communications in Sweden

COUNT A. HAMILTON, DIRECTOR GENERAL OF THE ROYAL TELEGRAPH ADMINISTRATION, STOCKHOLM

The German technical journal »Europäischer Fernsprechdienst» has recently published statistics covering telephone communications in Europe at the turn of the year 1936. Among other things these statistics give evidence that, as concerns the density of subscribers' stations, i. e., the number of subscribers' stations as compared with the number of inhabitants, Sweden has reached the leading position in Europe with eleven subscribers' stations per 100 inhabitants. This figure has increased to twelve during 1937.

Telephone communications in Sweden, together with telegraph and radio, are operated by the government through the Royal Telegraph Administration. This department, as well as others which operate on a commercial basis, occupies a relatively independent position within the government administration, although the general program of activity, especially as regards the financial side, is subject to the sanction of the Riksdag (parliament) or the government.

It is a known and acknowledged fact that the plant of the Swedish Telegraph Administration has from the start been projected along rational lines and that also subsequent development has been guided with competency and due consideration for modern requirements as well as according to fully up-to-date business methods. More than one example of a government operated telephone administration which markedly differs from the Swedish one in this respect could be cited.

Confronted by the existing situation resulting from the leading position now occupied by Sweden within the field of telephony, the Ericsson Review has requested Count Hamilton, Director General of the Swedish Telegraph Administration, to make a statement on the advance of the telephone in Sweden and some of the conditions related thereto.

The widespread and intense use of the telephone in Sweden has been accredited to various circumstances. Attention has been called to the favourable start, to the necessity for a prompt shortening of the great distances existing

Fig. 1 X 5446
Telegraph Administration Building, Stockholm

in a relatively thinly populated country — the mean density of population being at present fifteen inhabitants per square kilometer —, to the low tariffs and so forth.

Private initiative was responsible for the introduction of the telephone in Sweden and private enterprise was also responsible for the first telephone installation. As a result, telephone communications obtained a very propitious start. The activities in different localities could in detail be adapted to local conditions, the zones of operation of the various telephone concerns usually being very restricted. In some cases, the activities of the telephone concerns were carried on under the form of common stock companies; as a rule, however, the subscribers banded themselves together into so-called telephone societies, thereby forming a strong and widespread anchorage among the general public. Thus the telephone became an object for common solicitude, its success a matter of common interest. Due to the fact that the subscribers were in many cases financially interested in their telephone societies, it was their own purses which determined to what extent the personal requirements as to service and technical equipment should be gratified. As a result the installations were often very simple and this, in turn, made possible low tariffs and a relatively widespread use of the telephone.

Government constructed interurban lines soon gave the telephone a wider range of usefulness. From having been an instrument for purely local communication, it now developed a reach which extended over the entire country. At the same time, the government inaugurated a well planned organizing of local plants over the entire country through the acquisition and rebuilding of private networks or the construction of new plants. The fact that this government network could, at such an early stage, be projected and constructed along uniform standards with respect to engineering as well as traffic conditions, and that the purchase and manufacture of materials could take place on a comparatively large scale was of undisputed financial importance. Consequently, the intervention of the government undoubtedly came at a very auspicious moment for the furtherance of future development.

It has often been stated that without the intervention of the government the Swedish telephone network to-day could not have been so widespread as it is, with tentacles reaching to practically every community in the country. The policy which the Royal Telegraph Administration has been able to follow through a long number of years with the sanction of the government authorities has just made it a point to look after the interests of the country at large, *i. e.*, the good of the general public. Their aim has been to create such telephone conditions that any one, no matter where his place of residence, shall be able to obtain telephone service equivalent to that of any one else and at an equivalent price. It is also chiefly with this aim in view, *i. e.*, the realization of equivalent tariffs and advantages, that work for a further spreading and popularization of telephone communications is now carried on. The introduction of free-traffic zones for the smallest exchanges, the enlarging of the free-traffic zones, all-night service for smaller and smaller exchanges, the automatization of rural exchanges, the replacement of open wire construction by cables for trunk lines and a strong reduction of tariffs for trunk calls, especially over the longest distances, are some examples of changes and ameliorations in this spirit, which have taken place during latter years.

Some Historical Facts

Already in 1877 the first demonstration of a telephone instrument took place in Stockholm, and in 1880 Stockholms Belltelefon-Aktiebolag was formed. This was soon followed by other telephone concerns, in Stockholm as well as in the remaining country. The most important of these was Stockholms Allmänna Telefonaktiebolag, whose activities started in 1883 and soon outclassed those of the Bell company. Most of the small concerns were organized in the form of telephone societies in such manner that each subscriber contributed his own share towards the cost of installation, after which the yearly maintenance costs were assessed upon the subscribers.

The government's first telephone installation — intended for the use of the various government departments in Stockholm — was put in service on September 1st, 1881, and its first real local installation for the general public was opened towards the end of 1882 in the town of Härnösand. During the following years local telephone installations were constructed, chiefly in Scania and in Norrland. At the end of 1887 the total number of telephones in the country amounted to about 16 000, of which only 2 000 belonged to the plant of the telegraph department. In 1888 the telegraph department commenced the construction of the network of metallic trunk circuits covering the entire country. In order to be connected up with this government network it was required of the private plants with only earth return lines that they be reconstructed and equipped with metallic circuits. In general, however, the private enterprises did not have the necessary economic resources for such reconstruction. The government then intervened and purchased plant after plant so that already in 1900 practically all the telephone service in the country — with the exception of the Stockholm zone, however — was under government control.

Stockholms Allmänna Telefonaktiebolag still dominated within this last mentioned district. In 1891 the Telegraph Administration had made an agreement with the company whereby its future activities were limited to a district with a radius of 70 km and covering the capital and its surroundings. This agreement, however, dit not prevent the Telegraph Administration from establishing telephone communication within the zone of operation of the company, and during the nineties a very sharp competition arose between the Telegraph Administration and the company. To a large extent as a result of this competition the Swedish capital became one of the world's best equipped cities as regards the number of telephones — a position which it still retaines. In 1901, however, an agreement was drawn up covering the purchase also of the plant of the private company, but the preliminary purchase agreement was rejected by the Riksdag of 1902, according to the opinion of which a maintaining of the existing competition was considered desirable. Also, several subsequent proposed purchase agreements experienced a similar fate, and it was not until 1918 that the government obtained control over the private Stockholm plant. The purchase price for this plant, comprising 104 000 subscribers, amounted to some 47 000 000 Sw. Kr. Through this transaction the bringing of all Swedish telephone communications under government control was practically accomplished.

Tariffs and Other Conditions

Doubtlessly it is quite a well known fact that Swedish telephone tariffs are very low as compared with those of other countries. As an example it may be mentioned that a telephone subscription entitling the subscriber to a maximum of 1 200 outgoing calls a year within the largest networks — for instance Stockholm and Gothenburg — amounts to 20 Sw. Kr. per quarter year, the tariff rate in other localities usually being 17.50 Sw. Kr. per quarter. The quarterly subscription rate for 10 000 outgoing calls a year is 100 Sw. Kr. in the larger cities and 78 Sw. Kr. in the remainder of the country. A three-minute trunk call over an air-line distance of from 180 to 270 km costs 0.70 Sw. Kr. during the day and 0.50 Sw. Kr. during the morning or evening hours. Over air-line distances of more than 450 km a call during the day costs 1.10 Sw. Kr. and during the evening hours 0.70 Sw. Kr. on and after the 1st of July 1938. Consequently one may hold a three-minute conversation between Malmö and Kiruna, a distance of more than 1 400 km, for 1.10 Sw. Kr. during the day and 0.70 Sw. Kr. during the morning or evening hours. It is evident that the explanation of the widespread and intense use of the telephone within practically all classes of society is to be found in these low rates, especially as they have been combined with a high standard as regards both equipment and service.

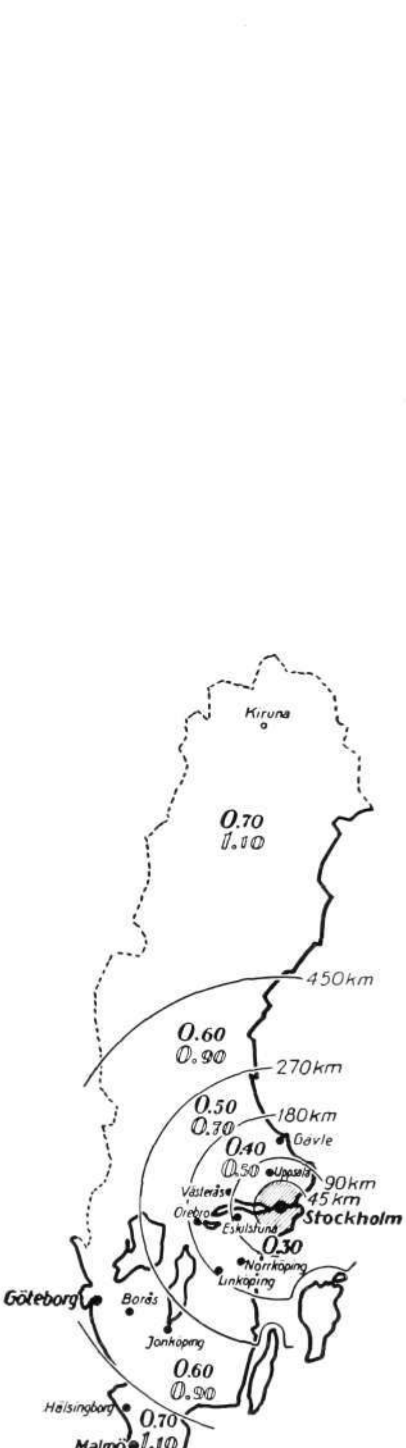


Fig. 2 X 3832
Trunk rate zones in Sweden

Compared with tariff system adopted in other countries the Swedish system has a couple of special features which originated already at the time of the telephone societies. At the smallest telephone exchanges, with less than 35 subscribers, the subscribers are required to jointly defray the expenses for housing and service, which they are able to do at a decidedly lower cost than the Administration. In compensation herefore they receive a certain reduction — amounting to at least 30 Sw. Kr. per year — on the established rates. This arrangement has resulted in reduced subscription rates and has given the administration the advantage of being able to construct such small exchanges much more extensively than would otherwise have been possible, thereby permitting also more thinly populated districts to obtain telephone exchanges and subsequent connections to the trunk network at a comparatively low cost. In this connection it must be borne in mind that the density of population in northern Sweden — more than one half of the country — does not average more than about 4.6 inhabitants per square km, a condition which naturally must be regarded as relatively unfavourable in respect to telephone communications. The entire number of main and sub-exchanges amounted to 5 481 at the end of 1937, 3 416 of these being of the type for which the expenses are defrayed by the subscribers.

Another unique feature of the Swedish tariff system is that the subscription rate entitles to a certain number of calls, not only within the own exchange but also to other exchanges within the same tariff zone. There is a total of 235 tariff zones in the country and they are often of a very wide extent. The established rate for trunk calls is consequently applicable only on calls between different tariff zones. The tariff zones are outlined on the principle that a subscriber, no matter where his place of residence may be, shall be able to telephone to one main locality without having to pay a special call fee. As a result these zones vary considerably as to form and extent. As an example it may be mentioned that there are tariff zones with free traffic over lines of more than 100 km in length, and within the Stockholm tariff zone, which comprises the greatest number of telephone instruments, there are not less than 165 exchanges with a total of more than 220 000 subscribers' stations. The construction of rural subscribers' lines, from the beginning devolving mainly upon the subscribers, has to an ever encreasing extent been taken over by the administration. Free districts — *i. e.*, areas surrounding the telephone exchanges, within which the administration undertakes to construct and maintain lines to the telephone exchange without cost to the subscribers — cover an area extending 2 km from the exchange — these areas being larger around the larger exchanges — and are provided also at exchanges where the subscribers themselves must defray the expenses for housing and service. Exchanges with at least 100 permanent subscribers are held open night and day at the expense of the telegraph department. In this manner about 499 000 subscribers or approximately 83 per cent of the entire number are at present connected to exchanges with night service.

In the more sparsely inhabited districts, chiefly in northern Sweden, the administration has attempted to provide the public with telephone communications — of especial value in these regions — by establishing public calling stations, *i. e.*, stations without any subscribers but consisting only of a telephone instrument suitably mounted for public use. In addition to the usual rates for trunk calls, a smaller pre-established fee is charged for each call, this fee amounting at present to 0.20 Sw. Kr. Such stations have also been extensively placed in the vicinities of light-houses and on islands along the coast. The number of such public call stations amounted to 912 at the end of 1937.

In this connection it should be noted that the widespread Swedish telephone net work has been constructed without any undue anxiety as to the financial returns obtainable on each separate detail. The providing of telephone communications for the more thinly populated districts has been regarded chiefly in the light of a sociological question, but it has without doubt been of no small value for the town residents as well, since the increase in value of the telephone is commensurate with the development of the service.

From an engineering point of view Swedish telephone communications had reached a high standard already at a very early stage due, among other things, to the contributions of Telefonaktiebolaget L.M. Ericsson to this field of endeavour. The handset had come into popular use in Sweden already during the nineties. Since quite some time back the Royal Telegraph Administration has own works for the manufacture of telephone material. Since 1913 these works are located in Nynäshamn, not far from Stockholm, their present staff numbering approximately 1 400 hands.

After the world war the exchanges in the larger cities have changed over to machine switching, the Ericsson automatic telephone system being used in Stockholm and Gothenburg, while in Malmö the administration's own system with cross-bar selectors has been adopted. Also, a number of medium-sized exchanges have been equipped with automatic switching, in which one or the other of the above systems have come into use. Since many years back work has been going on also for the automatization of smaller rural exchanges. At the end of 1937, however, not more than 269 459 telephone instruments, or a good 37 per cent of the entire number, were connected up to automatic exchanges.

Already during the years 1921—1923 a cable was laid for trunk traffic between Stockholm and Gothenburg over Västerås and Örebro, and the work of replacing open line construction by cables has since then advanced rapidly. At the end of 1937 the trunk cables had reached an approximate total length of 3 700 km, the yearly increase amounting to from 200 to 300 km. For the handling of international traffic three cables have been laid to Germany, five to Denmark and one to Finland. Recently it has been decided to lay a second cable to Finland, and an investigation is under way concerning the laying of still another cable to Denmark.

The total length of telephone lines — not including reserves — amounted to approximately 1 456 000 km at the end of 1937, 832 000 km of these being local lines, 225 000 rural lines for the free interlocality traffic within the tariff zones and 399 000 km trunk lines, in addition to which there was an approximate total of 209 000 km of duplex and high frequency communications. The trunk lines included about 89 000 km four-wire lines. The total number of telephone instruments in Sweden at the end of 1937 amounted to 740 000, corresponding to about 118 telephones to every 1 000 inhabitants. The density of telephones in Stockholm at the end of 1937 was not less than 360 telephones per 1 000 inhabitants. The total number of telephone calls handled during 1937 amounted to more than 1 000 000 000. Each telephone could figure with an average of 1 418 local calls and short distance interlocality calls (no fee outside of subscription rate) and 79 trunk calls (against a period fee).

The Swedish government issued the first telephone regulations on November 29th 1915, thereby laying the foundation for the present tariff system. Uniform rates for the entire government network were then introduced for the first time. The subscription rates were based on the call frequency rate and the toll fees were based on the air-line distance between exchanges and not, as previously, on the length of the telephone line. Subsequent alterations have in the main only concerned details and have consequently not influenced the fundamental principles. No one, at the present time, would attempt to deny the justice of the subscription rates being directly related to the number of outgoing calls. This did not, however, prevent the subscription rates calculated along these lines from being greeted with storms of protest at that time.

In order to rightly comprehend the import of this reform it may be necessary to lightly touch on the tariff conditions previous to 1915. During the first years of government operation the yearly rates were calculated according to certain simple principles. One paid 80 Sw. Kr. for a telephone if the length of the line to the exchange did not exceed 2 km, and an additional 20 Sw. Kr. for each additional km or part thereof. As private plants were from time to time purchased by the government the tariffs were often differently determined

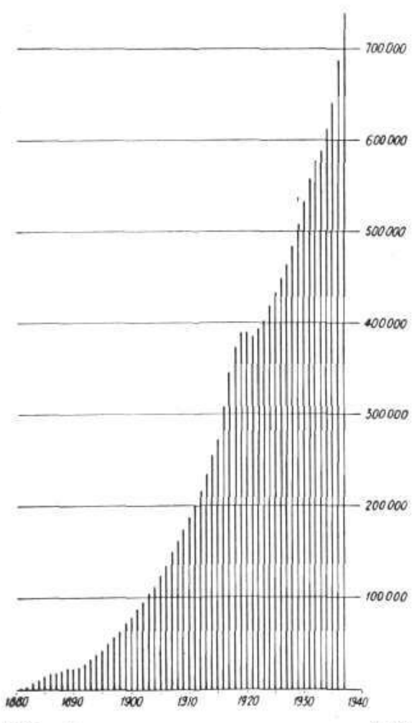


Fig. 3 X 3777
Growth in number of subscribers' stations in Sweden

according to arrangements made with the previous owners. In the telephone plant built by the government the tariff rates were usually fixed with regard to their financial bearing capacity. Thus the rates could differ very widely. The two extremes were represented by subscription rates of 8 and 100 Sw. Kr.

According to the telephone regulation of 1915 the subscription rates were fixed by allotting the subscribers to certain frequency groups or subscription classes depending on the frequency of calls made from their telephone instruments. For each such group the subscription was determined according to the average call frequency within the group. There is reason to believe that the setting of individual rates based directly on the number of calls would have been preferable, but such an arrangement at the time of the reform would have required such extensive changes in the older exchanges that it could not have been realized at reasonable cost. In connection with the rebuilding of exchanges for automatic switching, however, individual metering of calls is being introduced, and in step with the growth of automatic switching one may look forward to the adoption of subscription rates in direct proportion to the service given each individual subscriber.

Also, a reform of trunk rates became a matter of necessity due to the rapid growth of traffic between an ever increasing number of larger and larger local networks. The fact that the administration might lack direct lines of communication between a couple of exchanges and be instead forced to lead the traffic over more or less roundabout ways was of no importance whatever to the general public. Moreover, a uniform method of calculating trunk rates appeared most desirable to the administration which, at the time of the large rate reform, had direct telephone lines between practically all of the larger exchanges.

In Sweden, trunk calls are handled »in turn», a certain waiting time of shorter duration — as a rule from ten to fifteen minutes — being permitted, even for calls over relatively long distances. In this manner a most efficient use of the lines has been attained, permitting the establishing of extremely low trunk rates. When the calling party is in a hurry, it is possible to obtain connection precedence as to turn or an immediate connection by means of either an urgent call or a lightning call, both at an increased rate. In many foreign countries the problem has been reversed. It has been ruled that trunk calls shall be connected up immediately, the increased cost for this type of service being charged to the subscribers. In this connection it should be emphasized that for the short interlocality traffic — which does not call for any period fee in Sweden — direct traffic is largely established, *i. e.*, a requested call is immediately connected up directly to the called exchange.

Another detail is also worthy of notice. Different fees are charged for calls during the day — *i. e.*, that part of the day during which traffic is heaviest — and during evening and morning hours, when decidedly reduced rates are applied. During night hours, however, the rates are the same as in the daytime, as a reduction in the rates during that time would cause an increase in traffic and this, in turn, a marked increase in the cost of service. International calls form an exception, however, and a reduced rate is applied for these, usually between 7 p. m. and 8 a. m. The system with different rates at different times of the day has in later years been patterned after by other countries. In Sweden this differentiating was originally introduced to diminish the traffic load during office hours by stimulating private persons to telephone during evening hours, when the lines would otherwise have stood unused after office hours. In spite of the widespread use of the telephone within all classes of society it still remains a fact that the lines are just as heavily loaded during evening hours as during the daytime, sometimes even more so.

Financial Summary

At the end of 1937 the capital invested in the Swedish Telegraph Administration amounted to approximately 454 000 000 Sw. Kr., and the returns during the same year correspond to a rate of interest on this capital of 8.45

per cent. The following table gives the relation between the available capital and the surplus from the activities of the administration, which were handed over to the government.

year	available capital millions of Sw. Kr.	returns millions of Sw. Kr.	returns percentage of available capital
1928	323.0	20.1	6.57
1929	329.0	22.9	7.32
1930	340.6	25.1	7.87
1931	355.3	26.2	7.97
1932	362.8	27.4	8.01
1933	366.9	30.1	8.67
1934	386.7	34.1	9.60
1935	393.2	35.3	9.54
1936	421.7	35.7	9.28
1937	454.0	35.1	8.45

The capital required for the activities of the administration is obtained through the granting of loan appropriations by the Riksdag. The administration is not required to pay interest on these grants, but must instead hand over to the state treasury the entire surplus which remains after the required deposits to the renewal fund have been made. It is these surpluses that appear in the above table. The profit actually made by the government on the activities of the administration are represented by the given sum reduced by the expenses for interest which the government must pay on the loan appropriations granted the administration. During 1937, when the returns amounted to 35 100 000 Sw. Kr., this interest was figured to have amounted to 15 300 000 Sw. Kr., and the net surplus for the government consequently amounted to 35 100 000—15 300 000 = 19 800 000 Sw. Kr. during that year. The net profit calculated in this manner has amounted to very large sums during passed years. If one should regard these net profits as amortization by the administration on its debt to the government, the administration would in reality have repaid approximately 85 per cent of the capital placed at their disposal. The accounted net value of the telephone installations of the administration, including the value of the trunk equipment, but not including real estate (accounted value less the balance in the renewal fund), amounted at the end of 1937 to not more than 541 Sw. Kr. per subscriber's station, which must be regarded as an exceptionally low figure. The income of the administration during 1937 amounted to approximately 131 000 000 Sw. Kr. and the employees at the end of that year numbered about 20 200 hands.

Our system, such as I have here attempted to describe it, has obviously been successful in Sweden. But like any other form of activities, telephone communications must naturally be made to suit existing requirements and conditions, which change not only from time to time but also from one country to another. I am convinced, however, that the nucleus of the stand taken by the Swedish Telegraph Administration — to aspire towards conditions which geographically and economically will bring the telephone within reach of the greatest possible number of people — is more or less universal. In my opinion telephone communications should not be regarded merely in the light of a business proposition. Their possibilities for breaking the isolation of desolate and lonely tracts, to unite distant parts of the country and generally to simplify the problem of living are sociological factors of great importance.

The Ericsson Automatic XY System

D. LIENZÉN, TELEFONAKTIEBOLAGET L.M. ERICSSON, STOCKHOLM

Telefonaktiebolaget L.M. Ericsson has developed a new automatic telephone system, called the XY system, this name being derived from the new 100-line step by step XY selector used in this system; as regards selector and multiple design, however, it is based on the same principles which have made Ericsson's well known 500-line selector one of the most reliable and well adapted now in existence.
Various orders for rural and PABX switchboards according to the XY system are now in course of manufacture, and these switchboards will be put in service before the end of the current year.

It is now fifteen years since the Ericsson automatic telephone system with 500-line selectors was introduced, and since then it has given ample evidence of possessing most excellent qualities as to service combined with low cost of maintenance. Exchanges according to this system for a total of over one million subscribers' lines are now in operation. The Ericsson 500-line selector is a power-driven selector with a multiple field of bare wires arranged in the form of frames. These multiple frames are rigidly mounted in the selector racks, while the selectors, on the other hand, can be slipped into place one over the other in the rack where they are connected by means of plugs and jacks. Only as many selectors as correspond to the existing traffic need be mounted and the number of selectors can easily be adjusted to follow the fluctuations of the traffic. A simple manipulation is all that is required for their removal for inspection, this latter being greatly facilitated by the fact that the selector is built up on a flat base plate where all the parts are easily accessible for examination and cleaning. The bare wire multiple has not only proved itself to be a most economical and — due to the absence of soldering points — efficient multiple construction, but it has also been demonstrated that the contacts established between the moving wipers of the selectors and the multiple wires are exceedingly good and that contact disturbances do not occur.

The new selector which has now been designed by Ericsson is based on the same principles of construction as the 500-line selector. It has a smaller capacity, however, this being for 100 lines; also, it is graduated in decimals and step-by-step driven instead of power driven. The reason for its being called the XY *selector* is because the wipers — during the setting of the selector to a certain position — move in two separate rectilinear directions at right angles to each other, i. e., along the x and y coordinates of a right angled coordinate system. It is intended for use in smaller sized switchboards and exchanges where the 500-line selector — due to its larger capacity or to the fact that it is register-controlled — is not the most suitable. The XY selector is not the sole characteristic of the XY system, however, these switchboards being also in other respects designed along absolutely modern and, to a certain extent, entirely new principles. They are driven by a 24 V working current.

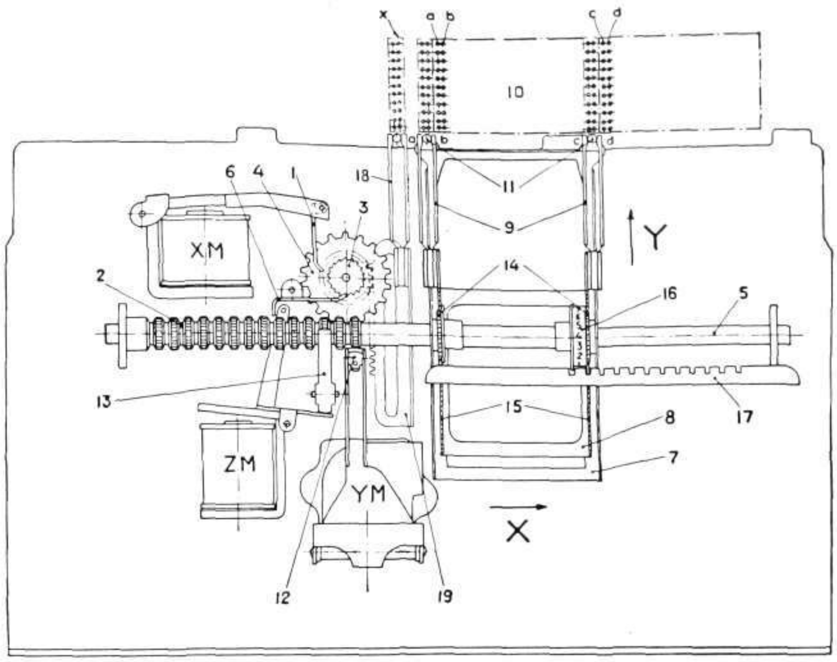
XY Selector

In the XY system the same type of selectors serve as line finders, group selectors and connectors. On the setting of the selector the wipers go through two separate movements perpendicular to each other, see Fig. 1. They are first stepped forward along the face of the multiple, the *X movement,* and thereafter enter into the selected multiple section, the *Y movement.* In order to obtain

Fig. 1 X 5449

Outline drawing of XY selector

XM	X magnet	9	wiper sets
YM	Y magnet	10	multiple
ZM	Z magnet	11	posts
1	X pawl	12	Y pawl
2	toothed sleeve	13	catch
3	ratchet wheel	14	cog-wheel
4	stepping wheel	15	rack
5	shaft	16	number drum
6	catch	17	scale
7	auxiliary carriage	18	X wiper set
8	wiper carriage	19	rack



these two movements the selector is equipped with two ratchets, one for the *X* movement and one for the *Y* movement, these being operated by means of stepping magnets, the *X magnet* and the *Y magnet*. The restoring to home position of the wipers is accomplished by means of a spring which is released by a special restoring magnet, the *Z magnet*.

The *selector mechanism*, Fig. 2, which is assembled on a flat rectangular base plate 170 × 275 mm, corresponds in principle to that of the *Strowger* selector. Thus, a toothed sleeve mounted in bearings on the base plate is stepped forward in its own axial direction, bringing with it the wiper carriage; the toothed sleeve is then rotated by means of the Y magnet, but the wipers — contrary to what is the case in the *Strowger* selector — do not follow the movement of rotation, but are instead stepped forward at right angles to the axial direction by means of a rack and pinion arrangement and enter into the wire multiple. The ratchets of both the *X* and *Y* magnets are operated by direct drive.

The pawl *1* of the *X* magnet does not directly actuate the toothed sleeve *2*, this movement being transferred over a ratchet wheel *3*, which is fixed to a stepping wheel *4*, the cogs of which engage circular grooves on the toothed sleeve. For each step that the stepping wheel rotates, the toothed sleeve is advanced to the right a distance equal to the spacing of the grooves, or 5 mm, in which motion it slides on the shaft *5*. A spiral spring around the spindle of the stepping wheel attempts to turn the wheel back to its home position, but is prevented therefrom by means of the catch *6*. During its step by step movement to the right the toothed sleeve pushes forward an auxiliary carriage *7*, which glides on the base plate of the selector. The auxiliary carriage carries a wiper carriage, on one end of which the wipers *9* are mounted. Thus, these wipers follow the stepping movement of the toothed sleeve and are moved along the multiple *10*, *i. e.*, they perform the *X* movement. The wipers *a*, *b* and *c*, *d* respectively are grouped in pairs at each side of the carriage *8*. These wiper sets form easily removable units. Each wiper consists of a double spring of german silver, completely insulated except at the points of contact by means of moulded insulation material, these points of contact — when the wiper set is in home position — resting against pillars of ivory *11*, mounted on the auxiliary carriage *7*. The wipers obtain current through a flexible cable surrounded by a protecting spiral of metal.

The movement of the pawl *12* on the *Y* magnet is transferred directly to the axial teeth of the toothed sleeve; for each step of the pawl, the toothed sleeve is consequently rotated one step. The tubular shaft 5 follows this movement of rotation, within the shaft is placed a spiral spring which attempts to turn the

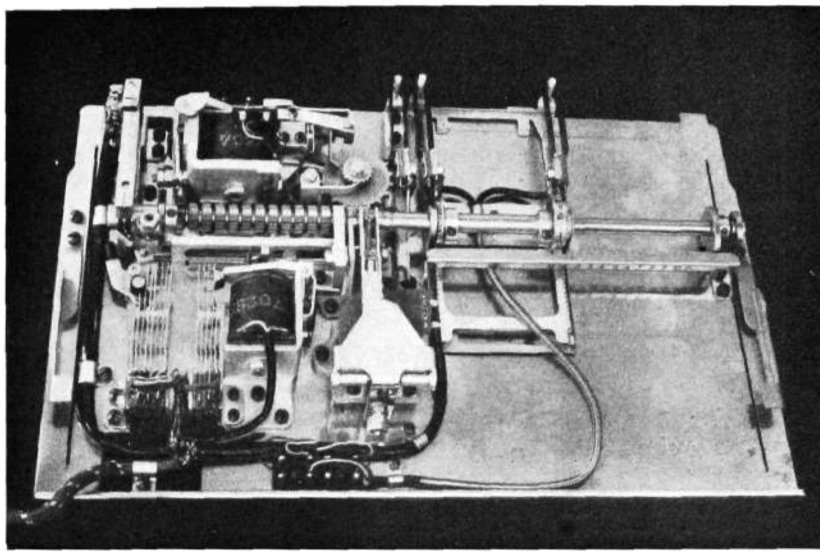


Fig. 2 X 5450
XY selector
at upper left, the X magnet, below which is the toothed sleeve; lower left to right, operating contacts, Z magnet and Y magnet; upper right, carriage with wiper sets

toothed sleeve back its home position, but is prevented therefrom by means of the catch *13*. Over the wiper carriage *8* the toothed sleeve is provided with two cog wheels *14* which engage two corresponding racks *15* on the carriage. When the toothed sleeve and consequently also the cog wheels rotate, the carriage is moved at right angles to the axial direction and the wipers are forced into the wire multiple, *i. e.*, they perform the *Y* movement. The gearing is selected so that the wipers shall move forward 3 mm for each rotation step, 3 mm being the distance between the wires in a multiple section. When the *ab* wipers move forward on either side of the wires in an *ab* section, the *cd* wipers move forward on either side of the wires in a corresponding *cd* section. The contact pressure for each wiper is at least 30 g per double spring, *i. e.*, at least 15 g per contact.

The selector is provided with a number of spring groups, which perform the necessary switching operations and are operated by the toothed sleeve in its home and end positions for the *X* movement as well as for the *Y* movement. The homing action of the wiper is performed by the *Z magnet*, whose armature releases the two catches *13* and *6*; the spring in shaft *5* then turns the toothed sleeve back to the home position of the *Y* movement, after which the spring around the spindle of the stepping wheel turns this wheel back, thereby moving the toothed sleeve back to the home position of the *X* movement.

The numerical movement of the wipers is obtained by means of impulses to the stepping magnets, the free movement in the line finders and group selectors being obtained over self-breaking contacts of special construction arranged on the stepping magnets. The operating speed amounts to 40 steps/s in the *X* movement and more than 50 steps/s in the *Y* movement.

The toothed sleeve is provided with a number drum *16* for indicating the position to which the wipers are set, this number drum moving — during the *X* movement — along a scale *17* attached to the baseplate. During the *Y* movement the number drum is rotated so that a certain number is in position just above the indicated scale number. Thus the position of the wipers is directly indicated by means of these two numbers.

In certain selectors, such as the line finders for instance, a testing must take place during the *X* movement in order to find out in which tenth group, *i. e.*, in which multiple section a call is located. Such selectors are therefore provided with a special *X* wiper-set *18* attached to a rack *19* which is engaged by a pinion on the spindle of the stepping wheel *4*. When the stepping wheel rotates during the *X* movement, the *X* wiper set is stepped forward into a special contact wire section, the so called *X* section, one step for each step which the wipers *a*, *b*, *c* and *d* move along in front of the multiple sections. When the *X* wiper set reaches a call-denoted wire in the *X* section, the current to the *X* magnet is broken and the wipers stop in front of the multiple section in which the call is located.

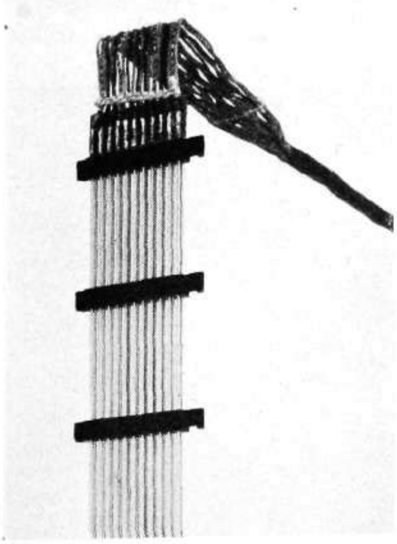


Fig. 3 X 3812
Multiple section

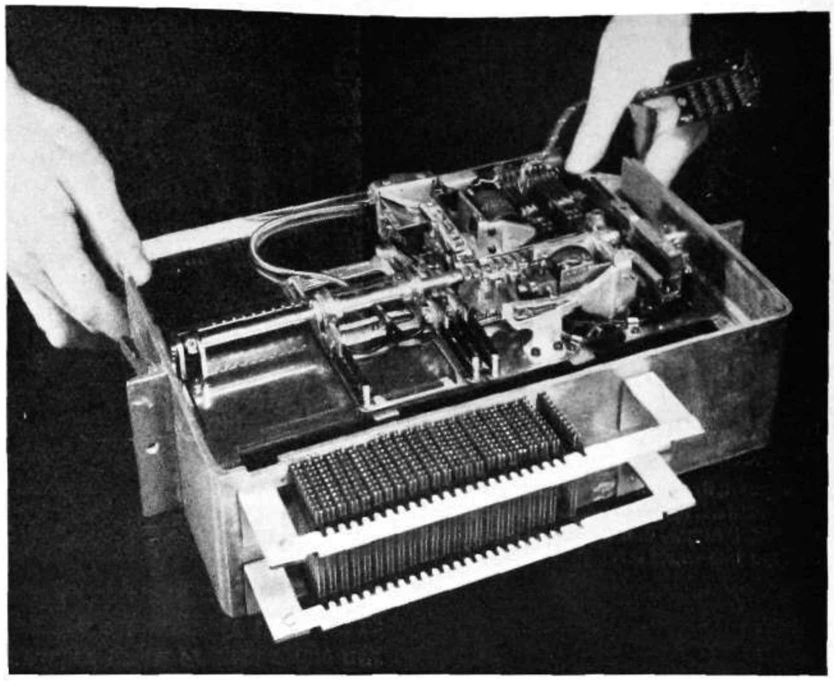


Fig. 4 X 5451

Placing of selector in cell

when selector is fully inserted, lugs on back edge of base plate butt against brackets on back side of cell and determine position of selector in relation to multiple; the selector is locked in this position when the depressed locking springs are released

Multiple

The multiple is built up of bare-wire sections of 1 mm bronze wire, Fig. 3. In each section there are two conductors for each line, the *a*, *b*, and *c*, *d* wires respectively. It is consequently composed of two layers with eleven wires in each, for instance eleven *a* wires in one layer and eleven *b* wires in the other. The wires are supported and held by means of *insulating strips of bakelite*, moulded directly on the wires with a spacing equalling that of the selectors. The eleventh pair of wires in each section is not used for a line connection but only for indicating purposes. The lengths of the sections are made to suite various types of switchboards and can vary from two to fifty selector spacings. Certain lines in the same section can be divided by cutting the wires, see Fig. 6. If individual contacts for each selector are desired the section is provided with extra insulation strips between the standard strips and the wires are cut at each point of support.

Ten sections placed beside each other form the *ab* field of the multiple and ten other sections beside the first ones form the *cd* field of the multiple, see Fig. 1. Thus for a four-point selector the entire multiple consists of twenty such sections. In certain automatic switchboards it is desirable that the selectors shall be able to make connections to certain outgoing lines without previous

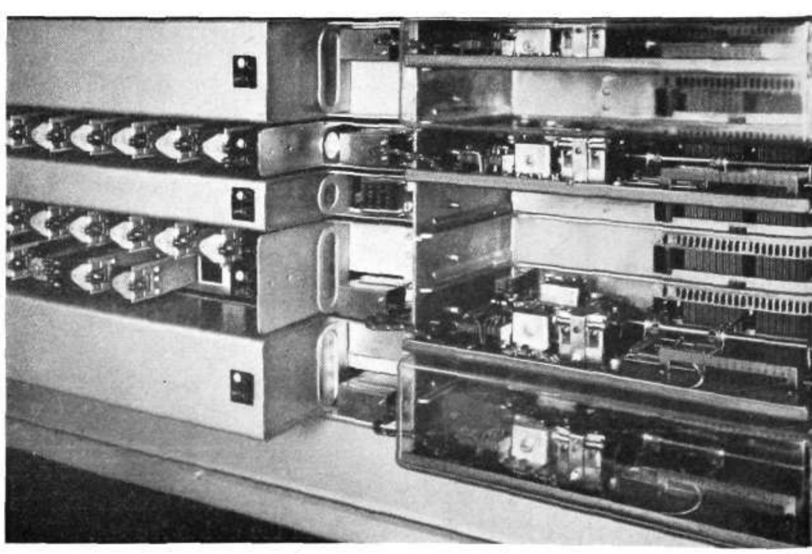


Fig. 5 X 5448

Selectors and relay sets

mounted on rack

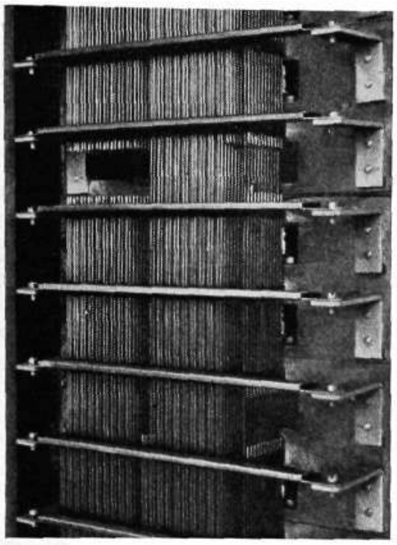


Fig. 6 X 3838
Multiple
mounted on rack

numerical selection of a certain outgoing direction. This can be accomplished with an *XY* selector by completing the multiple with an *ab* and *cd* section at the starting position of the *X* movement, see Fig. 1. The multiple for such selectors will then be composed of twenty-two sections. Selectors with an *X* wiper set must also have the co-operating *X* section, of the same construction as the other sections. Due to the fact that the multiple is made with both of the speaking wires of the same line placed very near each other, very long bare wire multiples can be used without danger of cross-talk between the different lines depassing permitted values.

Mounting of the Selectors in the Rack

The selectors are placed in the rack one above the other with a spacing of not more than 40 mm. In order that this mounting shall be as simple and accurate as possible, special *rack cells* of die-cast aluminium have been constructed, each cell being designed to receive two selectors, one above the other, see Fig. 4. The required number of cells, which are 80 mm high, are mounted one above the other on the rack, thereby forming a continuous selector bay enclosing the selectors from three sides, see Fig. 5. When being pushed into place, the base plate of the selector slides on strips on the inside of the cell. When the selector is fully inserted, a spring on each side of the selctor plate snaps in under pins in the sides of the cell and locks the selector in working position. When the springs are pressed down as shown in Fig. 4, the selector is released and can easily be removed from the cell. The fronts of the cells are closed by means of moulded *transparent covers* which are slid into place and are held in position by means of springs on the outside of the cells. Through the covers it is possible to note the positions to which the selectors are set; the covers also protect the selectors from dust. The cells and the covers make the entire selector bay practically dust-proof.

The base plate of the selector is provided with three lugs along the back edge; see Fig. 4, which fit into corresponding openings in the back of the cell. The middle lug determines the lateral position of the selector, while the two outer lugs rest against the brackets on the back side of the cell, see Fig. 6, thereby determining the position of the selector in relation to the back side of the cell. The multiple sections are mounted directly against this back side, the bakelite strips of the sections being at one end formed like hooks, see

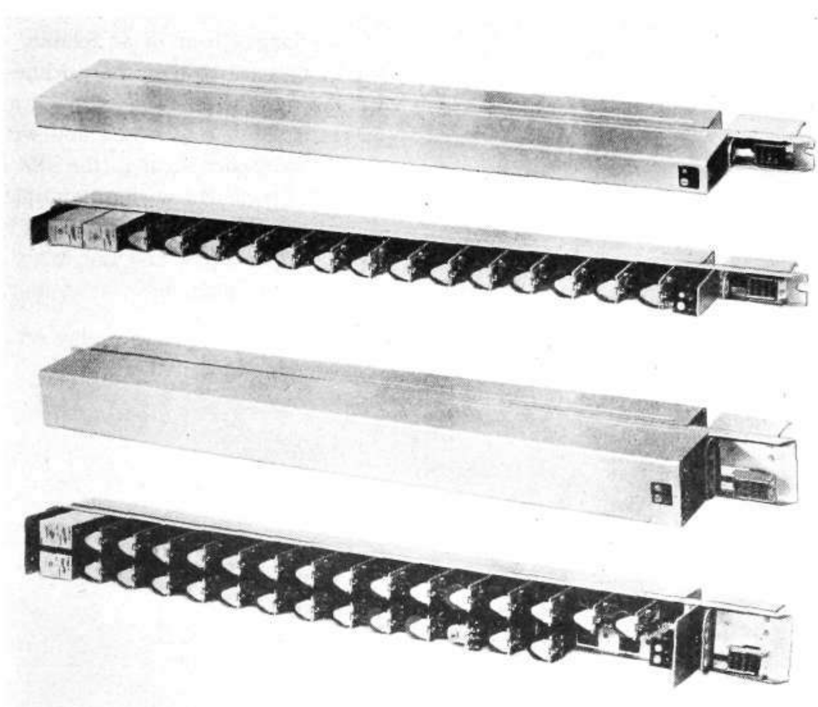


Fig. 7 X 5452
Relay sets
above, single file relay set, with cover and cover removed; below, double file relay set, with cover and cover removed

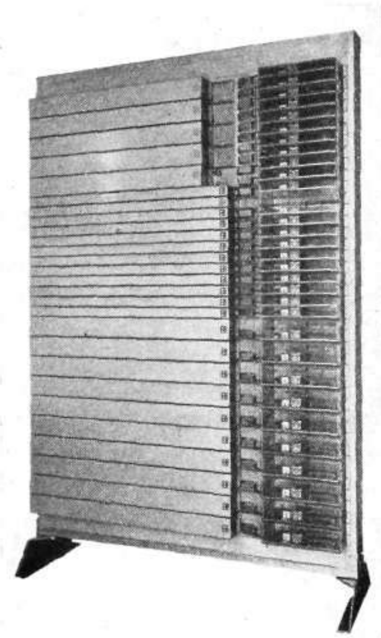


Fig. 8 X 3839
PABX switchboard, XY system

Fig. 3, which fit into slots in the back side of the cells. The sections are held pressed against the cells by means of metal bars with applied rubber strips, the bars being attached to the brackets and the rubber strips pressing against the back end of the bakelite strips. Thus, an exact locating of the selector and multiple in respect to each other is automatically obtained.

The connecting cable is soldered to one end of the multiple section. When the total capacity of the selectors is not required, it is not necessary to mount all of the multiple sections, for new sections can be introduced as the necessity arises; they are furnished with the connecting cable already soldered on.

The selectors are provided with 20-conductor cords and plugs, these latter being plugged into jacks affixed to the rack, or into jacks arranged on the metal strip on which the operating relays for the selectors are mounted.

Relay Sets

The relays required for operating the selectors are arranged in sets, Fig. 7, mounted beside the selectors with the same vertical spacing as these, Fig. 8. The selectors are mounted to the right and the relay sets to the left on the rack. The relay sets contains one or two rows of Ericsson standard relays, condensers etc. At the front right end of each set is mounted a jack for making the necessary connection to the selector plug and on the back side are one or more plugs which, when the set is pushed into place in the rack, fit into jacks permanently mounted on the rack. The relays are wired on the back side of the set where the wiring is protected by a sheet-iron cover which covers the entire wiring, this cover being held in place by means of two screws. On the front side the relays etc. are protected by a removable sheet-iron cover. Thus, the relay set forms a well protected and dust-proof unit. A test strip comprising two test jacks, a cut-out key and a pilot lamp is mounted at the right end of the relay set and is accessible from the outside through a hole in the cover.

Racks

The racks for the *XY* switchboards are of an entirely new construction. They are not built up of standard structural steel shapes, *i. e.*, angle or U-beams, but are made of thin, pressed sheet-iron welded into a very rigid and light construction. The sheet-iron is pressed to the form of a channel with the edges of the flanges bent in as follows [; the height of the web is 120 mm and the flanges are 40 mm, the thickness of the material being 2.5 mm. Such a rack weighs only about half as much as the type hitherto used. This construction makes it possible to mount and wire the racks in a finished state at the works and to transport them to the site of erection in this condition, *i. e.*, provided with all permanent wiring, multiple etc. The selectors and relay sets are packed separately. When the switchboard is mounted on the site it is only necessary to insert the selectors and the relay sets in the rack and connect them upp by means of the plugs and jacks, and to connect up the incoming lines.

The racks as well as the relay sets are given an attractive and protective coat of grey aluminium enamel.

Conduit Construction for Telephone Networks

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

Specially projected and constructed conduit systems in which the cables could be drawn and exchanged at will have for many years been used for the laying of underground telephone cables. The requirements on such a conduit system are firstly, that it be sufficiently spacious and of such practical design as to permit the cable drawing and splicing to be performed in a rational manner; secondly, that the cables — once drawn — be efficiently protected against all exterior damage, as well as chemical and electrolytical corrosion and other undesirable conditions. It is evident that the construction of such a conduit system entails considerable expense generally amounting to some 30 % of the total cost of the network or 20 % of the total cost of the entire telephone plant. Much effort has therefore been devoted to the designing of a conduit system along the most practical lines and many different propositions have been submitted to this end. The system used in networks constructed according to the Ericsson system is described in the following, this description dealing with the manufacture of the ducts as well as with the projecting and construction of a conduit system.

Conduit lines according to the Ericsson system are built up of concrete ducts with cylindrical ways. The ducts are layed one length after the other, thus forming the different conduit routes with a number of throughgoing conduits or ways for the cables. At suitable points in the line jointing chambers are placed to permit the drawing in and splicing of the cables and for making branchings at street intersections or for serving a city block etc.

Manufacture of Ducts

The ducts are manufactured in a special plant or factory, and are formed by tamping a concrete mix into specially designed forms or moulds. Troughing, bends, manhole covers, manhole blocks and bed blocks are also made as

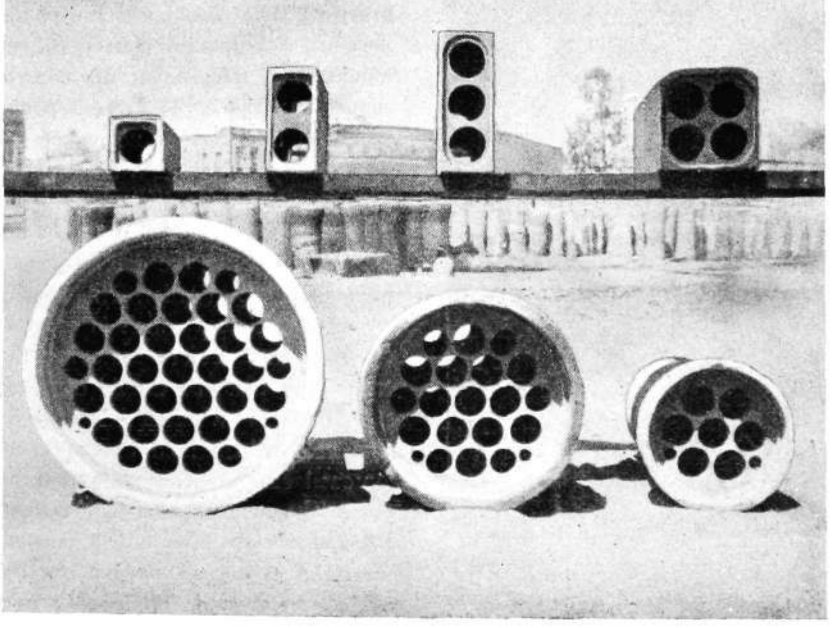


Fig. 1 X 5434
Cable ducts
above, square and rectangular 1, 2, 3 and 4-way; below, round 37, 19 and 7-way

Fig. 2 X 3816
Tamping round ducts

Fig. 3 X 3826
Turning the mould

Fig. 4 X 3818
Withdrawing the cores

required. Ericsson ducts are made in two models, round 37, 19 or 7-way, and square or rectangular 3, 2 or 1-way, see Fig. 1. The round model has the advantage of requiring somewhat less material per way, while the square and rectangular models are better adapted for building the underground network in consecutive stages and tiers. The ducts are self-aligning, *i. e.*, they are provided with spigot and socket ends. In certain cases, *e. g.*, when leading in a cable to subscribers' premises or for connection between underground and overhead lines, 1-way concrete bends are used.

Mixing of Concrete

The mix consists of one part cement, one part fine sand and two parts coarse sand, a richer mix being used for the sockets of the ducts in order to give them greater strength and prevent their crumbling. The cement must be slow-setting and of superior quality. The sand must be free from earth, as the individual grains of sand may otherwise become covered by a thin layer of earth which — due to the comparative dryness of the mix — would be sufficient to prevent a good binding between the sand and the cement. Furthermore, the grains of sand must be of uniform size, and it is therefore often desirable that both the coarse and the fine sand be suitably screened. Sea sand is unsuitable on account of its more or less heavy percentage of salt. Should any ingredient be used to render the concrete waterproof, it should not be added until after testing by a chemical expert in order to ascertain that it will not in any way corrode the lead cable sheath.

The mixing of the concrete must be done with great care, preferably by machine. Water should be added in such quantities as to make a fairly dry mix so that a lump of the concrete, when pressed together in the hand, just barely holds together without falling apart and without visibly giving off any water. Should the mix contain too much water, it often happens that the moulded duct sticks to the mould and to the duct cores, making these latter difficult to withdraw without damaging the duct. The mix used for manhole and bed blocks, however, can be much wetter than the mix for the ducts. When the concrete is ready mixed it is transported in suitable quantities to the different tamping gangs. In hot climates or during the warmer months of the year, these quantities should not be taken too large, so as not to risk the mix becoming too dry before it is tamped. Also, it is advisable to cover the mix with sacks or the like, which are kept well saturated with water, in order to prevent the mix from drying.

Moulding

When moulding ducts of the round model special Ericsson moulds NK 400 are used. The mould is screwed together and placed with the spigot end uppermost, a temporary platform about 0.5 m in height being built up around the mould. The tamping of the concrete is done with tamping irons of various shapes, see Fig. 2. The mix is poured in through the holes in the spigot end of the form in layers of not more than 5 cm thickness, each such layer being successively tamped to a uniform firmness until the mould is completely filled. This work is quite difficult and requires a great amount of skill in order to give good results. When the tamping is finished, a space of ground large enough to receive the duct, and where the duct is to stand during the curing process, is put in order. This space shall be covered with a layer of sand 3 to 4 cm in thickness which is carefully smoothed off before the duct is placed on the same. Before removing the duct cores and the mould sections, the entire unit must be turned over. For this purpose the mould with the duct should stand at a suitable distance from the prepared area, say from 1 to 1.5 m. The bolts which hold the end plate over the spigot end of the mould are loosened and the end plate removed, thereby freeing the spigot end of the duct. The mould and duct are then tipped over a suitable wooden horse, see Fig. 3, so that the unit will stand upright on the prepared surface. Great care must be taken so as not to break the newly tamped duct by jolting it against the ground. The cores are loosened by twisting and are carefully with-

Fig. 5 X 3819
Removing the mould

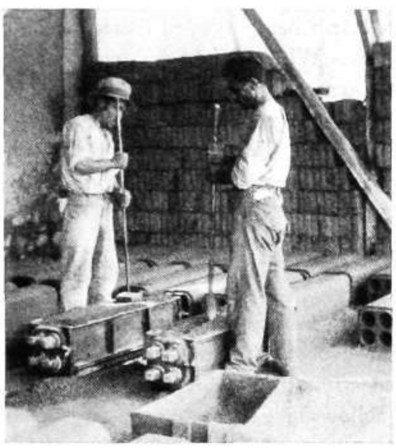


Fig. 6 X 3827
Tamping square ducts

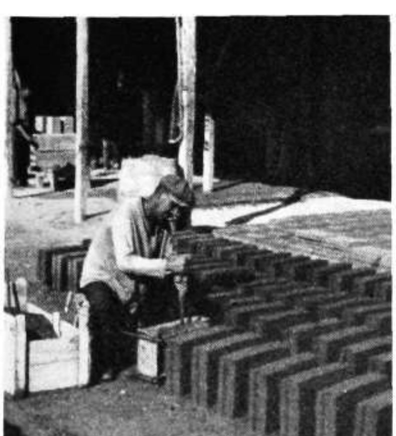


Fig. 7 X 3820
Manufacture of manhole blocks

drawn by means of specially made keys, see Fig. 4, after which the crown is removed and the sections of the mould carefully drawn away from the duct, see Fig. 5. The duct must then stand untouched until it has begun to set.

Square and rectangular ducts are also tamped in special Ericsson moulds in practically the same manner as above described, see Fig. 6. When these moulds are turned over, however, special care must be exercised, as these ducts are tamped from the side with the mould lying down, one side of the duct being free and without support when the turning takes place.

Throughings, bends, manhole blocks and bed blocks are also moulded in special forms, see Fig. 7. The manhole covers are tamped directly in the cast-iron frame on a hard and smooth surface. The slabs of the manhole covers are provided with suitable reinforcement.

Sprinkling

When the tamping has been finished and the form removed, the duct should not be touched during the first 24 hours. In hot climates and during the warmer months of the year, the duct should be sprinkled after 8 to 10 h, so as to retain its original humidity. Great care should be taken during the sprinkling operation, as during the first days the ducts are very easily damaged and will not even stand the force of a strong jet of water. The water must consequently be applied in the form of a fine spray, se Fig. 8. After a couple of days the concrete has set sufficiently to permit the ducts to be moved together in closer rows — so as to obtain more space — and after about four days they can be removed to an open storage yard. Here they must remain for at least forty days, during which time they are constantly kept moist by means of suitable sprinkling. Thus, in very hot weather, it may be found necessary to sprinkle the ducts three to four times a day. During the first weeks the ducts are suitably covered with straw mats which are spread out and thoroughly saturated with water. It will also be found necessary to remove the straw mats from time to time and sprinkle the uncovered ducts. Constant and careful inspection must be made during all of this time to ascertain that the ducts do not show the least sign of drying out. Sprinkling is most suitably performed by means of a hose attached to the water main or with the aid of a motor pump.

Manhole blocks and bed blocks are sprinkled with the same care as the ducts in order to give them the required strength, but they may be taken for use after somewhat shorter time than the ducts. The curing time, during which they are sprinkled, should be at least four weeks, however.

Asphalting

The suitability of asphalting the duct ways is a question which has given rise to much discussion. It has been contended that asphalting would make the ducts more waterproof and the surfaces of the ways smoother, as well as prevent the entrance of vagrant currents to the cable. A vital condition for obtaining these results, however, is that the asphalting is done according to a proper method and with the greatest care, as otherwise the quality of the ducts would be impaired rather than improved. For instance, if a wrong composition of asphalt is used, the coating may become sticky; if the coating is not evenly applied, cracks may arise, thereby increasing the deleterious effects of vagrant currents, since these currents and, consequently, electrolysis will be concentrated to these cracks. As a result, asphalting has in many cases been entirely dispensed with. Should this method be deemed desirable, however, the work should be carried out with very great care and in the following manner. Before applying the asphalt, the ducts should be placed to dry out in the sun for at least a fortnight. In bad weather, artificial drying by means of braziers may have to be resorted to. Irregularities on the edges of the duct openings are filed away, the ways being tested with the aid of special mandrels, which should have a diameter 2 mm less than that of the ways. The ways are then brushed out so as to be perfectly clean.

Fig. 8
Sprinkling of ducts

X 5433

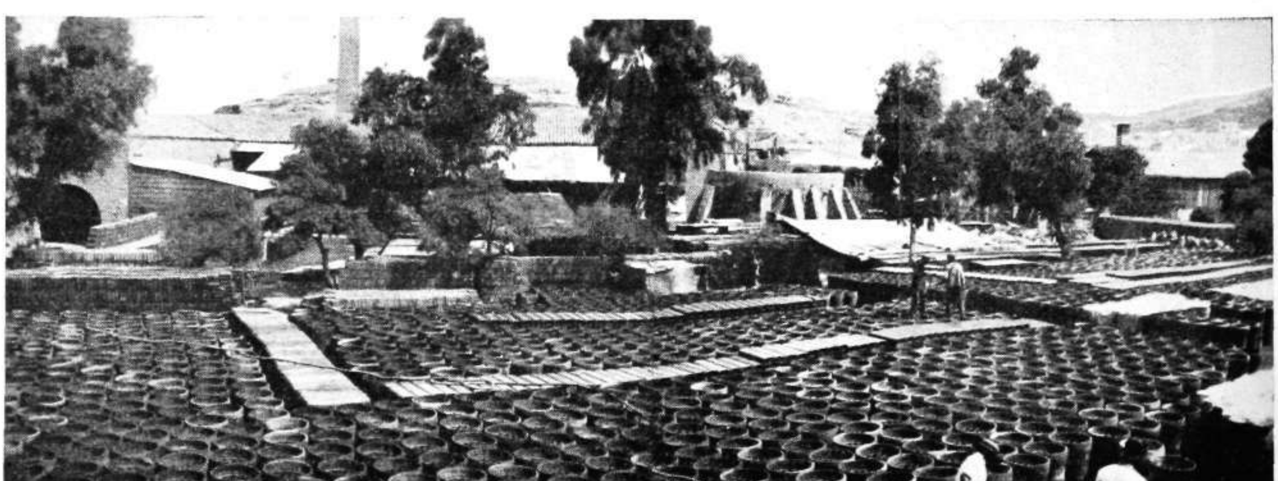
Over the asphalt kettle with its oven is built a platform, the platform being provided with a hole somewhat smaller than the spigot end of the duct and situated right over the kettle. The duct is then stood on end over the hole in the platform with the spigot end downmost. The special asphalt compound to be used is heated in the kettle to a suitable fluid consistency. The asphalt is applied by means of a brush NK 425, this brush being slipped down through one of the ways into the asphalt kettle below. When the brush has become saturated, it is lifted up and worked up and down at least three times along the entire length of the way, the brush being dipped down into the asphalt at each downward movement. This process is repeated three times more, but then with a rotating movement of the brush. The duct is then removed to the final place of storage, see Fig. 9.

Checking and Testing

No matter whether the ducts are a factory product or are manufactured on the site, they must be submitted to a most careful inspection. Sample tests are made to ascertain that the ducts have the required strength, do not corrode the lead sheathing of the cables etc. In short, the following general directions should be adhered to. A slow-binding cement of superior quality should be used for the concrete mix. The ducts should always be stored long enough to allow a perfect curing of the concrete before they are issued for use in conduits lines. This curing takes place from the surface inwards and takes a time of approximately one month; ducts which have been stored for a shorter time or have been carelessly sprinkled may under no circumstance be used for conduit work. The ducts must be free from cracks and damaged edges, and should fit perfectly. The outside diameter may not vary more than 2 mm and the surfaces should be perfectly smooth and even.

Fig. 9
Storage yard for ducts

X 7146



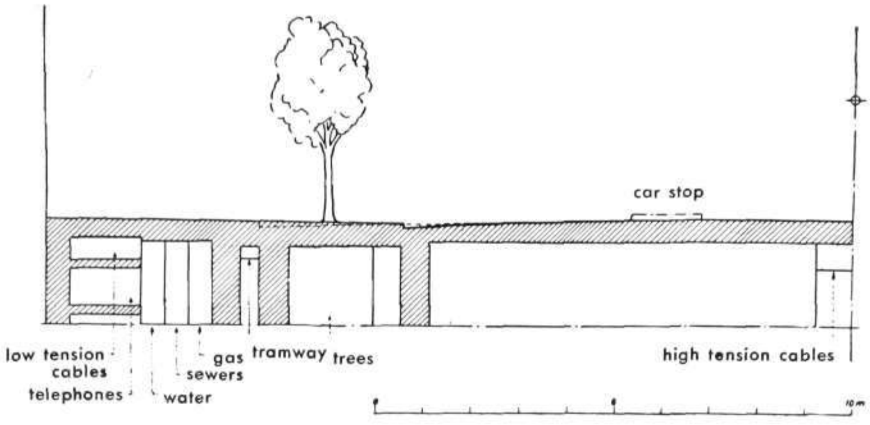


Fig. 10 X 5435
Standardized section for large street

Projecting Conduit Lines

When projecting conduit lines for a telephone network, the first point to be decided is to what points in the network the conduit system shall be extended. Comparative calculations covering — on the one hand — the cost of an underground cable network laid in a conduit system and — on the other hand — the cost of an aerial cable network and an underground armoured cable network respectively, are taken as basis for this decision. Generally, it will be found to advantage to provide a conduit system for the entire main cable network, the method of erecting the secondary cable network being decided on in each separate case.

In the more densely populated districts of larger cities, it may sometimes be to advantage to construct separate conduit routes for main and secondary cables. After having determined the scope of the conduit system, the next point is to determine the location of the different conduit routes and the number of ways in the different routes.

Routing

The conduit routes must be selected with a view towards obtaining the shortest line at the least possible expense. When choosing the most suitable streets the character of the soil must be considered, the firmer soil being preferable, although — due to the greatly increased cost — one should try to avoid streets where much blasting of rock would be necessary. Naturally, very swampy and waterlogged areas should also be avoided when possible. Another important consideration in the choice of streets is the danger from vagrant currents. In this respect, it is of importance to avoid routes running parallel with electric tramway lines and other direct current circuits, or in such manner that the cables will serve as return conductors for the vagrant currents. Further, it is necessary to figure with different types of street pavement for which the cost of reinstatement — after the laying of the conduits — may be greater or smaller. Finally, due consideration must be given the street traffic as well as sewers, gas, water, electric light and other mains which may obstruct the laying of the conduit lines. In some towns *standardized sections* for streets, se Fig. 10, have been adopted by the authorities, in which case it is important that the space reserved for this purpose be used for telephone cable lines. In the majority of localities, however, such sections will not be found; nevertheless, attempts should always be made to use the same portion of the street section in streets of the same type.

The conduit routes should preferably be laid under the footways, the traffic here being much lighter at the same time as the laying of the conduits and the drawing in and splicing of cables can be carried on without serious interruption. Moreover, the lighter traffic load permits the laying of the ducts at lesser depth than under the carriageway, while manholes and manhole covers may be of a lighter construction. The footway depth of the conduit lines need not be more than 30 to 40 cm, while the carriageway depth should be from 60 to 70 cm, measured from the surface of the ground to the top of the duct. Where the earth is of a very loose character, it may be found necessary to lay the ducts still deeper.

The manholes should be located at street intersections in order to facilitate the branching of cables to the side streets, the manhole covers being preferably located in the footways, thereby facilitating the entering of the manholes and reducing the wear on the covers, as well as giving the manholes better protection against the penetration of rain water. Along conduit lines for main cables, the distance between two manholes will depend on the length of the city blocks, usually about 100 m. This distance should never exceed 130 m, however, as difficulties will then be encountered for the drawing in of the cables. With longer city blocks, it will therefore be necessary to place a manhole or jointing chamber in the middle of the block. Already during the first stage of the work, it is important to provide for the placing of manholes at all points where, in the near future, branchings may be required, thus avoiding the construction of new manholes along an already built conduit route, which is often very troublesome for the drawing of the cables. For instance, it is objectionable to draw a conduit line across an intersecting street without placing a manhole at this point, even if this manhole should not be required during the first stage of construction. Furthermore, manholes should not be placed squarely in front of portals or building entrances, thereby unduly obstructing traffic while work with the cables is going on.

Joint boxes, for serving the various buildings or for the leading up of cables to distribution poles, are used only in such cases when the point in question is too distant from the nearest manhole for a direct branching off in the manhole. The joint box should be placed as near as possible to the point of entrance and, in case of a smaller conduit line, is built directly against this latter, but in case of larger conduit lines the joint box is joined to the nearest manhole by means of separate one or two-way ducts. The joining of a joint box directly to an adjoining larger conduit line is very uneconomical and should be avoided, as the through-ways, which are intended for larger cables extending over longer distances, will become obstructed by the smaller service cables. In other respects, what has been said of manholes is valid for joint boxes also.

Capacity

When determining cable and conduit sizes it is necessary first to establish the final capacity of every route as to the number of pairs of conductors. The capacity of the route, figured in pairs of conductors, and a cost estimate form the basis for calculating the most economical cable dimension. Such a cost estimate will show, for instance, that a 600-pair cable is generally the most economical for the principal route in the main cable network, this being also confirmed in general practice. With a knowledge of the final capacity of the route in pairs and the most economical cable dimension, one may then determine the number of ways required for the final stage of construction, one individual way being always allowed for each cable. It is only when dealing with smaller, secondary cable routes that exceptions to this rule can be made, and a number of small cables be placed in the same way. After this, there only remains to determine the stages in which the route is constructed most economically, this being based on the subscribers' curve. It will then be found that the manholes should be built at once to their full capacity, the conduit lines, on the other hand, being generally built in stages.

Conduit Laying

The staking out of a conduit route, with its manholes and branchings, is based on lay-outs and sketches made during the projecting of the entire network. This can only be done after careful study, however, so that poles for electric light and trolley wires, sewers, water, gas and electric mains will not obstruct the work. Information as to the location of such obstructions is obtainable from the authorities or companies in charge of such service mains. Wherever the conduit line is expected to cross such obstructing mains, test holes are first made to ascertain the position and dimensions of the crossing main. Only thereafter is it possible to determine the exact position for the conduit line. It may be accepted as a general rule that the conduit route be placed or selected in such manner as to necessitate the fewest possible changes in the obstructing mains. In this connection it may be well to mention one other rather common obstruction, viz., the roots of adjacent trees, and it is consequently desirable to avoid narrow streets planted with rows of trees. When encountering such obstructions, an injudicious cutting away of the roots may result in the destruction of the trees and costly reparation expenses for the responsible party. In addition to the above, the street department of the town should be consulted as to any contemplated changes in the widths or levels of the streets, in which case the conduit lines should be placed so as to fit into the new street section. Much expensive alteration and reconstruction work is thereby avoided.

Trenching for Conduits

Standard sections for conduit trenches have been established for the different types of ducts and for trenching in footways or carriageways, and with due consideration for the prescribed depth, figured from the surface of the ground to the top of the duct. If the earth is composed of gravel or sand, no extra bed is required in the bottom of the trench. If the earth is loose, the trench must be dug to a sufficient depth to permit the laying of a 10 cm thick layer of gravel under the ducts, and it may even be required to lay a special bed of concrete. When the trench is blasted through rock, only sufficient gravel is laid on the bottom to make it level. Further, the bottom of the trench should be given an even rise from the manholes of from 0.1 to 0.2 per cent to provide for the draining off of any water which may accumulate in the ducts. Special levelling rods, placed at suitable intervals along the trench, are used for this purpose. When stone pavement must be removed for trenching work, it is often necessary to arrange some kind of timbering to keep the edge of the pavement in position and prevent it from sliding down into the trench. This is accomplished by means of walings placed against the pavement on both sides of the trench, and held in position by means of wood struts. A similar procedure must often be resorted to for supporting mains running parallel with the trench, such as water mains, sewers, etc. Also, when working in loose gravel or sand, it may be found necessary to drive poling boards behind the walings in order to keep the earth in position.

Fig. 11 X 3821
Laying of ducts

The actual laying of the ducts should be planned so as to be of the least possible hindrance to traffic. To this end, the broken up pavement as well as the excavated earth should be placed alongside the trench in such manner, that it will take up the least possible room. Also, longer stretches of trenching should not be opened up at the time but that the laying of the ducts is able to keep step with the work of excavation. When a suitably long stretch has been excavated, the bottom of the trench is levelled off and covered with a suitably thick layer of gravel, which is then tamped with a special tamping iron. As the laying of the ducts proceeds, the excavated earth is filled back into the trench. The earth that is placed nearest the ducts should be finer and free from lumps, and it may sometimes be advisable to screen it. The refilled earth should be watered and tamped in order to avoid subsequent settling. If timbering has been resorted to, this is then removed, after which the earth is well tamped along the edges of the trench, so that the spaces left by the timbers and poling boards will be well filled. In streets with a cut stone pavement, the trench should be filled to within 20 cm of the surface in the footway, and to within 30 cm of the surface in the carriageway, thus leaving room for a sufficiently thick layer of gravel under the stone pavement. Where the pavement is of asphalt, a concrete slab should be poured over the trench, even if there should not have been any such slab previously; this slab should be 5 cm thick in the footway and 20 cm thick in the carriageway. The reinstatement of the pavement is usually done on contract.

Fig. 12 X 3822
Jointing of ducts with asphalt

Laying

While laying the ducts, the trench must be kept free from water. The ducts should be laid in an absolutely straight line between two manholes. If local obstructions should make this impossible, smaller deviations may be permitted, although the setting at the joints should not exceed 2 cm per length of duct. In such a case, the ducts are laid on an even curve with as large a radius as possible. Should the necessary deviation be too great, an extra manhole must be constructed, thereby permitting an angle in the conduit line. A double or S curve between two manholes is under no circumstances to be permitted. As already mentioned, the ducts are laid with a gradual rise from the manhole, so as to permit the draining off of any water in the ducts.

The bottom of the trench should be levelled off and smoothed. If bed blocks are used so support the ducts, these should be placed in their respective positions and levelled off by means of a levelling line. Another line is then stretched along the side of the trench at a height with the centre of the ducts, for the lateral alignement of the ducts. After having been well cleaned out with a duct brush, the ducts are lowered into the trench one after the other and placed on the bed blocks, after which a most careful alignement must take place, see Fig. 11. The ducts shall not only be well levelled and aligned, but it is also of the greatest importance that the ways in the different ducts come exactly opposite each other. This is accomplished by means of special mandrels which are introduced into two diametrically opposed ways in the two lengths to be fitted together.

The jointing of round ducts is done in the following manner. After the duct has been perfectly aligned — with a little cement between the duct and the bed blocks, if necessary — it may be found advisable to fill in a little earth around the middle of the length of duct and tamp it into place, so as to give the duct necessary stability and prevent any displacement during the jointing. The interstice at the bottom of the joint — formed between the two ends of the adjoining ducts — is calked with oakum soaked in tar, to prevent the asphalt mixture subsequently used to fill the joint from entering into the duct. A special angle ring is then fitted around the joint, after which the asphalt mixture is poured into the joint, see Fig. 12. This hot asphalt mixture completely fills the joint, forming a very tight packing. The asphalt mixture is then left to cool and stiffen during about 20 min., after which the angle ring is removed and the joint is finished. Joints prepared in this fashion have a

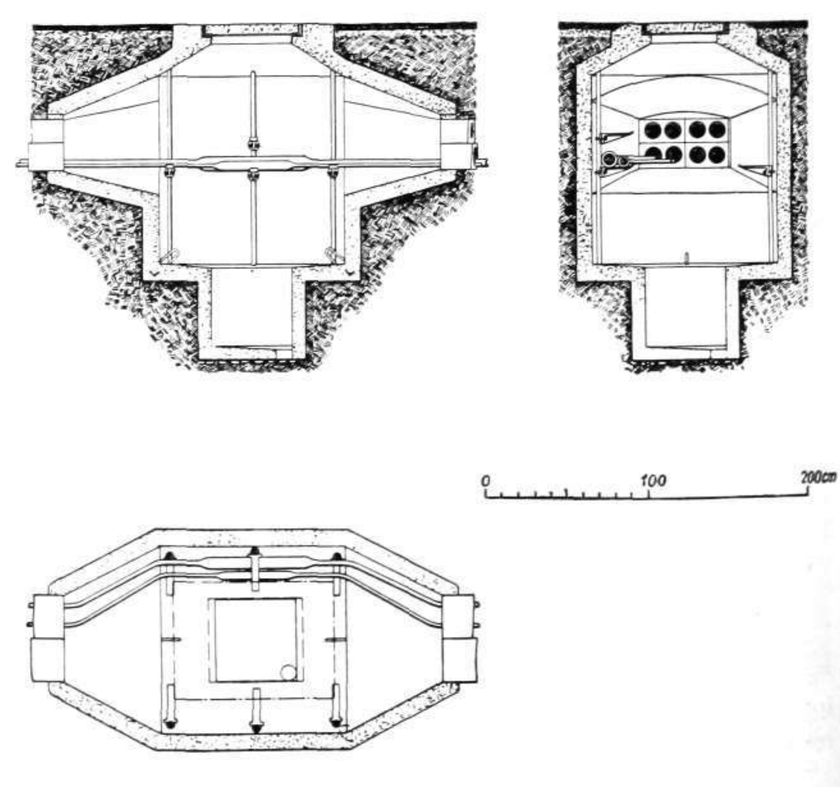


Fig. 13
Straight two-way manhole
poured on the site

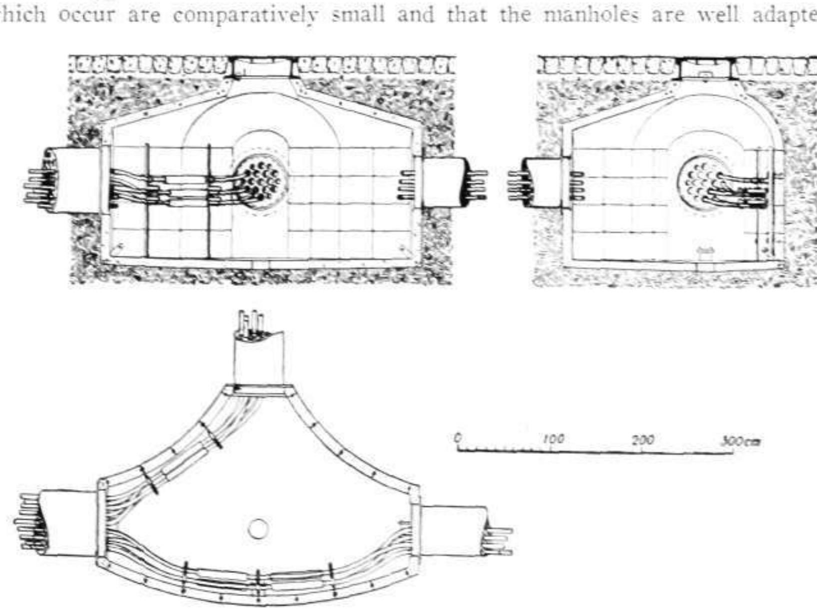
I 5440

certain degree of elasticity, this being of special importance in countries where earth-quakes are prevalent.

For the jointing of square and rectangular ducts, a mix of one part cement and two parts fine sand is poured around the joint, thus cementing the ducts to the bed blocks as well. The alignement of the ducts is accomplished in the same manner as above described. When filling the joint, care should be taken that no lumps of cement remain over the joints, thereby causing trouble for the laying of subsequent tiers of ducts. Should it be found necessary, for some reason or other, to break off the work of laying the ducts, the open end of the duct should be covered so as to prevent earth or gravel from entering the ways. The number of ducts laid at one time should not be greater than that the trench can be filled in during the same day; otherwise one may risk that the ducts be displaced by tampering. When the duct line between two manholes is finished, it is carefully inspected to ascertain that all the ways are clear and true. This is done with the aid of a specially constructed mandrel, to both ends of which lines are attached.

Manholes

The size of a manhole depends first of all on the number of ways in the conduit lines which meet at this point, the shape of the manhole, on the other hand, depending upon the relative positions of the conduit lines and the ensuing placing of the cables. With due consideration for these various conditions, certain standard types of manholes have been designed, to be used wherever local conditions so permit. As to size, there are three standard types, the largest of which will accomodate from 39 to 19 ways, the middle size from 7 to 4 ways, and the smallest size from 3 to 2 ways. The middle size is generally used for cabinet manholes. The large and middle sized manholes are dimensioned so as to permit at least two men to work simultaneously in them with the drawing or splicing of cables. On a small conduit route, however, it may be found necessary to use a size of manhole intended for a larger route, for instance if the conduits must be laid deeper than usual. As already mentioned, the manholes should at the very outset be dimensioned for their final capacity, thereby avoiding costly and troublesome replacing of cables. As regards the shape of the manhole, there are, generally speaking, two different series of standard types, *viz.*, square manholes, see Fig. 13 — as a rule made of reinforced concrete — and vaulted manholes, see Fig. 14 — built up of factory-made concrete blocks or units. Also, the shape may vary depending on from which direction the conduit routes arrive, and one differentiates between straight two-way manholes, three-way manholes and right-angled two-way manholes. Regarding the strength of the manholes, required tests of the standard types have been carried out. It has then been found that the stresses which occur are comparatively small and that the manholes are well adapted



X 5441

Fig. 14
Three-way manhole
built up of manhole blocks

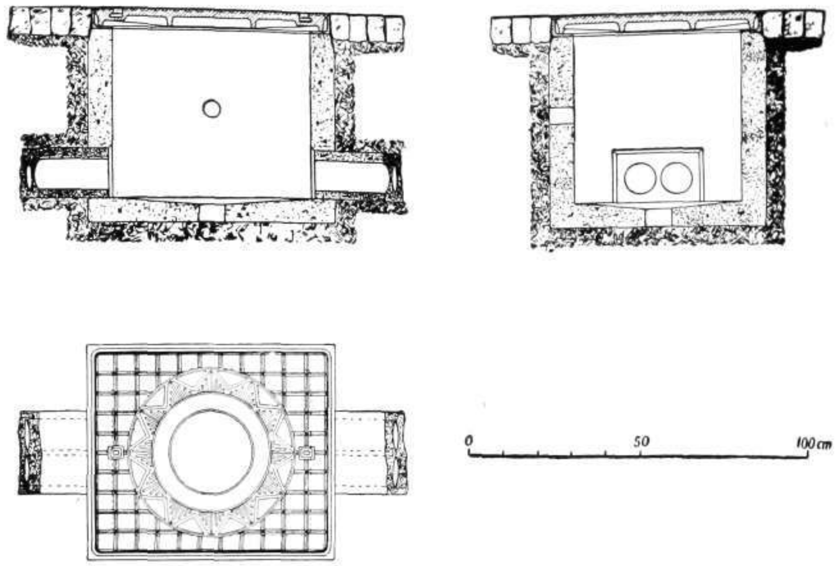


Fig. 15
Joint box

X 5412

to resist the earth and traffic loads which may occur. Should a specially designed manhole be required, however, careful investigations and the necessary calculations must be made.

For a service branching to a building or a connection to a distribution pole on a smaller conduit line, a joint box may suitably be used, see Fig. 15, this box being joined to only one or, at the most, two ways of the conduit route. As previously mentioned, such joint boxes must under no circumstances be joined to a larger conduit line; in such a case, the service ducts must be drawn to the nearest manhole.

Manhole covers and frames are made in round as well as square models, both of these models having different types for carriageways and for footways. The manhole covers for carriageways are made of cast iron, Fig. 16, those for footways being generally made of concrete in a cast iron frame. In order to make the covers tight fitting, some types are provided with a rubber packing between the cover and the frame, and an under cover, which can be furnished with a special locking device.

In the manholes, the cables are supported on special cable brackets. Earlier it was the custom to use cable brackets with a capacity of three to four cables each. When locating faults etc., it was then often necessary, not only to lift down the cable under investigation, but also the other cables on the same bracket. According to the latest practice, however, the cables are as far as possible distributed vertically over the face of the manhole wall, vertical bars with individual cable brackets being provided, thereby permitting the removal of one cable without having to disturb any of the others. On larger conduit lines, or where the manholes are very low, this is not feasible, however, and it is necessary to use the first type of cable brackets, although here also the cables must be distributed as much as possible and provisions made for a large number of brackets with as few cables as possible on each bracket. Also, the cables are no longer laid on the tops of the brackets, but are fastened — each one separately — on the under sides of the brackets. In this manner the cables are well secured in the manholes and the workers are not able to move them about at will or step on them when entering the manhole. Faults due to careless handling etc. should not occur on cables secured in this manner.

Eye bolts for the snatch blocks used when pulling in cables should be provided in the manholes. Loose or fixed ladders are provided for descending into the manholes, the latter type being generally arranged so that it may be hoisted up against the roof of the manhole.

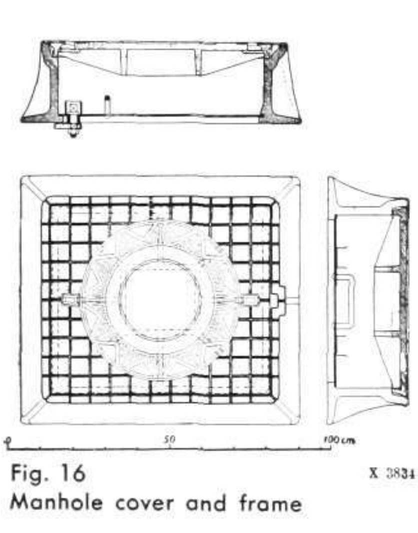


Fig. 16
Manhole cover and frame

X 3834

Excavation Work

After the location of the manholes has been determined in conjunction with the staking out of the conduit route, the outline of the hole to be excavated is marked out on the ground, specially prepared tables giving the size of the excavation for different sizes of manholes. During the work of excavation, a sufficient slope must be given the sides so as to prevent their caving in; if necessary, timbering must be resorted to. The hole is excavated to sufficient depth to allow for a good foundation under the manhole, and also to permit the laying of a 10 cm thick layer of gravel over the roof of the manhole and under the pavement. Struts are placed in position as required, while the work of excavation is being carried on. The bottom of the excavation is covered with a 40 cm thick layer of gravel, well tamped and levelled off. After the completion of the manhole, the space around it is filled with coarse gravel which is well tamped to avoid all subsequent settling of the pavement.

Concrete Work

The character of the work will differ somewhat, depending on whether the manholes are poured in forms built on the site, or built up of factory-made blocks. For manholes poured on the site, a mix consisting of one part cement, two and a half parts sand and four parts aggregate is used. Waterproofing material should not be added to the mix unless it has been tested by an expert to ascertain that it contains no chemicals which may prove injurious to the lead sheaths of the cables. If necessary, a wooden form is now erected on the bottom of the excavation; in many cases the earth will be found sufficiently firm to act as outer form for the concrete walls. The form for the sump-hole is then placed at the intersection of the centre lines of the conduit lines, *i. e.*, squarely under the future manhole cover. This sumphole is intended to serve as a collecting place for any water seeping into the manhole. If the sumphole lies above the subsoil water level the bottom of the sump should be provided with a hole beneath which is placed a bed of gravel, through which the water will drain off. Should the sumphole be lower than the subsoil water level, the bottom of the same should be completely closed. The bottom slab of the manhole is then poured, with necessary eye bolts located exactly opposite the various duct opening. The bottom slab should be left to set for one day after which the inside forms are erected, collapsible steel forms being used as much as possible, see Fig. 17. Should local conditions prevent the building of a standard type of manhole, the inside form is built up of rejected boards. Care should be taken to always place the frame of the manhole cover over the intersection of the center lines of the conduit lines or, in the case of a straight line manhole, in the exact middle of the same. Further, it is important that the edges of the bottom slab, where the side walls are to rest, are kept well watered until the walls are poured. The vaulted roof is provided with a reinforcement of bars, previously assembled for the purpose. If the manhole is not of standard design, a similar reinforcement is assembled on the site. The concrete walls and roof are then poured, after which the concrete is allowed to set for a few days, before any of the form work is removed. All the exposed concrete surfaces must be kept well moistened, this being best accomplished with sacks or straw mats which are kept wet by sprinkling as soon as they show a tendency to dry. If an outside form has been used, it may be removed already after three or four days, while the inside form — on the other hand — should remain in place for a week. The frame for the manhole cover is then placed in position and well levelled, so that the top of the cover will be flush with the pavement; it should also be ascertained that the cover fits well into the frame. The inside of the manhole is then given a finishing coat of fine cement mortar and smoothed off with a trowel, the top of the manhole being given two coats of asphalt on the outside. The vertical supporting rods for the cable brackets are mounted in the manhole, holes being drilled in the walls for the anchors, which are then cemented in place. All iron fixtures in the manhole are then given two coats of red lead and one coat of rust preventing paint. In some cases, for instance, when building manholes in street intersections where the traffic is very heavy, quick-binding cement which binds in from 24 to 48 hours should be used. Such cement is very expensive, however, and should consequently be used only as a last resort in case the street traffic cannot be diverted.

Fig. 17 X 3833
Pouring of manhole in mould of sheet iron

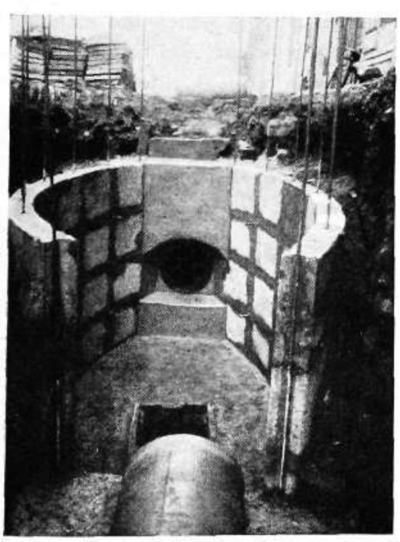


Fig. 18 X 3823
Building up walls of manhole with blocks

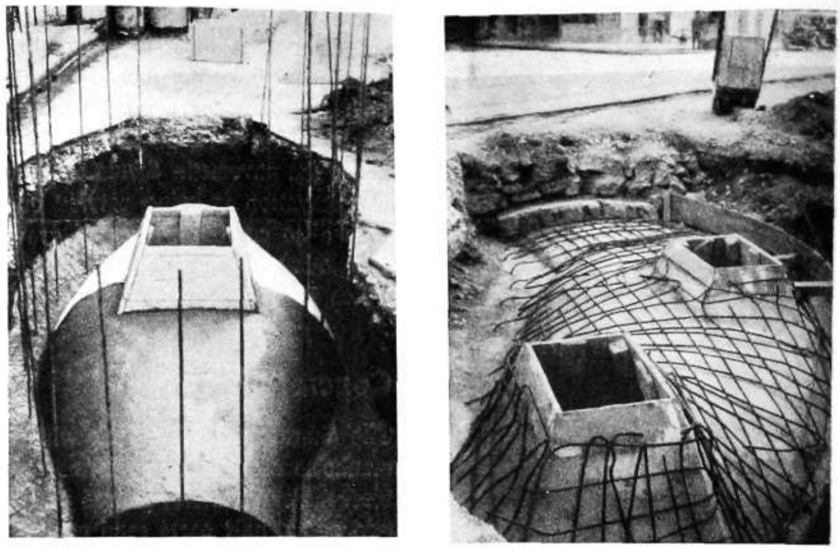


Fig. 19 X 3824 X 3825

Building of manhole roof

left, form moulded to shape; right, reinforced formwork

Manholes built up of previously manufactured concrete blocks are constructed as follows. The blocks, the manufacture of which has already been described, are made of a mix consisting of one part cement and two and a half parts sand. The joints are cemented together by means of a somewhat richer mix. For those parts of the manhole which are poured on the site, such as the vaulted roof, for instance, the same mix is used as for the previously described manholes. The bottom slab is made as in the above description, the only difference being that the lower ends of the vertical reinforcing bars are placed in their correct positions. When the bottom slab has set, the walls are built up of blocks which have first been wetted along their edges, see Fig. 18. The reinforcing bars are fitted into the grooves between the blocks. The anchors for the cable bracket rods are slipped over the reinforcing bars at suitable points, the anchors being thus cemented into the walls. Walls with an outside concave surface must be strengthened on the outside against the earth pressure, this being done by pouring concrete against the outside of the wall. The roof is formed by building up an inside wood form over the manhole, about 5 cm below the top edge of the walls. The formwork for the manhole opening is then placed on top. Above this wooden roof earth is placed and moulded into shape to form the under side of the vaulted roof, Fig. 19, moist clay being best for this purpose. The reinforcing bars in the walls are then bent down over the vaulted form and placed in their correct positions. The concrete roof and the base for the opening are then poured. After the roof has been allowed to set in the usual way — during which the manhole opening must be left open to permit the circulation of air, the better to dry out the inside of the manhole — it is given a finishing coat, after which the cover frames are fitted. The outside of the manhole is then given two coats of asphalt, after which the excavation is filled in as usual. No inside finishing coat is required. The cable brackets are not mounted during the pouring of the manholes, this being done from time to time as required when drawing the cables.

The pouring of the joint boxes is carried out in exactly the same manner as for the manholes. The smallest type of joint box is poured in advance in the factory and placed in position in the conduit line in its finished state.

The Telephone in the Service of the Railways II

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

An account covering conditions responsible for the more and more widespread use of the telephone in railway operation is found in Ericsson Review No. 4, 1937. Also, a description is given of the simplest type of telephone system designed for the use of the railways, i. e., the magneto system, intended for service over shorter sections of a railway line.

Should it be found desirable, however, to extend the telephone communications over longer distances and arrange for automatic intercommunication between the telephone instruments installed along the line and to introduce automatic operation of the exchanges, a selective calling telephone system with decentralized switching and possibilities for intertraffic with automatic telephone exchanges should be adopted. Such a system, already extensively used by the railway administrations of several countries, has been designed by Ericsson.

The purpose of the district telephone system is to provide for telephone communication within a railway district, *i.e.*, an administrative area comprising a limited portion of the railway net of a country. The extent of such a district is very variable, depending on the organization of the railway service and the density of population in the areas in question; thus, in smaller countries, the entire country may form one single administrative area, or district. In spite of the varying sizes of the districts, the telephone calls exchanged within the same district are largely of a similar character, for which reason similar telephone systems may be used in districts of varying form and extent. In order to make this possible the telephone systems in question should adapt themselves to the existing railway net with all its branch lines and must be able to operate over longer as well as shorter lines. These requirements are fully met in the Ericsson selective calling telephone system with decentralized switching, where all the connections are controlled by means of a standard dial.

In order to establish speaking connections within the own section of a selective calling line, it is sufficient to dial the number of the desired telephone instrument, after which a ringing signal is automatically sent out. If the call is to be extended to another section of the selective calling line, or to an automatic station exchange, the direction digit must first be dialled and then the number of the desired telephone instrument. Should automatic intercommunication be provided for between the different station exchanges in the district, automatic connections can be successively built up between all of the telephone instruments in the district. Automatic net groups are then obtained, the upbuilding of which will be described later.

The Ericsson Selective Calling Telephone System

A selective calling telephone installation is understood to mean an installation where several telephone instruments are connected up to the same telephone line and where the different instruments can be called individually, *i.e.*, without ringing the bell of a telephone instrument not concerned. Such telephone systems have been designed according to various principles, differing mainly in respect to the method for sending impulses to the selectors, as the impulses may consist of direct current, alternating current or inductive current pulsations, and consequently in certain systems there must be a source of impulse current in each telephone instrument, while in other systems this source is centralized to one single location on the selective calling line. Impulsing can take place either over both conductors of the speaking circuit, or over the speaking wires and earth or a third conductor.

When designing the Ericsson selective calling system entirely new principles have in many respects been applied, which has made it possible to develop a system which in every respect meets the demands placed on a modern selective calling telephone plant for railways. The most important characteristic of the Ericsson selective calling system is the method of impulsing, based on the properties of a metal rectifier to permit the passage of current in one direction only. In the practical application of this principle the dial impulses are permitted to influence a combination of relays — the line relay equipment — common for the entire selective calling line and from which impulses of an opposite polarity are sent out over the line and are received by the selectors connected to this line. Two impulses with opposed direction of current are consequently simultaneously travelling over the line, these impulses being separated by means of metal rectifiers so that the one impulse influences an impulse receiving relay in the line equipment and the other influences the selectors connected to the line.

A number of advantages are obtained by this method of impulsing. Thus, all impulsing takes place with direct current over the two speaking wires in a loop, without earth return. The selective calling line is consequently fully balanced and cannot disturb other parallel lines on the same pole line. To be able to dispense with an earth circuit is of great advantage when the selector line runs in the neighbourhood of and parallel with an electrified railway, since the power lines can easily give rise to induction current which can destroy the impulses passing through earth; this risk is eliminated when the impulsing takes place over a loop.

With the described method of impulsing the line voltage on the selective calling line can in most cases be kept as low as 24 V, and it is only when the selective calling line is exceptionally long that this tension is raised to, say 48 V by means of an extra battery. On the other hand, a higher voltage is used for the controlling impulses to the selectors, the voltage being determined by the number of selectors and the electric properties of the selective calling line. This voltage may vary between 120 and 180 V for different installations. Since current consumption takes place only during the impulsing, however, no storage battery is required as source of current for the impulses, but only a smaller rectifier connected to the mains and a dry battery, *e. g.*, as reserve.

In the Ericsson selective calling system, the entire power plant and the line equipment are consequently concentrated to one single point along the selective calling line, a point which may be arbitrarily chosen. For practical reasons, however, this equipment should be mounted in some larger railway station where personel for inspection and supervision is always at hand. This centralizing of the most important devices in the system has also made it possible to make the equipment of telephone instruments along the line very simple and efficient, this being of the greatest importance for a railway telephone system where the equipment in question is usually placed in localities entirely lacking in technically trained staff which would be able to intervene in case of trouble. In addition to the telephone instruments — of practically the same construction as a common automatic telephone instrument — the equipment comprises only one selector with two magnets, two rectifiers and a small 4.5 V dry cell.

Since all switching operations in the Ericsson selective calling system are controlled by a standard dial, this system offers excellent and simple solutions for the arrangement of automatic intercommunication between a number of sections of a selective calling line and with automatic telephone exchanges. Thus the dividing into sections can be quite arbitrary and can adjust itself without difficulty to all cases occurring in actual practice.

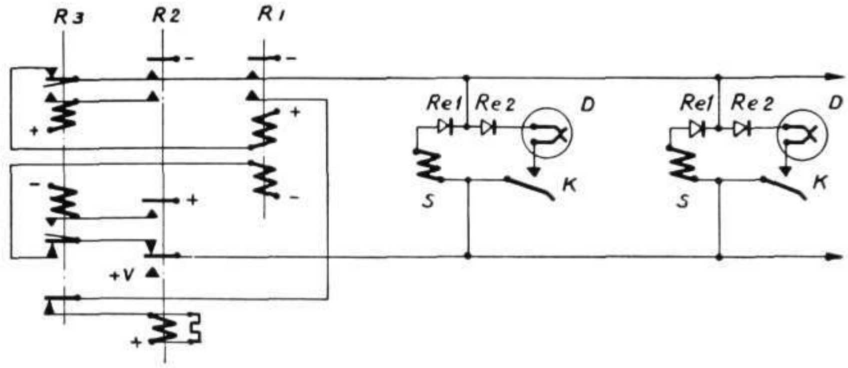
Impulsing

The impulse circuits of the selective calling lines are shown in Fig. 1. The selector magnet and dial are connected in parallel, besides which each one is

Fig. 1 X 5436

Impulse circuit in the Ericsson selective calling system

D	dial
K	cradle contact
R 1	impulse receiving relay for dial impulses
R 2	impulse sending relay for selector magnets
R 3	impulse receiving relay for dial impulses
Re 1, Re 2	rectifiers
S	selector magnet
V	impulse voltage



connected in series with its own metal rectifier; these rectifiers are turned in opposite direction with reference to the line branches. The selector magnets are constantly connected up to the line so that the rectifier in series with the selector magnet blocks current in the direction of the permanent voltage when the line is not induced. On the making of a call, contact *K* of the cradle switch is closed and the dial bridge with its rectifier is connected up between the line branches, causing the closing of a circuit through the telephone instrument, and relay *R1* is energized. As soon as its upper make contact is closed, it receives additional current and is fully actuated. Relay *R1* closes a circuit to relay *R2*, which sends out an impulse of opposite direction on the line, all of the selectors being thereby advanced one step. Relay *R3* is simultaneously put in circuit, thereby cutting out both relays *R1* and *R2* and obtaining holding over the line loop; relay *R3* does not deenergize until the loop circuit is broken by the dial contact.

A closer analysis of the described relay switching process will prove that it is especially well adapted for use in a line equipment for a selective calling line. Since the length of the impulses transmitted to the selectors is determined by the length of the time during which relay *R3* is energized and relay *R2* is deenergized, this length is independent of the impulse relationship and speed of the dial; thus, comparatively large variations in the manner of operation of the dial and selectors are permissible, thereby concentrating maintenance to practically one single point on the selective calling line, *i.e.*, the line equipment.

The selective calling lines of different railways often vary considerably as to length and construction, and when supplying material for such lines it is often very difficult to obtain information as to the properties of the line; for this reason it has been found desirable to design the line equipment so that it may be suited to all occurring line conditions. This rather difficult problem has been solved by replacing the receiving relay for the dial impulses by two relays of which the one *R1* is sensitive for attraction and the other *R3* for release. The sensitivity of each relay can be further varied by varying the connections of the relay coils. Due to this connection the same line equipment can be used with practically all existing kinds of selective calling lines.

The variations in intensity and voltage which occur on a selective calling line and in the apparatus equipment during the sending of impulses are indicated on the oscillogram, Fig. 2. Since the line current consists of currents passing through the selector magnet and the telephone instrument, the current *IL* must in each moment be equal to the sum of the currents *IS* and *IA*. Approximately, we also find that the current *IS* is equal to the negative direction of the line current and the current *IA* equal to its positive direction. At the instant *T1* the current is cut for the first time by the impulse contact in the dial, on which the line current as well as the instrument current are comparatively soon reduced to zero. This condition is retained until, at the instant *T2*, the contact of the dial again is closed. The line current and the instrument current then increase in value and, were it not for the fact that the relays in the line equipment begin to function, would reach the value they had before the instant *T1*, *i.e.*, the calling condition of the line, since the value of the line current is determined only by the elements of resistance in the circuit, *viz.* impulse relay *R3*, line, selector unit and telephone instrument. Immediately

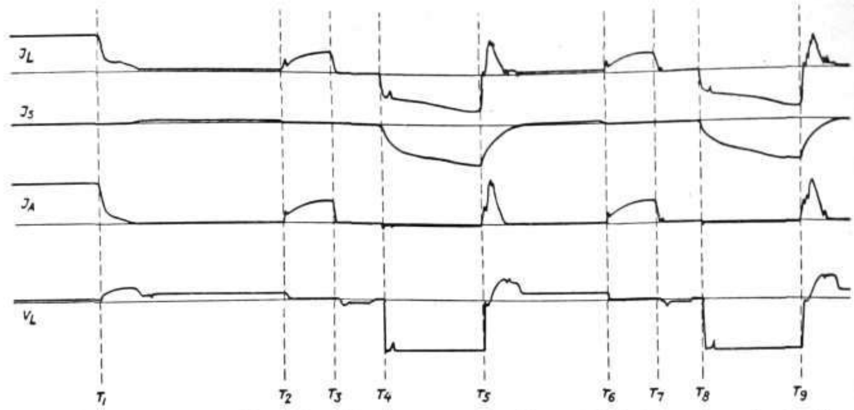


Fig. 2 X 5342

Oscillogram of impulsing in the Ericsson selective calling system

- IA instrument current
- IL total line current
- IS selector current
- VL line voltage

following the instant *T2*, relay *R1* is actuated, after which the relays in the line equipment function independently of the condition of the line loop, the line voltage then being zero. At the instant *T3* relay *R2* is put in circuit, after which it is actuated and reverses the line polarity at the instant *T4*, the voltage on the line being simultaneously increased. The line current then changes direction and the selector magnet is energized and attracts its armature. At the instant *T 5* relay *R 2* is released and the original line polarity is restored: this results in a sudden increase in voltage accompanied by a rush of current through the instrument. This increase in voltage is of the greatest importance as it tends to give the selectors a high working speed. Shortly after the instant *T5* the dial again breaks its impulse contact, after which relay *R3*, which has taken over the function of relay *R1* as an impulse relay, is deenergized. The conditions are now the same as at instant *T1*, after which the described process is repeated.

The curves between instants *T5* and *T6* are of special interest, as they represent the length of time available from the termination of the impulse to the selectors and until the dial has again closed its impulse contact. During this period the line shall, as far as is possible, return to the condition it had when at rest and this interval must therefore be as long as possible. This condition is automatically attained by means of the above described connection, since impulses are sent out to the selector magnets as soon as the relays *R1* and *R2* have hade time to function after the closing of the dial impulse contact. Consequently, the impulse to the selector magnet will not occur during the interval between two makes of the dial impulse contact, but instead coincides to the greater part with the impulse sent out from the dial; this explains the fact that impulse-sending over a selective calling line can take place with the same speed as generally occurs in automatic telephone engineering, *i.e.*, 10 impulses per second.

Selector

The selector used in the Ericsson system is a relay selector installed at every point along the selective calling line where telephone instruments are connected up, its object being to connect up a ringing signal to the desired telephone instrument when a call is made or — on the giving of a general call — to the desired instruments. The selector consists of two electromagnets, a stepping magnet *S1* and a catch magnet *S2*, together operating a ratchet mechanism, see Fig. 3. The stepping magnet operates a pawl *1*, a contact spring *4*, which closes the circuit to the winding of the catch magnet, and another contact spring *5* which closes the ringing circuit. The catch magnet, which is actuated when the stepping magnet operates, influences a catch *2*. Thus, when the stepping magnet alternately energizes and deenergizes, the ratchet wheel *3* is stepped forward; when this wheel has reached a predetermined position, a contact arm *6* attached to the ratchet wheel reaches the above mentioned contact spring *5*, thereby closing the ringing circuit. The stepping magnet has two windings, see Fig. 4, one of which is connected to the selective calling line and receives the impulses which step the ratchet wheel forward. The other winding causes an inductive transfer of part of the ringing current to the line, thereby permitting the calling subscriber to hear that a ringing signal

Fig. 3 X 3829

Working principle of two-magnet selector

- S_1 stepping magnet
- S_2 catch magnet
- 1 pawl
- 2 catch
- 3 ratchet wheel
- 4, 5 contact springs
- 6 contact arm for individual call
- 7 contact arm for general call

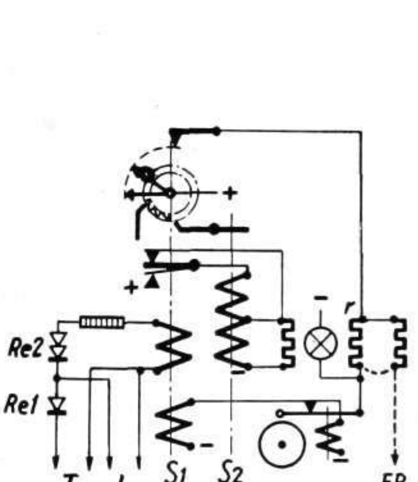
is actually being sent out. The catch magnet has also two windings connected so that the magnet is slow-working, causing it to remain in actuated position when the stepping magnet is deenergized during the intervals between the reverse polarity impulses. The slow-working of the catch magnet is caused by the short circuiting of one of its windings when the stepping magnet is deenergized. This slow-working feature is especially suitable for use in an arrangement with local battery feed, the slow-working being practically unchanged with variations in the battery voltage exceeding 30 %. When the stepping magnet is actuated by an incoming train of impulses, a local circuit from a 4.5 V dry cell is closed to the catch magnet, causing this latter to attract its armature at the same time as the ratchet wheel is stepped forward. The ratchet wheel is provided with a homing spiral spring, the homing action being prevented during the sending of impulses, however, by means of the catch *2*. Thus, the selector is stepped forward a number of steps corresponding to the number of impulses sent out.

The winding of the stepping magnet connected to the line has a resistance of 20 000 ohms. The rectifier which is connected in series with the winding has a resistance of about 10 000 ohms in the direction of the current; furthermore a resistance of 70 000 ohms is included in the same circuit. The resultant ohmic resistance is consequently about 100 000 ohms. The impedance at voice frequency is about 0.75 megohm. The attenuation of such a shunt on the line is very low and on no account does it exceed 0.01 neper.

Numbering Scheme

The number series has been chosen so as to permit the calling of all instruments by means of two-digit numbers. This has been made possible by providing for the mechanical locking of the ratchet wheel during the interval between the dialling of the two digits, so as to prevent it from returning to home position in the pause between the trains of impulses. The mechanical locking device consists of a tripping cam on the ratchet wheel, which holds the armature of the catch magnet in operated position in spite of the fact that the magnet winding is not in circuit. For instance, if the call number of a telephone instrument connected up to the selective calling line is *76*, the ratchet wheel in the instrument with number *76* as well as those of all other instruments whose calling number begins with *7* are locked after the first train of impulses. When the next train of impulses is sent out from the line equipment, all these selectors are stepped forward but only instrument number *76* will receive a ring signal. With this numbering scheme it is taken for granted, however, that merely one digit will not be able to step forward the selector to ringing position. Consequently, the ringing contact must be placed after that position on the ratchet wheel which corresponds to the digit with the highest value, this being *0* in the Ericsson system and corresponding to 10 impulses. The ringing signal is then obtained by means of a long supplemental impulse sent out from the line equipment immediately following the end of the second impulse train; in the called instrument this impulse will then cause the closing of a local circuit to a battery bell. After the ringing signal all the ratchet wheels except those which have been locked after the second train of impulses are returned to home position. These selectors are disconnected by means of a special disconnecting impulse at the end of the conversation.

In most cases it is desirable that the selective calling installation shall permit the giving of a general call. For this purpose, the ratchet wheel of the selector is provided with still another contact arm *7*, see Fig. 3. The digits *00* are commonly used as a general call number, and in some cases also *11*. If *00* is used for general calls, the numbering will have a capacity of 36 instruments, which is more than sufficient for installations with decentralized selection. If *11* is used as a general call number the capacity will be 54 instruments, which may sometimes be required for installations with centralized selection. The maximum capacity of 36 instruments in an installation with decentralized selection holds good for one single section of a selective calling line; should the line be divided up into several sections, which is the usual condition, the maximum instrument capacity of the installation is practically unlimited.



X 3831

Fig. 4
Circuit diagram of selector unit

EB	extra bell
L	line
Re_1, Re_2	rectifiers
r	resistance
S_1	stepping magnet
S_2	catch magnet
T	telephone instrument

Selective Calling Telephone Installations

Fig. 5 shows the layout for a selective calling telephone installation comprising one line section with *n* telephone instruments. Such an installation will require one central equipment — usually located in the most important station in the section — and *n* smaller equipments, one for each telephone instrument. The central equipment comprises one line equipment *L* and a power plant comprising a distribution board *D*, one 24 V storage battery *BA* and one 150 V dry battery *BB*. The distribution board is connected up to the distribution network of the station and the line equipment to the selective calling line. Each instrument connection *A1* to *An* comprises one telephone instrument *T*, one selector unit *S* and one 4.5 V dry battery *B*. If open line construction is used for the selective calling line both the central equipment as well as each instrument connection must be protected by means of protecting devices *P* against injurious tensions and inductive currents which may arise on the line.

Line Equipment

As long as a selective calling telephone installation does not comprise more than one section, the principal duty of the line equipment is to receive the impulses sent out from a telephone instrument and to send out new impulses to the selectors on the line; this process of impulse repeating has already been described. After the repeating of the last setting impulse to the selectors, the line equipment also sends out an extra impulse of about 3 seconds' duration, whereby a local ringing circuit is closed in the called telephone instrument, causing a bell to ring during a corresponding length of time. When the selective calling installation comprises more than one section, the line equipment has still another duty, *i.e.*, to link together two sections. For this purpose, each line equipment — in addition to the impulse relays — is provided with a selector and some additional relays. The selector is connected up so that it will follow the first train of impulses sent out from a telephone instrument. If this train represents a direction number to another section, the selector will be set to the desired direction, after which both sections are linked together by the relays. The component parts of the equipment form one single unit which may vary in character depending on how many equipments are connected up to the same station, as well as on the local conditions at the station. If the section does not have more than one or two equipments, these are usually mounted in a box which is fixed to the wall; if a larger number of equipments is required, it is more practical to mount these equipments on strips which, in turn, are mounted on a special rack and connected up by means of plugs and jacks.

The above described line equipment must be provided for each selective calling line section. In such cases where a line section shall have intertraffic with other line sections over both of its end points still another although differently composed is required. This line equipment is called interconnecting equipment and has the same general character as the line equipment, the difference being that the impulse relays are substituted by a relay for receiving the reverse

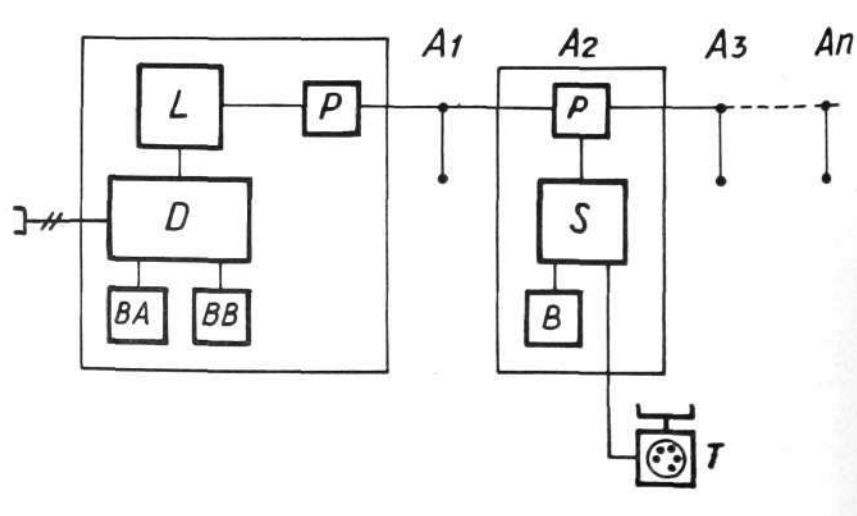


Fig. 5 X 5437

Schematic diagram of selective calling telephone installation in one section

$A_1 - A_n$	connecting points for telephone instruments
B	dry cell, 4.5 V
BA	storage battery, 24 V
BB	dry cell, 150 V
D	distribution board
L	line equipment
P	protectors
S	selector unit
T	telephone instrument

polarity impulses sent out by the line equipment. The interconnecting equipment will consequently operate synchronously with the line equipment, and the selectors in these equipments intended for the connecting up of new sections will consequently be advanced the same number of steps. With this arrangement one obtains the possibility of connecting new selective calling line sections to a previous selective calling line section at any place along the line, and it is consequently evident that the Ericsson selective calling system can without difficulty be adapted to all existing railway nets.

With intercommunication between several selective calling line sections the functions performed by the line equipment are as follows, *viz.* busy designation of the own section; interconnection with an adjoining section; automatic connection from a busy section to one that is disengaged and which runs parallel with the busy one; connection to an automatic exchange. The busy designation of a section takes place at those points where new sections are connected up. A calling party is connected up so that either both impulsing and speaking connections are obtained or only a speaking connection, depending on whether the called section is disengaged or not. If, on obtaining a connection to a new section, the desired conversation is of a rush character, the calling party can request both parties already engaged in conversation to replace their handsets, after which he can immediately start impulsing over the new section.

The greater part of the traffic over a selective calling telephone line is limited to one and the same section. Consequently, in order to put the available lines to the most efficient use, only as large a part of the line as is really required should be used on the making of a call. In the Ericsson selective calling system only the own section is occupied when making a call. If the call concerns a telephone instrument within another section, one or more *direction* digits are dialled depending on the number of sections which are to be bridged over. When the calling party has been connected up to a new section by dialling a direction digit, a new dial tone is received from that section if the line is disengaged. Should the section be engaged, the calling party obtains a speaking connection only with those instruments within the section over which conversations are taking place.

We will illustrate the above with the example in Fig. 6, which shows a selective calling telephone network for part of a railway district. Two selective calling lines arrive from a larger station *S* over a station *U* and terminate in station *V*. One of these lines to which only a small number of stations are connected is intended for the direct traffic between *S* and *V* while the other line is divided into two sections at station *U* and serves chiefly for the local traffic between the stations and linemen's cottages connected to these sections. Interconnecting equipment only is used for the sectioning at *U*; at *V*, on the other hand, line equipments are used. At station *S* — which is not shown on the diagram — it is assumed that the direct line to *V* is equipped with an interconnecting equipment and the local line to *U* with a line equipment. From station *X*, where two line equipments and one interconnecting equipment are installed, one line continues to *Y* and another to *Z*; at this last point two interconnecting equipments are used.

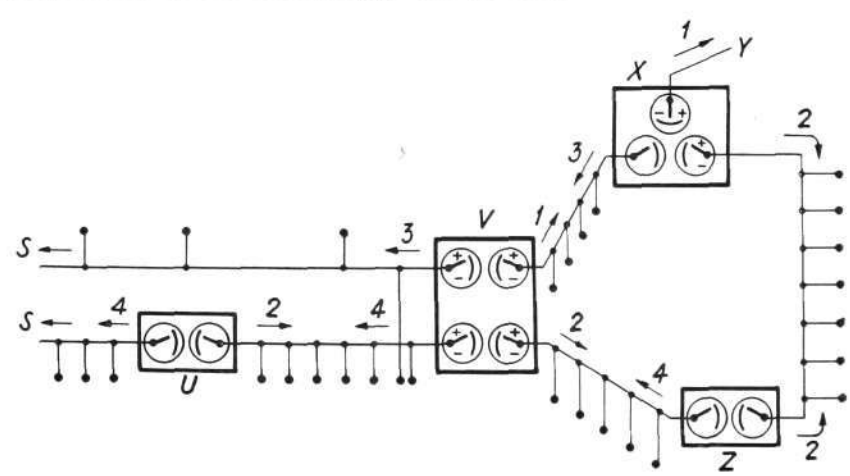


Fig. 6 X 5438

Schematic diagram of selective calling telephone installation in several sections

line equipment

interconnecting equipment

telephone instrument

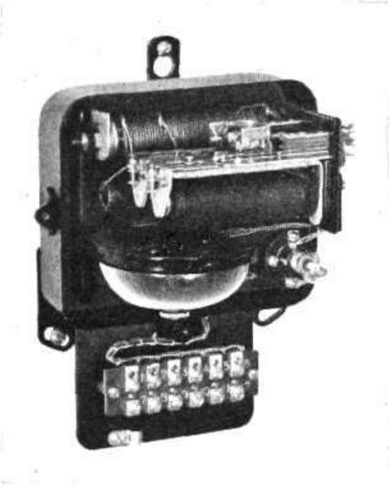


Fig. 7 X 3835
Selector unit OV 1101
top, rectifier; middle, selector; below, bell, lamp and terminal block

On making a call from a telephone instrument between *U* and *V* to another one between *X* and *Z*, the first direction digit *2* is dialled twice after which the calling number of the instrument, for instance *76*, is dialled. If the line between *V* and *Z* is busy, one may instead dial the direction digits *1* and *2* and obtain the desired connection over station *X*, *i.e.*, if the line *VX* is disengaged; should this line be busy the calling party can request the parties talking over the line *VZ* to terminate their conversation and, when they have replaced their handsets, he can obtain his connection. With the aid of the direction digit shown on the diagram, it is easy to work out the necessary procedures for obtaining other connections.

By means of sectioning it is possible to divide up a selective calling line into so many parts as may be desired from an administrative point of view, as well as with due consideration for the intensity of the telephone traffic. With normal traffic the number of telephone instruments connected up within the same section should not exceed 15 to 20. If the intensity of the traffic is not so heavy, as many as 36 telephones may be connected to the same section.

Selector Unit

The selector is usually mounted separate from the telephone instrument in a selector unit OV 1101, which is fitted in a black enamelled cover of sheet iron and intended for mounting on the wall, see Fig. 7. The selector unit comprises the selector, two metal rectifiers and one ringing device, consisting of a standard DC bell connected in parallel with a 4 V lamp; a resistance *r* is connected in series with the lamp and bell, see diagram in Fig. 4. When a circuit is closed over the ringing device, the bell is shunted by the lamp — the filament of which is not yet heated — the initial resistance of which is small as compared with that of the bell. Consequently, the bell does not start to ring until the lamp has begun to glow, *i.e.*, when the contact has been closed longer than 0.5 seconds. The lamp and bell obtain current from the same 4.5 V dry cell which energizes the catch magnet and feeds the transmitter. The magnet winding as well as the lamp and the bell are so dimensioned as to require a minimum of current even when the traffic is heavy. Three common dry cells of 1.5 V each are consequently sufficient to provide the necessary current during at least one whole year.

Telephone Instrument

For selective calling lines with decentralized selection telephone instrument DS 1100 is used, see Fig. 8, this being a modern table telephone instrument in a bakelite housing, the appearance of which is similar to that of the instruments generally used with automatic exchanges. In addition, it is provided with a push button to be depressed after the calling party has ascertained that the selective calling line is disengaged. Under normal conditions the telephone

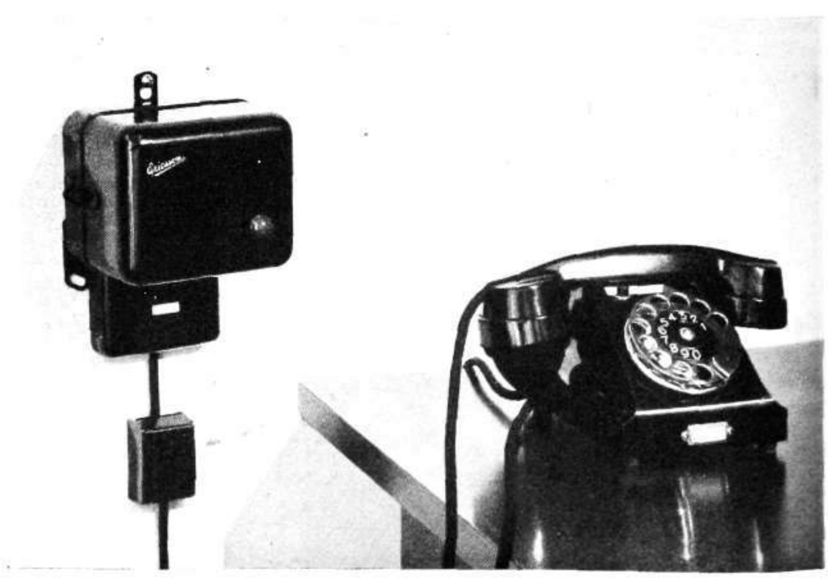


Fig. 8 X 5444
Selector unit OV 1101 and telephone instrument DS 1100

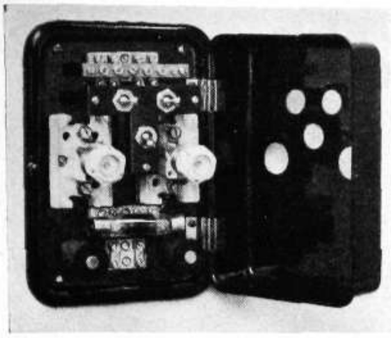


Fig. 9 X 3840
Line protection and sectioning unit ND 10101
top, terminal block with spark path; middle, sectioning switch and fuses; below, rare gas arrester and choke coils

instrument is connected to the line over a condenser which is short-circuited when the push button is depressed and then remains short-circuited until the handset has been replaced at the end of the conversation when the push button is automatically released.

Due to the fact that the telephone instrument and the selector unit are built in separate units, the same telephone instrument can be used in cases where several selective calling lines enter the same station. Each line is then equipped with a selector unit, but one single telephone instrument suffices for all of the lines. The necessary connections are made by means of a line switch RL 5001, suitable for up to ten lines, or switch RL 201, which is used when connections to only two lines are required.

Many railway administrations desire to have a selective calling telephone instrument installed on every train. With the aid of this telephone the train crew is able, when necessary, to connect itself up on a selective calling line along the railway line in order to report any accidents or the like. To cover this need there is a specially constructed portable telephone MS 1102, comprising a selector unit as well as the telephone instrument with dial and batteries. This apparatus is very light in weight and of small dimensions.

Line Protection

When the selective calling line is of open wire construction, the instruments and line equipments should be effectively protected so as to keep the line of communication in serviceable condition even after severe thunder storms. For this purpose, a line protector ND 10101, see Fig. 9, is provided, this protector filling all possible requirements as to safety. The protector comprises a point arrester, fuses, rare gas arresters and choke coils. Also, it is provided with sectioning devices, permitting the disconnecting of the instrument from the line, the through-connecting of the line or the connecting of the instrument to either of the line directions. In countries where thunderstorms are not of a very severe character and do not occur very often, more simple protectors — for instance ND 311 with carbon protectors, or ND 312 with rare gas arresters — can be used. Very effective protection is afforded by a rare gas arrester NB 3301 together with two fuses. The larger protectors ND 10101, however, should be connected up at a couple of points along the line and in the vicinity of the line equipment, thereby facilitating trouble seeking along the line and also providing such safety as is necessary for such an important means of communication as the selective calling telephone system.

Power Supply

The power distribution board generally used for selective calling installations is provided with the following instruments: a 24 V, 0.5 A rectifier for the charging of the storage battery; an automatic charging controller; a 150 V, 0.1 A rectifier for the impulsing current; a switching and protecting relay for the source of impulsing current and the tuning fork buzzer. Power plants for DC networks are similarly designed but the rectifiers are substituted by charging resistances.

The duty of the charging controller is to keep the voltage of the 24 V battery within definite limits between 22 and 28 V. The 150 V rectifier is used normally as the source of current for the impulsing voltage. It is controlled by a switching relay arranged so that a reserve source of current for impulsing is automatically put in circuit if the mains supply should fail. A 150 V dry battery is generally provided as reserve. The protecting relay functions if a short-circuit should occur on the line, when it automatically increases the resistance of the impulse circuit at the same time as an alarm contact is closed. The tuning-fork buzzer is used for generating the humming tone which is sent out from the line equipment when the selective calling line is disengaged. However, it is not necessary for all the distribution boards along a selective calling line to be provided with all the above equipment. At places where only inter-connecting equipments are required, only a 24 V charging device with automatic charging control need be mounted on the distribution board.

Rural Automatic Exchanges in Finland

G. JOHNSON & O. SIEWERT, TELEFONAKTIEBOLAGET L.M. ERICSSON, STOCKHOLM

Most of the local telephone plants in Finland are owned by private telephone companies or societies, many of which own only a smaller number of rural exchanges; due to economic reasons, the automatization of the manual telephone exchanges has consequently hitherto chiefly comprised town exchanges, of which Tammisaari, Hamina, Jyväskylä, Kokkola, Loviisa, Tampere, Waasa and Oulu are built according to the Ericsson automatic telephone system with 500-line selectors, these exchanges having been put in operation during the years 1931 to 1937.

During latter years, however, the rural telephone companies have also begun to take an interest in machine switching, as a result of which the Ericsson company has received orders for a number of rural automatic exchanges, the most important of these being from Kervo Telefonaktiebolag, Nylands Telefonaktiebolag and Pori Telefonförening. Most of the automatic exchanges already delivered are incorporated in the telephone network as individual exchanges with automatic call to a manual main exchange, the calls being relayed to the desired exchange by the aid of a telephone operator. Some installations, however, form small automatic plant groups with automatic traffic between the exchanges. Of these latter, we will find the one in Kervo to have the most interesting system.

The plant of Kervo Telefonaktiebolag comprises six exchanges, three of which have now been automatized, see Fig. 1. These three exchanges together form a center area, consisting of a center exchange, Tusby, and two end exchanges, Hyrylä and Nahkela. Direct junctions connect the two end exchanges with the center exchange, from which outgoing junction groups proceed to the two manual exchanges, Kervo and Järvenpää. After these exchanges will have been automatized at some future date, they will be included as center exchanges in the fully automatized telephone network to which, in turn, end exchanges may be connected up. The adopted automatic system — in principle similar to the Ericsson system for automatic operation of rural networks described in Ericsson Review No. 3, 1937 — is therefore planned so as to permit the junction network to be retained unaltered even after a complete automatization has taken place. For the present, the trunk traffic is handled over both of the manual center exchanges. When the entire network has been automatized, all the trunk traffic will pass over only one exchange.

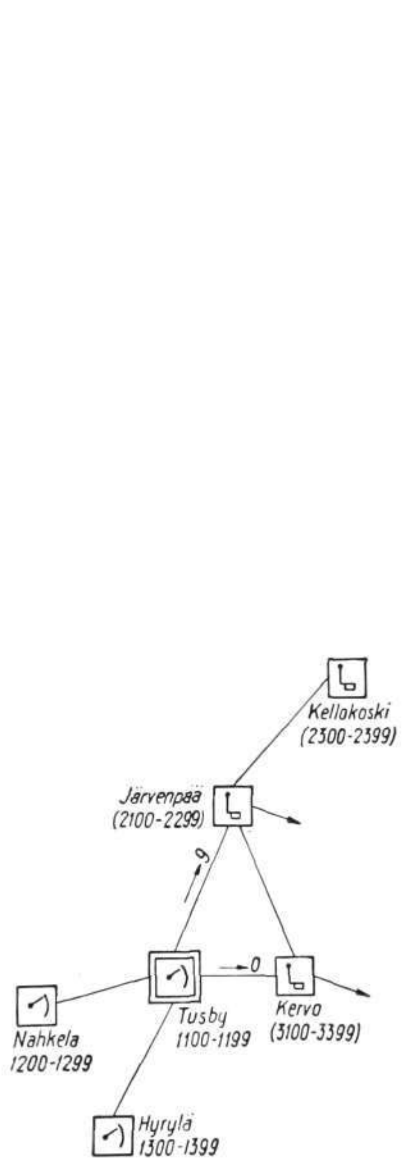


Fig. 1 X 3828

Layout of Kervo telephone network

automatic center exchange

automatic end exchange

manual exchange

Numbering Scheme

The numbering of the subscribers' lines in the automatized exchanges has been planned with due consideration for a continued automatization of the telephone network, a numbering scheme with *closed numbering* having been chosen, see Fig. 1. This numbering scheme is characterized by the fact that a subscriber is always called with the same number, no matter whether the calling subscriber belongs to the same exchange or to another exchange within the automatized network. For the network in question — which, from an administrative point of view, forms a distinctive unit — the adopted numbering scheme offers decided advantages, since the subscribers never need worry about the exchange to which the desired subscriber is connected, but only need to dial his number. This numbering scheme has been obtained by the introduction of four-digit numbers composed so that the first digit represents the center group, the second digit the exchange and the two last digits the subscriber's line. The capacity of each center group will thus be 1 000 subscribers' lines, with the limitation that the end exchanges can accommodate a maximum of 100 subscribers, the maximum capacity of the center exchanges, on the other hand, being 1 000 less a number of hundreds equal to the number of connected end exchanges. Should the number of subscribers at some end exchange increase to more than 100, the subscribers at this exchange will be given five-digit numbers or else the center exchanges will be provided with registers, thereby permitting the retention of four-digit numbers. The planned series of numbers is expected to suffice for the network in question for all future requirements as far as may now be foreseen. For the present this numbering has been introduced only in the automatized section of the telephone network, the subscribers connected to the manual exchanges still retaining their old numbers. For calling manual subscribers, the subscribers with machine switching use *open numbers*, *0* or *9*, on which they are connected up to the one or the other of the manual center exchanges. The subsequent switching is handled by the telephonists at the exchanges in question. When requesting trunk calls the automatic subscribers normally dial the exchange digit *0*; only in exceptional cases may the digit *9* be dialled, on which the request is received by another exchange.

Telephone Exchanges

The junction lay-out for the automatic exchanges is shown in Fig. 2. The only selectors used in all of the exchanges are of the step by step type, controlled by the subscribers' dials. The system is so planned, however, that registers can be introduced, if this should be found expedient with due consideration for the planning of the network and the numbering of the subscribers' lines. All of the selectors with which the automatic exchanges are equipped are of exactly the same type, no matter whether they serve as line finders, connectors or directory selectors. As shown in the diagram, a local connection at the end exchanges as well as at the center exchanges is controlled by a line finder, a directory selector and a connector. The traffic entering the end exchanges is directed over special connectors belonging to the junctions. At the center exchanges — which, according to what has already been said, may comprise more than 100 subscribers — the incoming automatic traffic is directed over the same connectors as the local traffic.

In order to obtain a uniform numbering within the entire network without the use of registers, the end exchanges must operate with advance occupation

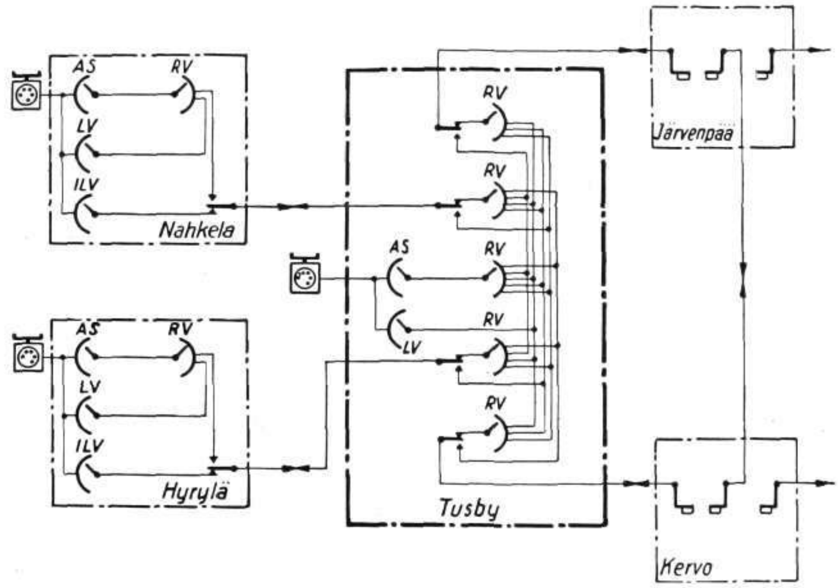


Fig. 2 X 5439
Junction diagram of Kervo telephone network

AS line finder
ILV junction connector
LV connector
RV directory selector

to the center exchanges. Since the three center exchanges are interconnected by means of direct line groups, no advance occupation of the junctions between these exchanges is required. As a result, each center exchange can be regarded as the main exchange of the group of exchanges. When an end exchange subscriber removes his handset, his call will — on condition that there is a disengaged junction line — be immediately connected to the nearest center exchange, where a direction selector is consequently occupied. The subscriber then receives a dial tone and dials the desired number. On calling a manual exchange by dialling the digit *0* or *9*, he is connected to the desired exchange, where the telephonist answers his call. On making a call to an automatic subscriber, on the other hand, four digits are required, of which the first two represent the desired exchange. If the call is to a subscriber within another center group, the directory selector finds a disengaged junction line to the desired group immediately after the dialling of the first digit, the following digits being received by this desired group. On the other hand, if the first digit designates the own center group, the directory selector remains in home position until after the dialling of the second digit. When this has taken place, and on condition that the call is not intended for a subscriber belonging to the own exchange, the direction selector occupies a disengaged connector at the desired exchange, which then receives the remaining digits. If the call is intended for a subscriber belonging to the own exchange, on the other hand, the advance occupied junction is liberated — after the dialling of the second digit — by the aid of a discriminator at the originating end exchange, after which its directory selector hunts a local connector, which is operated by the impulses from the remaining two digits. Should all the junctions be occupied on the making of a call from an end exchange, the subscriber will receive a dial tone and make local calls in the usual manner. Outgoing connections, however, cannot be built up and the subscriber will receive a busy signal should he attempt to obtain such a connection. Since the four digits may be dialled in unbroken succession for all connections, those switches which are to complete a hunting movement during the interval between two consecutive digits, are made for quick searching so as to have sufficient time for the free selection of a following switching device. Other switching operations within the automatized network may be deduced directly from Fig. 2.

On planning the lay-out for the automatic exchanges, due consideration has been taken to the fact that the entire network consists of open line construction, where earth faults, line ruptures and disturbances from power lines are of much more common occurrence than in a cable network. For this reason, every subscriber's line has been equipped with an automatic locking relay, which disconnects the line from the automatic exchange as soon as a short-circuit or a strong leakance between the line branches occurs, or when a subscriber's handset is removed without any connection having been made. Furthermore, the exchanges are designed so that the junctions between them are de-energized when not in use, and all impulses and signals during the switching operations are transmitted over loops and independently of the resistance of the earth returns of the exchanges as well as of the difference in voltage between the batteries of the exchanges. In order to prevent the connecting up of subscribers to broken junctions, the repeaters are provided with an arrangement which bars faulty lines.

A speaking connection established in the network is verified by the calling subscriber, and release takes place as soon as this subscriber has replaced his handset. In order to prevent a blocking of the called subscriber by the calling subscriber, arrangements have been introduced for the disconnecting of the connection after about 0.5 min, even if only the called subscriber should have replaced his handset.

As the automatic exchanges are planned to operate without supervision, they are equipped with fault signal senders which function automatically as soon as any fault occurs at the exchange, a signal being sent out to one of the manual center exchanges. Since these faults may be of varying importance

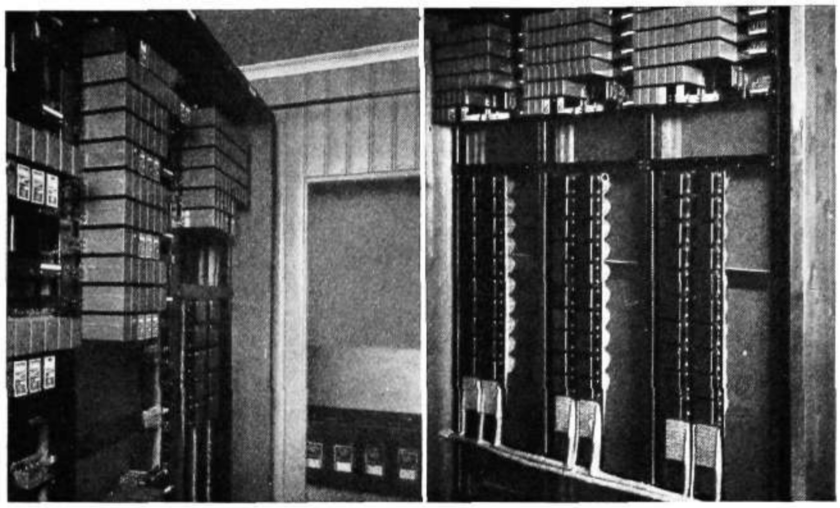


Fig. 3
Rural automatic exchanges
left, at Nahkela; right, at Hyrylä

X 5443

for the functioning of the exchange, they have been divided into *minor faults*, comprising disturbances in the operation of some single switching device, and *major faults*, comprising more serious disturbances requiring the immediate services of a repair man. Without regard for the character of the fault, the fault signal sender emits a signal which, at the manual exchange, operates an indicator representing the exchange where the fault has occurred. The signal is transmitted over the junction lines intended for telephone traffic but does not disturb this traffic. When a fault signal has been received at the manual exchange, the staff of this exchange should immediately call the exchange in question by dialling the fault number of the exchange, after which the different faults are distinguished by means of acoustic signals.

For the present, all connections obtainable within the network are considered as local calls and are registred on the subscribers' meters by one single unit. However, the exchanges are designed so that automatic zone metering can be introduced whenever desired.

The automatic exchanges operate on a 24 V current. The batteries are charged by means of rectifiers; single battery operation with automatic supervision of the battery voltage is introduced at all exchanges.

The automatic switching equipment is mounted in racks enclosed in wooden cabinets, see Fig. 3. In this manner, the relays and selectors are less influenced by changes in temperature, which may be quite large, as a regular heating of the exchange premises cannot be reckoned with. The switchboards are mounted in regular apartment buildings, the necessary space being rented for this purpose.

Trunk Traffic

The technical requirements set up by different telephone administrations for the handling of the trunk traffic vary considerably, and the switching method used in the Kervo plant, therefore, should not be regarded as standard for the Ericsson system, but only as a form considered suitable for this plant.

Trunk connections can be offered to the automatic subscribers from both of the manual center exchanges. A trunk connection is established with the usual cords but over special trunk jacks belonging to the junction circuits. A trunk signal is then automatically sent out over the circuit, thereby giving the subsequent switching operation the character of a trunk connection. After the telephonist has dialled the desired number, she receives varying signals depending on whether the subscriber's line is disengaged or busy.

If the desired subscriber's line is disengaged, a trunk signal is immediately obtained, but no ring signal is sent out to the called subscriber before the telephonist has manipulated a signal button on the switchboard. Meanwhile, a pilot lamp glows until the called subscriber answers. When the subscriber replaces his handset at the end of the conversation, the clearing lamp is made to glow; however, the connection is not broken until the telephonist has pulled down the cord.

If the subscriber's line is busy, the operator receives a busy tone, this tone varying in character, depending on whether the subscriber is occupied by a local or by a trunk connection. In order to cut in on a conversation, the telephonist must depress the signal button for a moment. After having given notice of the awaited trunk call, the operator can break the local connection by depressing the signal button a second time. Should the subscribers be occupied by a trunk call, on the other hand, no breaking of the same can take place and the called subscriber himself must decide whether the new trunk call is to be connected up immediately or later. During the entire switching process, the pilot lamp on the switchboard glows and is not extinguished until the call in progress has been disconnected. In this manner, the telephonist is able to check up on whether the new trunk call has really been established to the desired subscriber. Should the subscribers have terminated their conversation before the operator has sent out a disconnecting signal, a ring signal is sent out to the desired subscriber when the telephonist depresses the signal button, and the pilot lamp continues to glow until the called subscriber has again removed his handset. From then on, the switching process will conform to that for a disengaged subscriber. The switching process and the signals are the same, either the connection is to be offered to a center exchange or to an end exchange.

The automatic plant was put in service in october 1936 and has consequently now been in operation for over a year. During this time it has given most satisfactory service, resulting in a continued increase in the number of subscribers as well as orders by the telephone company for extension equipment.

New Adaptation for Speaking Machines

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

The Ericsson photo-electric speaking machine for the announcement of weather forecasts, described in No. 3, 1936, of the Ericsson Review, can be used to advantage also for making other announcements to telephone subscribers. In january 1938 a speaking machine was put in operation in Oslo for the giving of information, in winter as to skiing weather and conditions, in spring and autumn as to the state of roads and lanes for country walks, and in summer as to the temperature of the water in nearby lakes. This machine is expected to be the fore-runner of many similar ones in other places.

The environs of Oslo are known to offer exceptionally good skiing in winter, and walks and bathing possibilities in the summer, and the inhabitants of this town are known to take good advantage of them. On a normal winter Sunday, the Holmenkollen railway alone transports about 50 000 skiers who, after a trip of from one half to one hour, start out on their ski excursions in the Nordmark and adjacent country. The country here is very hilly and rough, and offers a climate which differs considerably from that down in the city; for this reason it is often difficult or even impossible in the town to judge whether conditions in the surrounding country are suitable for skiing or excursions.

Comprehensive weather reports from the environs are broadcast by wireless, it is true, but these are naturally confined to certain times which are not always so suitable for listening in. Naturally, it is much more convenient if interested persons can call up the speaking machine when it suits them — a machine which without pause repeats the desired report. The traffic chief of a telephone exchange operating at full capacity may experience undue anxiety when confronted with the report of heavy traffic received from exchanges equipped with speaking machines for announcing time and weather forecasts, but his anxiety will no doubt vanish when he discovers that the peak-load does not coincide with that of the regular traffic and that, consequently, no increase in the switching facilities is required when such speaking machines are installed.

Fig. 1 X 3837
Skiers waiting for the Holmenkollen train

The report on skiing conditions covers only that section over which the greater number of skiers are assumed to plan their excursions during the day. This permits the required concentration of the wording, which is necessary in order to prevent the calling parties from occupying the switching devices for too long a time. To start with, the speaking machine in Oslo gives reports from two localities with characteristic conditions, for instance »*Kikut minus four; mist, sun higher up; snow plentiful, good gliding; Lövlia minus two; Heggelivann unsafe; snow plentiful higher up*». This report requires a few commentaries for those who are unacquainted with local conditions. Kikut is the name of a tourist station, at which locality the temperature for the moment is minus four degrees, centrigrade. There is mist down in the valley but the sun is shining on the surrounding higher country. Lövlia is another sports headquarters where the actual temperature is minus two degrees centigrade. The ice on the adjacent lake Heggelivann is unsafe. Snow is plentiful on the higher surrounding country. Since this latter notation does not apply to the entire district it may be deducted that there is a poor supply of snow in the valleys.

At first glance it may seem unbelievable that such detailed reports can be given by means of the Ericsson speaking machine for weather forecasts, this machine having only six film discs, which are caused to speak one after the other; the choice of suitable wordings for the different film records, however, has made this possible. On the first disc is recorded the information »*Kikut minus four*», »*Kikut minus six*» etc., *i.e.*, the name of the locality and the temperature. Since the disc can accomodate twenty such wordings, it is apparent that there are good possibilities for variation. The second record gives the information »*mist, sun higher up*»; »*sunshine, good gliding*»; »*clear weather*»; »*good skating*»; »*new report to-morrow*» etc. and the third record »*snow plentiful, good gliding*»; »*good snow-crust*»; »*dry weather*» etc. The fourth, fifth and sixth record have corresponding communications concerning Lövlia.

The use of this machine is not restricted to the winter season, however. The wordings are so chosen that reports concerning promenade weather can be sent out during the spring and autumn, the first record giving the temperature in degrees and the third record the road conditions. In summer, the film records are replaced by others which give the temperature of the air and of the water at three bathing beaches in the immediate vicinity of Oslo. For instance, one report may be formulated »*Hovedöya twentyfive, nineteen in the water; Ingierstrand twentythree, twenty in the water; Kikut twentytwo, twentyone in the lake*». The air and water temperatures are given by means of two records, the first one of which says, for instance »*Ingierstrand twenty-three*» and the other one »*twenty in the water*». With the six records of the machine it is consequently possible to give reports covering three different bathing beaches.

The telephone number for calling the machine is *09*. The junction relay equipment is common for both this machine and the speaking machine giving weather forecasts — which latter has the telephone number *06* — a suitable number of relays being connected up to the one or the other machine by means of a lever switch and depending on the requirements of the traffic. The reports are repeated twice during each connection, after which the subscriber receives a busy signal. The reports are repeated every twelfth second.

Fig. 2 X 5447
Tourist headquarters in Nordmarken

New Ericsson Exchanges in 1937

During 1937 the following automatic telephone exchanges on the Ericsson system vith 500-line selectors were put into service:

month	town	exchange	lines
January	Wasa, Finland		3 000
	Borås, Sweden		7 500
	Gothenburg, Sweden	PABX	300
	Stockholm, Sweden	Enskede	6 000
February	Bofors, Sweden	PABX	500
	Stockholm, Sweden	PABX	360
March	Gothenburg, Sweden	PABX	90
	Stockholm, Sweden	PABX	140
	Uddeholm, Sweden	PABX	120
April	México D.F., Mexico	Piedad (extension)	500
	Gothenburg, Sweden	PABX	50
	Stockholm, Sweden	PABX	250
May	Stockholm, Sweden	PABX	470
	Västerås, Sweden	PABX	700
June	México, D.F., Mexico	Apartado (extension)	500
		Portales (extension)	500
	Warsaw, Poland	Mokotów	4 000
	Stockholm, Sweden	PABX	330
July	Gothenburg, Sweden	PABX	50
	Stockholm, Sweden	PABX	230
August	Oulu, Finland		2 500
	Stockholm, Sweden	PABX	50
September	Tripoli, Libya	(extension)	500
	Gothenburg, Sweden	PABX	120
	Stockholm, Sweden	PABX	910
October	Campina Grande, Brazil		300
	Jyväskylä, Finland	(extension)	250
	México D.F., Mexico	Tacubaya (extension)	1 000
	Gothenburg, Sweden	PABX	130
	Stockholm, Sweden	PABX	270
November	Fortaleza, Brazil		1 000
	Reykjavik, Iceland	(extension)	1 000
	México D.F., Mexico	Coyoacán (extension)	500
	Gothenburg, Sweden	PABX	250
	Stockholm, Sweden	PABX	860
December	Santa Fé, Argentina	Maipú (extension)	500
		Noroeste (extension)	1 000
	Tallinn, Esthonia	Central (extension)	1 500
	Tampere, Finland	(extension)	1 000
	México D.F., Mexico	Chapultepec (extension)	500
		Roma (extension)	2 000
		Valle (extension)	500
	Gothenburg, Sweden	PABX	140
	Stockholm, Sweden	PABX	480
	Västerås, Sweden	PABX	120
	Mukačevo, Czechoslovakia		420

During the same period the following exchanges built by Société des Téléphones Ericsson, Colombes, using the Rotary system, were opened:

May	Paris	Avron	4 000
July	Paris	Flandre	2 400
	Clermont-Ferrand	(System R6)	4 000
August	Sous-le-Bois	(System R6)	400

Ericsson Telephones Ltd, London-Beeston, have supplied during the past year the following exchanges, constructed on the Strowger system:

month	town	exchange	lines
January	London	Wanstead	3 800
February	Kettering	Kettering	1 400
	London	Colindale (extension)	700
	London	Grangewood	4 100
	London	Shepherds Bush (extension)	500
	Manchester	Radcliffe	500
March	Peterborough	March	400
April	Market Harborough	Market Harborough	400
May	Edinburgh	Dalkeith	400
	London	Thornton Heath	2 600
June	Hereford	PABX	500
July	Manchester	East	1 500
August	Crewe	Willaston (extension)	600
	Manchester	Trafford Park (extension)	300
	Swindon	Swindon	1 100
September	Canterbury	Canterbury	1 800
October	Birmingham	Priory (extension)	400
	Manchester	Droylsden (extension)	100
	Manchester	PABX	50
November	Ayr	Ayr (extension)	200
	Edinburgh	Dalkeith (extension)	100
	London	Gladstone (extension)	800
	Taunton	Taunton (extension)	700
December	Birmingham	Marston Green (extension)	200

Ericsson Technics

Ericsson Technics No. 1, 1938

T. Laurent: Gain of Capacity Balancing by Crossing

The use of carrier telephony on lightly loaded or unloaded cables having no phantom circuits has put capacity balancing in an entirely new position. The suppression of the phantom circuits facilitates, of course, capacity balancing to a great extent, but the high frequencies, which only permit of balancing comparatively short cable sections and do not allow of neglecting the inductive unbalances, introduce new difficulties. Although the conditions for an efficient capacity balancing by a crossing method are quite unfavourable in this case, this method is the only correct one with a view to the inductive unbalances. The lack of efficiency in the balancing must therefore be compensated by correspondingly finer manufacturing tolerances, but if this compensation is to be made in the best way possible from the point of view of manufacturing as well as of operation, it is necessary to know what gain the crossing will give in an arbitrarily chosen case. The information necessary for calculating this gain is given in the present work.

Correction: In the article »High-Frequency Attenuation of Open-Wire Circuits» published in the Ericsson Review No. 1, 1937, page 20, instead of

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

read

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

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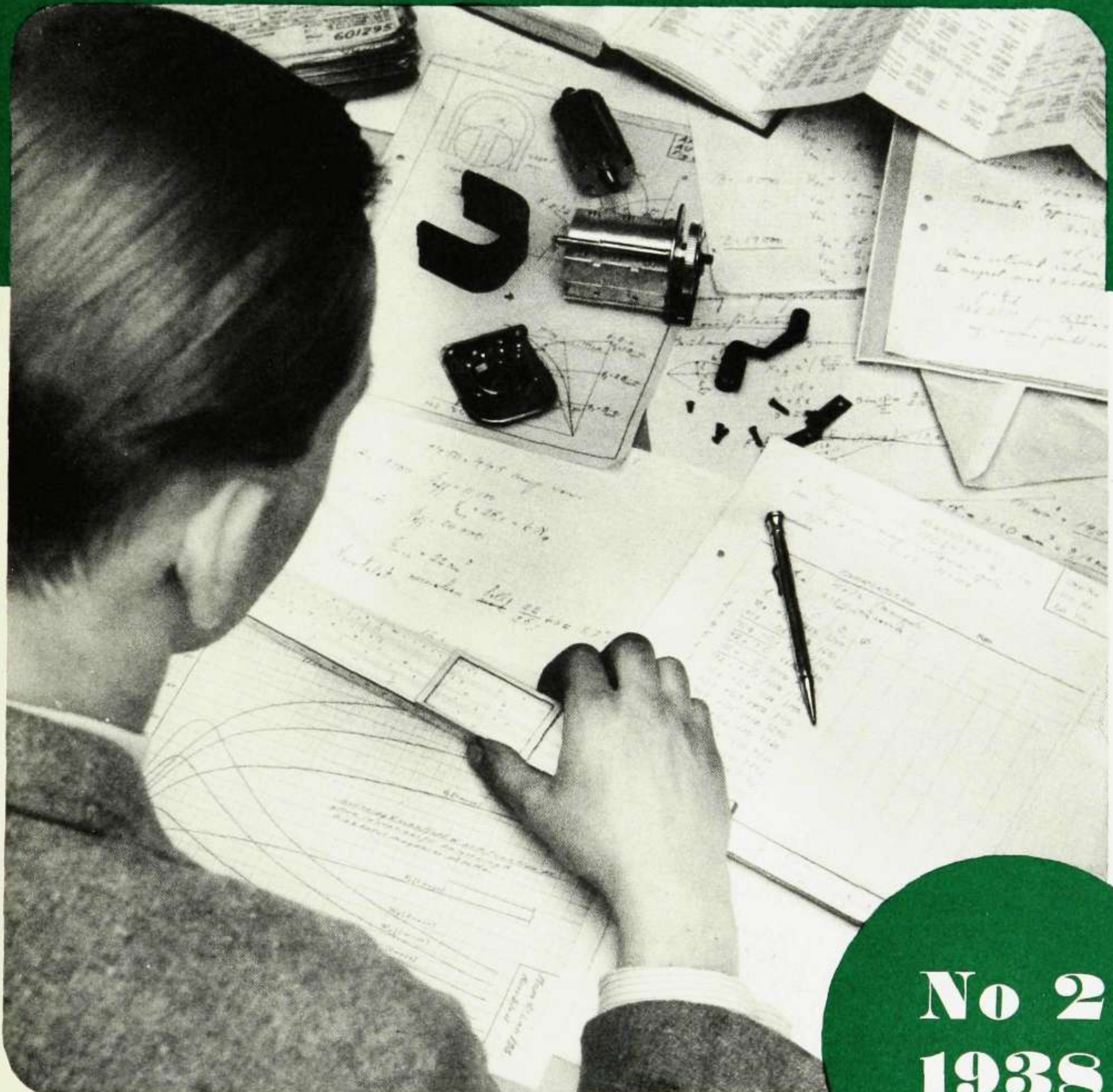

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CONTENTS

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Telelectrical Engineering of To-Day and of To-Morrow

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Due to the unremitting evolution — during the last decades — of the art of telelectrical engineering, the experts and industries occupied in this branch of electrical engineering have hardly had an opportunity of summing up the results obtained, still less of sorting out — from among the variegated and more or less valuable ideas of to-day — those likely to be of definite value in the future. A conception of what the future has in store must be based on an objective knowledge of the trend of events at the present moment, but depends also to a large extent on subjective opinion, resulting in varying conceptions for different individuals. In the following paper a summary is given of some important results of technical activities — scientific as well as practical — which can be expected to influence telelectrical engineering of to-morrow.

Obviously it is a hazardous undertaking to attempt to prepare a forecast for a line of engineering of such recent date as the electrical one, where everything seems to indicate that coming generations will participate in still more revolutionary events than those experienced by the engineers of to-day. If this holds good in regard to electrical engineering in general, the difficulties are still greater when prophesying concerning the future of telelectrical engineering.

The evolution of the electronic valve to a serviceable form for technical purposes, the quadripole theory as adapted for practical use and a broader knowledge of electromagnetic radiation — free, as well as restricted to physical conductors — are responsible for the development since the beginning of this century of modern telephone and telegraph practice, radio engineering and television. Which of the amazing developments in physics and chemistry, as applied within the field of electrical engineering, are ready to-day, in the nineteen-thirties, to make their appearance in the technical and economical domains and to revolutionize the telelectrical engineering of to-morrow?

Will electronic valves in the future be equipped with cathodes of radioactive or photo-electrical material, thus rendering superfluous the application of electrical energy for producing the required emission of electrons? Will carbon granule microphones be replaced by electrodynamic microphones with permanent magnets of hitherto undreamed-of steel alloys? And, if so, will it be necessary to retain the central battery system, hitherto used — among other purposes — for microphone feed, merely in order to provide remote control of switches in automatic telephone systems with DC impulsing? Will it be necessary for the coming generation to write letters, when the telephone and teletypewriter are within every man's reach? Are there not many indications that electric sound reproduction has now advanced sufficiently to permit the replacing of paper and fountain pen by a celluloid tablet and an engraving device? A sound letter or diagram recorded in this manner and dispatched by night air mail would constitute a complement to the telephone message, would reach the recipient with sufficient speed and be as permanent as our ancient parchment documents. Will the televisers of 1950 voice complaints over the all too simple television features, just as the radio listeners of 1938 vent their spleen over the broadcasting programs?

Questions of such tenor could be multiplied indefinitely. The aim of this paper, however, is not to put questions, but to answer them. Consequently, in the following, some problems which are of present interest in telelectrical engineering will be touched upon, to the practical and economical solution of which science and engineering have already submitted material of a most promising character, even though much remains to be worked out.

Telegraphy

Since the world war the increase in telegraph traffic in all countries has been markedly less than in telephone traffic, and in certain cases a decided drop in the number of telegrams as well as in the total length of telegraph lines has been noted, due, undoubtedly, to the exceptional simultaneous increase in telephone traffic. The possibility, with a telephone communication, of obtaining an immediate answer to a question and to come into direct contact with the called party by means of the spoken word is given preference over the greater accuracy offered by the exchange of telegrams.

During the last decade, however, telegraphy has been endowed with a new apparatus, the teletypewriter, which admits of a direct written contact between the two parties with the possibility of obtaining an immediate answer. It is evident that the art of telegraphy has entered a new era with the introduction of these instruments, which are now used for the general exchange of telegrams and cables as well as for direct telegraphic communication between different telegraph subscribers, such as banks, industrial houses, the police, military authorities etc. The experience gained by those countries which have pioneered this means of communication would indicate that this development has merely reached a primary stage. Teletypewriters, telegraph repeaters with symbol correction, and other expedients for the rebirth of telegraphy will undoubtedly be subject to improvements in design and construction, and in the same measure as the number of subscribers increases, the manufacturers of these devices will be enabled to adopt mass production with reduced prices, which will increasingly stimulate interest for this means of telecommunication. Teletypewriting has had some difficulties in gaining a foothold in countries with a highly developed system of telephone communications and where reliable night airmail service has been introduced at an early stage. However, a change in these conditions is expected to take place during the next decade as commercial circles become aware of the advantages teletypewriting has to offer in speed and reliability.

Although the pushing of telegraphy into the background may, to some extent, be due rapid development within the field of telephony, this very development on the other hand has, as a by-product, provided efficient long distance lines for telegraph communications; thus, for instance, it has made possible the use of cable lines for simultaneous telephone and telegraph traffic with the aid of superphantom telegraph communications over telephone quads or by sub-audio and super-audio telegraph systems. Even though the telegraph traffic over certain routes may require a greater number of connections than these three systems can offer, it may, in the future, be economically well motivated to construct special cables for telegraphy, possibly with the exception of certain main cables. With voice frequency telegraph systems operating over two or four-wire lines in existing or newly built telephone cable lines, extensive demands for more further telegraph lines between different localities may be met. The teletypewriter or the telegraph relay of to-morrow will be regarded and used in the same light as the microphone of to-day, namely as an electromagnetic converter, the main purpose of which is to convert, by modulation, signs or sounds into electric oscillations of a suitable amplitude and frequency for long distance transmission. During transmission it is not necessary to differentiate between code signs or sounds in the original message, since the technical procedure for the transmitting of a message will be the same in both telegraphy and telephony.

Developments of a more revolutionary kind in telephotography are hardly to be expected. Improvements of the equipment, tending to produce more sharply defined pictures and quicker service through more simple and convenient operation, will no doubt take place here as in other technical lines. One would presume that the exceptionally strenuous efforts which have been made towards the development of television would have suggested new ways and means for the improvement of picture telegraphy. So has undoubtedly been the case if one regards the matter from a purely technical point of view, but the commercial value of picture telegraphy is quite limited, even though in certain cases it renders the press and the police most excellent service.

Telephony

At the present moment two problems loom large within the field of telephony, namely, the automatization of telephone networks in smaller communities and rural districts and the use of modulated carrier frequencies for long distance communications. Both of these problems occupy prominent positions in present day discussions and endeavour within operating companies as well as in the telephone industry.

Before discussing these problems, it may be of interest to center our attention on the design of telephone instruments and new features to be expected in connection therewith. For instance, if our experts on electricity and materials working in collaboration were to succeed in replacing the carbon granule microphone — the now dominating construction in the field of telephony — by some other type of microphone equally simple, efficient and economical, this would mean a new era in the history of telephone communication. The methods now available for such an evolution are the use of permanent magnets — alloys of iron and aluminium, nickel, cobalt etc. — in electrodynamic microphones, or the application of the piezo-electric effect for the same purpose. Another problem in harmony with efforts to relieve the harried humans of to-day from the din and hubbub of our technical appliances is the introduction of harmonic calling signals instead of strident ringing signals. Finally, inventors and designers have for a long time devoted their efforts to the construction of an automatic impulse sender with keyboard as on a calculating machine, intended to replace the calling dial. No matter how interesting such a solution might be from a technical point of view, one can hardly hope that any such device will be able, on economic grounds, to supplant the dial, hitherto unsurpassed in simplicity of design. On the other hand, efforts devoted to the construction of telephone instruments provided with a separate table microphone and loud speaker give promise of better success. The advantage of being able to hold a telephone conversation from any point in a room, without being restricted by the handset and its cord, will probably some day be so highly valued by the general public that loud-speaking telephone instruments will be installed, not only in up-to-date offices, but also in the homes. An innovation not to be ignored will be found in the investigations and tests carried out with carrier telephone systems on party lines, permitting of a simultaneous exchange of several conversations. Further, telephone instruments with enclosed microphone and loudspeaker have made their appearance, these instruments being intended for the exchange of local calls with the aid of modulated carrier frequencies over the electric mains, from which the instruments obtain the required current for converting the frequency and for amplification.

Automatization

The complete automatization of the telephone plant in larger cities will now soon be an accomplished fact. Automatic operation is superior to manual as regards both traffic and economy when the number of subscribers is large and the traffic very heavy. Such conditions are not yet present in rural areas, even though each year brings about an increase in subscribers and traffic. The sociological importance of better telephone service in the country — in this case the

24-hour service made possible through automatization — may be quite great, but the automatization of rural districts must be built up on sound economic principles, as otherwise the complicated and consequently expensive rural automatic switchboards will result in increased rates, thereby nullifying the advantages obtained. The first stage in rural automatization will consequently comprise the local traffic within certain network groups. Hand in hand comes the automatization of the telephone networks in the relatively densely populated suburbs around the larger cities, including, as well, the automatization of the junction traffic between these localities and the cities. Following this, the rural automatization will encompass the trunk traffic over shorter distances and finally over longer distances. The time for the completion of such an extensive program in more sparsely populated countries, however, must to all appearances be quite remote.

Another phase of automatic operation, which has already been solved and the influences of which will be felt during the next decade, is the automatization of private branche exchanges. One of the most evident advantages is that larger concerns need not clutter the desks of their staff with two telephone instruments or their premises with two separate telephone networks, one for the intercommunication traffic and one for exchange traffic. This is possible because the PABX switchboards can be equipped with devices for the transfer of calls, requesting information from a third party during an exchange call, restricted service, night connection and other attractive features. Another proposition falling within this line of service and which is being discussed at present is the combining inte one large exchange of a number of private automatic branch exchanges for city offices. In this manner, both operation and maintenance will be centralized and the services of the operators required for the handling of incoming exchange calls be more efficiently utilized, these being advantages of the utmost importance for the future development of the telephone service.

Long Distance Telephony

Is it probable that loaded telephone cables will disappear? The use of modulated carrier frequencies for telephone communications over physical lines has been subject to an unusually rapid development since the world war. Open wire lines can transmit a frequency band many times wider than what is now considered necessary (250—2 700 c/s) for one voice frequency circuit. It is just for the turning to profitable use of this feature that carrier systems have been developed and utilized for some time. This development has given prominence to two varieties, *viz.* a single-channel system for one extra speech channel and a three-channel system for three extra speech channels over and above the voice frequency channel. In certain cases carrier frequencies are used also for the transmission of broadcast programs, in which case the transmission need only be unidirectional, although requiring a rather wide frequency band (about 8 000 c/s). Open wire lines have many disadvantages, however; they are exposed to the weather, resulting in unreliable operation for voice frequency as well as for carrier channels; also, their capacity for traffic is limited and maintenance and upkeep are relatively high. Consequently, they are not used over longer distances with heavy traffic, this traffic being handled to an ever increasing extent over dry core cables with loading coils and repeaters (amplifiers). Such cable plant is used either for two-wire or four-wire circuits, the former being generally of lower quality and consequently used over shorter distances, the latter on the other hand, providing first class connections even over very long distances. The trend of future development will no doubt be towards more and more four-wire circuits at the expense of two-wire circuits which will still be used, however, for short rural lines with but one or two repeaters for each circuit.

Loading results in a reduction of attenuation, not for all frequencies, however, but only for a limited frequency range. For this reason, carrier channels over loaded cables can be used only in certain special cases. The lighter the loading, the higher the cut-off frequency, permitting a larger number of carrier channels to be superimposed on one and the same pair. Should loading of cables be entirely discontinued, from twelve to sixteen carrier bands can without difficulty be transmitted over one pair without reducing the distance between the intermediate repeater stations and making the carrier installation economically inferior to a loaded cable installation. With coaxial cables the number of carrier channels can amount to several hundred; this type of cable can also be used for the transmission of television programs, for which a frequency range of a couple of million cycles per second is required.

The opinion that loaded cables offer the only and best solution — technical as well as economical — to the problem of highly efficient long distance communication must, without a doubt, now be seriously reconsidered. The intensity of the traffic, the planning of the telephone networks, the coordination of existing and projected plants as well as the initial and maintenance costs for different systems will now be the determining factors. To-day, the prospects for the introduction of carrier systems over non-loaded cables are most bright; to-morrow, improved methods of manufacture and lower prices for cables and loading coils may have upset the calculations in favour of the traditional type of loaded cables. Were it possible to manufacture, lay and splice these cables without capacitive balancing or compensation of capacity deviations, this type of cable could register an additional gain to its credit in the calculations.

Telesignalling

Telesignalling is understood to comprise all the various branches of telelectrical engineering which cannot be assigned to telephony or telegraphy proper, but which, to some extent, make use of the same apparatus and methods as these arts. *Although the boundaries of the various branches are not very clearly* defined, the following definitions are tentatively given: telephony and telegraphy comprise the *transmission of communications between two or more persons,* while telesignalling is understood to be the *transmission of an order or a report from a person to a technical device or vice versa.* Consequently, telesignalling would comprise electric clocks and time announcing machines, fire and burglar alarm systems, supervisory and signalling equipments for railways, supervisory and checking systems for machinery as well as staffs, signalling systems for homes and offices, remote supervision, remote control, and remote measuring.

Remote Signalling

Electricity is being, in our daily pursuits, employed for varying purposes to an ever increasing extent and in more varied fields of occupation, at our place of work, in the home and in all forms of traffic control. Here, telesignalling has ample room for development, and we will find that the evolution of new apparatus and systems based, for instance, on the use of photo-electric cells, bimetallic contacts and so forth has been just as rapid as in the already mentioned telelectrical groups. One notes, however, that the designs are not so thoroughly developed or the apparatus so standardized as within the other branches of telelectrical engineering, this condition being no doubt correlated with the fact that telesignalling is still reaching out for a firmer hold on the various problems which arise in overwhelming numbers. First of all telesignalling should aim towards limiting its problems to what is really essential, that is a more assiduous treatment — in which the constructive element is not the least important — of the most important technical elements as well as a consolidation based on efficiency in production as well as in business.

A continued improvement of various types of photo-electric cells, tending primarily towards increased sensitivity and efficiency, will permit the solution of many problems relating to production control, problems which have not as yet been taken up for treatment. Traffic signals, doors and escalators, registrering counters and automatic machines can be controlled by invisible light rays acting on photo-electric cells. Especially in sports and athletics there are many occasions for a general adaptation of automatic registering devices founded on the photo-electric cell as a substitute for the human eye, thereby eliminating subjective human failings. The photo-electric cell in its present form may possibly find a serious competitor in the new contact relay based on the photo-chemical effect.

In the future telesignalling will be increasingly used for solving many of our defense preparedness problems, especially as to defense against air raids. Alarm and darkening precautions during air raids must be so speedily taken that hardly any except electrical means can be considered, the problem being to control from one central point all the organs which are to function on the occurrence of an air raid. We undoubtedly stand in the presence of marked developments within this special branch. Special attention is being devoted to the finding of simple methods for the transmission of control signals and controlling impulses, to develop transmitters for acoustic signalling, and apparatus for the control of relays and valves. Requirements as to effective operation during the most adverse conditions — for instance during a break in the feed circuit — must not be neglected and are sure to cause many difficulties, though the resources now available are amply sufficient to overcome them.

Effective and excellent means of meeting a large number of requirements and desires tending towards increased safety and comfort in our daily work, principally in offices and workshops, have already been brought to light in the field of telesignalling. As an example we only need mention the staff locating systems, sometimes combined with private automatic branch exchanges, hotel signalling systems and traffic control systems. New technical features of a revolutionary trend are hardly to be expected in this field, but there will most certainly be an increased activity for the utilisation of the material on hand. Greater safety and comfort will in all probability be increasingly valued by humanity. Within the field of telesignalling, this means increased turnover and livelier installation activities. A telesignalling installation within a large hospital for the purpose of transmitting alarm signals and calling for assistance may to-day be considered desirable; while to-morrow it will have become an absolute necessity which must be provided at any price. Automatic optical or acoustical announcing of the names of railway stations, the times of arrival and departure of trains and other means of traffic, etc. to travellers in waiting rooms, on trains, boats and busses and so forth may possible appear utopian to many people of to-day but will probably be a future reality.

Remote Control

The methods for establishing remote control are obtained from the arts of telegraphy, telephony and measuring. Their application, however, is chiefly within the field of power transmission, which is probably the reason why this branch — lying, as it does, on the boundary between telelectrical and power engineering — has not yet reached a form of final evolution. The constructions which first appeared were fetched either from telelectrical or power engineering. During their evolution, it was soon discovered that a direct transfer of ideas or apparatus from the one or the other field did not give solutions corresponding to the special demands which of necessity must be met by remote control systems. It is true that telelectrical devices give excellent service over extensive periods but their adjustment and maintenance requires expert attention and continuous supervision, which is foreign to the form of operation which has been evolved within power engineering. On the other hand, the instruments derived within power engineering are too clumsy, bulky and expensive, besides which their current consumption is far too great.

In late years, however, certain changes have occurred in these conditions, and one can already discern fairly clear lines for the future development of remote control. For example, if we take a system for the remote control of an automatic power station, we can easily discern three principal functions in the system: firstly, orders given — for the starting of the generators for instance or reports concerning the load — must be translated to magnitudes suitable for long distance transmission. Secondly, these magnitudes must be transmitted from the sender to the receiver in a suitable manner; and thirdly, certain devices such as a turbine throttle or a power meter, must be actuated and controlled by the receiver. The first and last functions must be performed by organs or devices especially designed for this purpose. Since the most important uses of remote control, as already mentioned, lie within power engineering, it is natural that these devices be designed in such manner as has already been found suitable within this field. For the intermediate function — sending, transmitting and receiving of the remote control magnitudes — it is equally natural to apply experience gained within telelectrical engineering.

There is no doubt but that large and important problems within the field of remote control await their solution and these problems will be satisfactorily solved only through a most intimate collaboration between the departments of transmission and installation — or more generally speaking, between power engineering and telelectrical engineering — under close observation of the above mentioned functions of differing nature. The transmission problems involved must be the decisive factor when determining whether or no the choice shall fall on DC or AC impulsing, on back impulsing for supervisory purposes, on transmission lines with two or more wires, on separate control lines or the power lines themselves, on voice frequency or carrier systems, for the long distance transmission proper. Similarly, for the various local functions it is necessary to choose sources of power and methods of operation — compressed air, compressed oil or electric power, DC or AC, magnetic operation or motor drive — with due consideration for transmission problems.

Remote control has hitherto been developed chiefly with the aim of controlling one or more substations from a main station. Such problems arise in the coordinate operation of power plants along a water course, in the feeding of electrified railways, *e. g.*, from a number of rectifier stations, and in distribution networks with several feed points. Another problem of technical and economical importance is the remote control of an arbitrary number of instruments connected to a distribution network. Objects for this type of remote control — which must be available to one and all, in the same way as broadcasting — are electricity meters with double tariff metering, devices for the switching on and off of street lights and for the connecting and disconnecting of various loads at times, determined by the electric power stations with respect to the supply of surplus power etc. Interesting future problems for telesignalling are here foreseen.

Wireless

Hardly any other branch of telelectrical engineering is so dependent on the development of the electronic valves as that of radio engineering. For wireless sending stations we find that first of all it is the low overall efficiency as compared with other types of electrical plants that is the most strikingly characteristic. This is to a large extent due to the imperfections of the otherwise so highly developed electronic valves. A continued development of electronic valves, resulting in a higher specific emission, better screening and more advantageous qualities for the short and ultra-short wavelengths, is desirable from an economical as well as a technical point of view. As an example of the tendencies in development which would imply that this desire is likely to be realised, there may be mentioned high power water-cooled pentodes and a number of attempts towards a radical change in the placing of the electrodes in the valves.

Also, the quality of reception depends largely on the types of electronic valves available. Valves for all imaginary purposes, from triodes to octodes, are now available in an unusually large variety of models. This is largely due to competition, to the search for new combination valves for automatic volume control, for instance, as well as for other special purposes, and to demands for a higher degree of amplification, greater output and smaller distortion. Due to its dominating economic importance, broadcasting dominates the manufacture of valves for reception purposes. Valves for other purposes, such as for telephone repeaters and carrier equipments for telegraphy and telephony, for commercial radio receivers and for measuring purposes, are still to be regarded as by-products, seen from an economic point of view. As regards development, the wireless receiver valve still leads the field, and this condition will probably prevail for some years to come. It is to be hoped, however, that a certain standardization of the types of valves will be arrived at, even though improvements may be expected to take place for a long time to come.

The interest of the general public as to what equipment or parts are contained in a radio receiver is definitely on the wane. Even the radio expert must admit that it really does not concern the customer whether the case contains a superheterodyne or a more or less straight receiver, a loudspeaker with gilded wire-screening, silver tone and copper windings, x circuits or n valves, if only the receiver possesses those qualities which have a definite bearing on the rendering of sound and a finish which appeals to the eye and to varied tastes. Development within this branch has a tendency to identify itself with that of automobiles, vacuum cleaners and telephones. In this connection it may be of interest to mention that certain attempts have been made to obtain norms for judging the inherent qualities of radio receivers. Is it possibly along such lines that better quality will be obtained or will competition between the different manufacturers be the necessary incentive for development in this direction? Will certain marks of quality be resorted to in order to denote the quality of a radio receiver, or will certain trademarks constitute the criterion of a good quality as in other branches of industry?

Another question of vital interest in broadcasting is how to make room for the growing number of wave-lengths for commercial telegraphy and telephony as well as for broadcasting programs without causing reciprocal disturbances. The short wave range will be — in fact, it probably already is — as crowded as the long wave and intermediate wave ranges now are. The ultra short wave range will be used, not only for television, but also for other radio traffic, in spite of the fact that these waves have a limited range of action. The allocaton of wave-lengths for different purposes will, for some time to come, be a question of administrative, economic and technical importance. Synchronized operation of relatively weak stations within limited geographical areas and of large stations at great distances from each other will be utilized to an increasing extent. Related problems of a purely technical character are improved arrangements for the synchronizing and stabilizing of carrier frequencies and the design and construction of aerials which restrict radiation to areas in the immediately vicinity of the sending antenna.

The purely oppositional problem, *i. e.*, of concentrating electro-magnetic radiation within a certain small solid angle, is of vital importance for radio lighthouses and for direct radio communication between two localities. In connection with the development of short wave and ultra short wave, commercial wireless telegraphy and telephony, this problem gains in interest, and it is to be presumed that scientific technical research within this branch has not yet said its last word. Another difference in character between broadcasting and radio communication between two localities is the demand for secrecy in the latter case. Radiation confined to a certain channel causes no difficulties in this respect; with the use of code it is possible for wireless *telegraph* communication to evade these difficulties, but the continued success of wireless *telephony* will, to a certain extent, most surely depend upon whether the measures now taken for the retaining of the private character of a conversation — the dividing up of the voice frequency range into a number of frequency bands and a mingling and reversal of frequency of these bands — can result in constructions reliable in operation and at reasonable prices without any lowering of the quality of speech.

During the forty years that wireless has existed, research and engineering in this branch has proved to be of value, not only directly for the development of wireless but also indirectly within other branches of science and engineering. A knowledge of the nature of the atmosphere and the ionosphere, as well as investigations of all types of electromagnetic radiation now controlled by man, have been stimulated by radio-technical research. Metal rectifiers, electron and ion-discharge tubes, cathode-ray tubes and new material with special dielectric qualities have, to a certain extent, been produced as a result of and complementary to developments within wireless engineering. It is as desirable as it is certain that this reciprocal influence shall continue and be further developed during coming years.

Television

Following years of serious endeavour, the technical development of television has now reached a certain stagnant condition, presumably of a temporary character, however. From a technical point of view the lines to be followed are clearly discernible even though the working out in detail of many problems still remains. The clearness of outline has been greatly improved due to the increase in the number of lines and the introduction of interlaced scanning by leading manufacturers. The size and the luminosity of the pictures are still insufficient to satisfy a layman television spectator, however. On account of these defects, as well as for other reasons, the production of television receivers has heretofore only taken place on a very small scale, prices being consequently prohibitive.

Although many signs indicate that these difficulties can be solved, the future prospects for television must nevertheless be considered as anything but bright, economic factors preventing it from coming into its own. One must bear in mind that the broadcasting of a television program is most expensive and of very limited scope, for which reason ultra-short wave lengths must be used. In order to make television as widespread and of the same social importance as radio broadcasting, the installation of a very large number of sending stations would be required with present technical resources. The financial outlay for separate studios with all the necessary equipment is considerable. As in radio broadcasting, however, it is possible to use common programs for several sending stations. The previously mentioned coaxial cables provide a solution which no doubt will attract much attention, but the cost will be the same or even higher than for the television senders themselves. Instead, the final solution may possibly be a combination of directed ultra-short wave transmission between the relay senders and of the broadcasting from these senders of the programs stage by stage from the studio to the television spectator. Many interesting technical novelties may with certainty be expected as by-products of the assiduous research work which has taken place and is still going on in the field of television. To restrict ourselves to a single example, we will mention the night telescope, the functioning of which is based on the use of photo-electric cells and electron multiplers for the converting of invisible ultra-red radiation to visible light.

For the present the economic problems within the field of television are much more difficult to master than the technical ones; this is applicable especially to such questions as touch on competition between the theatre, the sound film, broadcasting and television. The first sure signs that television is a factor to be reckoned with will possibly be discussions concerning unemployed stage and movie actors and their attitude to this new technical creation. This was the case with musicians during the early years of radio broadcasting, and such will also probably be the case when television has come to the front.

The Telephone in the Service of the Railways III

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

In the Ericsson Review No 4, 1937 and No 1, 1938, the telephone systems used for communication between instruments connected to a common two-wire circuit along a railway line were described. In order to obtain the most valuable service from such telephone installations, however, intercommunication — preferably automatic — should be provided with the telephone installations at the railway stations.

In the following will be found descriptions of some automatic switchboards built by Ericsson for this purpose, as well as an account of how the telephone installations in a railway district can be combined to automatic network groups.

The most important requirements, with regard to traffic, which in general must be met by automatic switchboards intended for railway telephone networks can be summed up as follows: automatic internal traffic, automatic or manual main exchange traffic; automatic or manual traffic with other exchanges within the railway telephone network; automatic traffic with selective calling lines connected to the exchange; automatic outgoing and manual incoming traffic with railway telephone lines connected to the exchange.

The demands for telephone facilities at the different stations within a railway system vary considerably, however. In many cases two or three telephones are sufficient, while in other cases several hundred are required. In order to meet these varying demands, Ericsson has designed a series of suitable automatic switchboards, each size and model of which provides the most favourable solution as regards economy as well as traffic.

Small Automatic Switchboards

At small railway stations, where the number of telephones will not exceed nine and where the traffic is so light that one single link is sufficient, a switchboard OV 1200, Fig. 1, should be used. This switchboard is especially designed for intercommunication with the Ericsson selective calling telephone system with decentralized selection and it can be regarded as a selective calling section concentrated within the station area, where all of the telephone connections proceed from the selector units of which the exchange is formed. This switchboard has a capacity of 9 telephone instruments, and terminals for 8 selector sections. The discriminating digits are *1—8* and the instrument numbers *01—09*. On the other hand, the switchboard cannot be provided with equipment for main exchange facilities; direct lines or a PBX switchboard must be provided for this traffic. However, since switchboard OV 1200 is intended for the use of very small stations only, one single telephone is usually sufficient to handle the main exchange traffic and it is consequently uneconomical to complicate this automatic switchboard with the necessary equipment for the above-mentioned facilities.

Fig. 1 X 3857
Automatic switchboard OV 1200

The switchboard OV 1200 is designed for direct connection to the line equipment or interconnecting equipment of a selective calling line, see the Ericsson Review No 1, 1938. With the aid of this equipment it is possible for the telephones connected to the switchboard to obtain communication with all other telephones within the network of the railway and which can intercommunicate with the selective calling line in question. The component parts

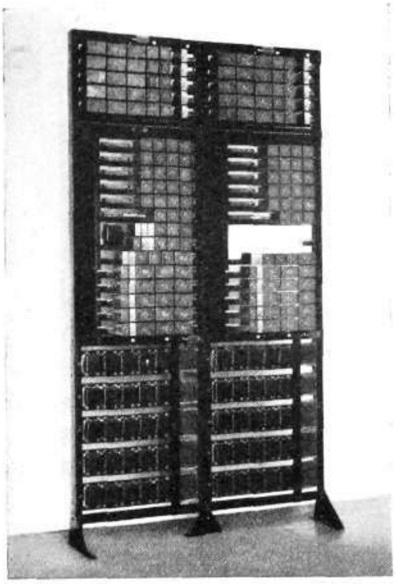


Fig. 2 X 3850

Automatic switchboard OL 45

top, relay repeaters for main exchange traffic; center, line relays and link equipment; lower, switches

of the switchboard — a twelve-line selector switch and some relays — are mounted under a dust proof metal cover of small dimensions. The connecting up of the switchboard with the selective calling line and station equipment takes place in a terminal box.

Normal selective calling telephone instruments DS 1100 equipped with an extra DC bell RA 420 or a buzzer RC 5420 are used with this switchboard. Since a call between a selective calling telephone and a station telephone occupies the selective calling line as well as the automatic switchboard, it is suitable to provide the telephones having heavy traffic to the selective calling line with a two-way switch RL 201 and with a calling device on the selective calling line a well as on the line to the switchboard. Connection can then be obtained as required either to the selective calling line or to the automatic exchange. Calling signals are received over both lines independently of the position of the switch.

The switchboard operates on a 24 V current, the required current being obtained from the ordinary 24 V battery for the selector equipments. The amount of current required for the switchboard is negligible, since the feed for the telephone instruments as well as for the selector telephones is obtained from 5.5 V dry cells connected to each telephone.

Medium Size Automatic Switchboards

Switchboards to suit varying demands as to traffic and range of usefulness for medium size stations have been designed by Ericsson.

The automatic switchboard OL 45, Fig. 2, specially designed for smaller telephone networks with a small number of connections between the exchanges, is the one hitherto most extensively used. This switchboard is intended for a maximum of 90 extension and junction lines and 20 simultaneous calls, but is furnished also for smaller numbers of extensions and links. As long as the number of telephones is less than 40 and the links are less than 5, only one rack is required, on which all the required switching devices for the internal traffic are mounted. When extended to its full capacity the automatic switchboard comprises four racks. The switchboard is provided with equipment giving main exchange facilities, for inter-traffic with selectice calling lines, railway telephone lines and other automatic exchanges within the railway network. The required number of repeaters is mounted either in a bay on top of the rack or, if the number of repeaters is large, on a separate bay which also has room for 5 extra link equipments.

The selector switches are composed of 25-point step-by-step rotary switches, which are used both as line finders and connectors. All relay sets are joined to the switchboard cables by means of plugs and jacks, no soldering being required. The switchboard requires a 24 V battery current. The call numbers series is *10—99*. Normal telephone instruments, such as DBH 1101, DBK 1101 or DBN 2201, are used.

The traffic possibilities of this switchboard may be quite extensively varied and are consequently easily adapted to the requirements of different railway administrations. If main exchange facilities are desired, the switchboard is provided with specially constructed relay repeaters as well as a manual switchboard. Outgoing main exchange connections are obtained by dialling the digit *0*, causing a disengaged main exchange circuit to be automatically hunted out. The main exchange can be of any system, *i. e.*, LB, CB or automatic. In the latter case, the connection is automatically obtained. The incoming traffic is always handled by an operator. If the automatic exchange is equipped with repeaters for the main exchange traffic, the following are some of the available special features, *viz.:* restricted service for certain telephone instruments; manual making and breaking of connections by the operator; night connection for certain telephone instruments, permitting the originating of intercommunicating and main exchange calls as usual; inquiry call to operator; inquiry call to arbitrary extension instrument; transfer of a main exchange call to an arbitrary extension instrument with unrestricted service;

special waiting connection for incoming calls to busy extension. The switchboard can also be provided with other facilities of a more special character, such as staff locating, conference calls etc.

Automatic junction traffic between switchboards of type OL 45 and other automatic exchanges or selective calling lines is established by means of open discriminating digits. The repeaters are designed for DC, AC or voice frequency impulsing, depending on the characteristics of the junction lines. Since the Ericsson selective calling system operates on direct current, the repeaters for junction traffic with an automatic exchange and a selective calling line are very simple. A relay repeater is connected for this purpose between the automatic exchange and a line equipment or interconnecting equipment on the selective calling line. For traffic from the selective calling line to the switchboard, a single discriminating digit is dialled, followed by the desired number. For traffic in the opposite direction, the number to which the selective calling line has been connected in the automatic exchange is first dialled, followed by the number of the desired selective calling instrument. If the selective calling line is engaged, connection is nevertheless obtained with the parties engaged in conversation, who can then be requested to terminate their conversation in order to receive a more urgent call.

Railway telephone lines with code signalling can also be connected to the automatic exchange, in which case traffic to the railway telephone line can be automatically handled, traffic in the opposite direction being always handled over a manual board. Code signalling with automatic traffic is obtained by means of the dial, in which case a low digit, for instance *1* or *2*, corresponds to a dot, and a high digit, for instance *6* or *7*, corresponds to a dash in the Morse alphabet.

Large Automatic Switchboards

In the largest railway stations, in which the administration offices are often located, the need for railway telephone extensions is exceptionally large. On certain occasions, for instance on the days preceding holidays, traffic intensity reaches decidedly higher values than is the case in other private exchanges of a corresponding size. The automatic exchange which is to handle the telephone traffic at such railway stations must consequently have

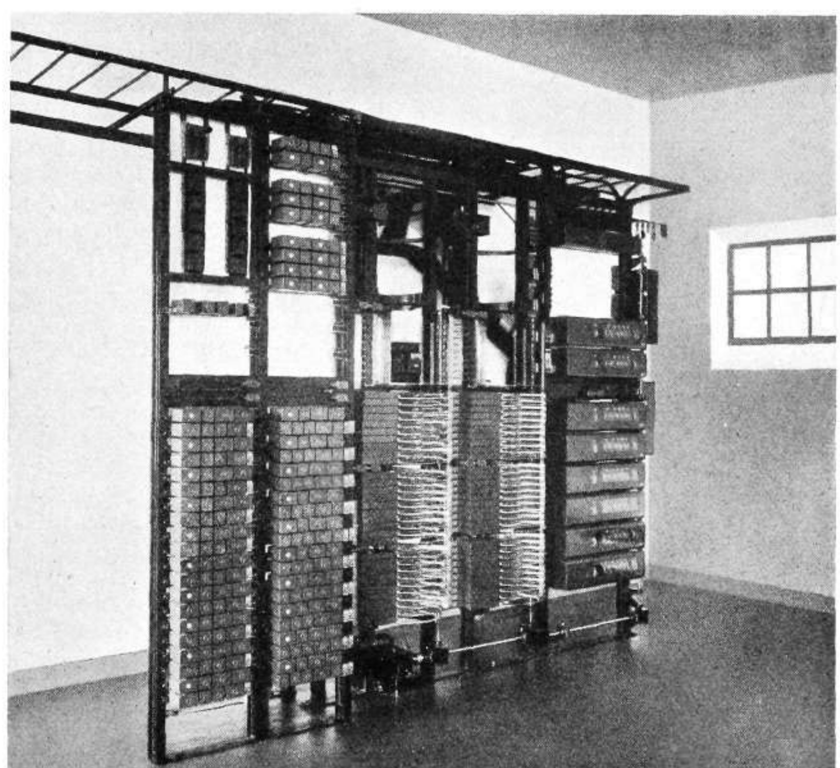


Fig. 3 X 5473

Automatic switchboard, system OS

at left, relay repeaters for inter-traffic; in center, line finders and connectors; at right, registers; the line relays are mounted on separate rack

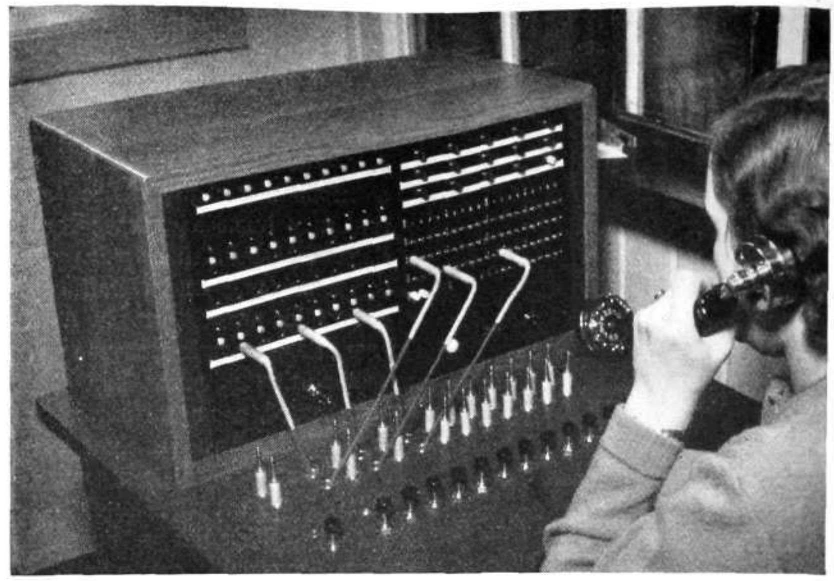


Fig. 4 X 5398
Manual board for automatic exchange

facilities for a very large number of subscribers, must be able to handle a large number of calls per telephone instrument, and easily adapt itself to fluctuations in the traffic load. These requirements are fully met by Ericsson automatic switchboards, system OS, with 500-line switches. This type of switchboard can be provided with an arbitrary number of extension lines and a number of links corresponding to all traffic loads of practical interest. The excellent adaptability of these switchboards to fluctuating loads is due to the large capacity of the switches. For instance, if the switchboard is built for 500 lines, all these lines constitute one single group in which each telephone has access to every disengaged selector within the exchange, no matter how the load is distributed within the group.

The design of the automatic switchboard, Fig. 3, as well as of the manual board, Fig. 4, must naturally vary with the size of the installation and the traffic requirements to be met by the installation. The traffic features offered by the switchboards, system OS, of regular design have been described in the Ericsson Review No 4, 1935 and No 3, 1937, these being chiefly as follows: originating of automatic main exchange calls by dialling the digit *o;* manual transfer of incoming main exchange calls; restricted service for certain extension sets; manual making and breaking of connections by the operator; automatic inquiry and transfer possibilities during the course of a main exchange call; night connection. In addition to these features, which are part of the standard equipment, the switchboards can be equipped for a large number of additional features, such as conference calls, preference calls, staff locating and supervisory service. As with the above described switchboard OL 45, a switchboard of the system OS can also be provided with relay repeaters for automatic as well as manual junction traffic between this switchboard and other telephone installations within the telephone network of the railway. These repeaters are largely of the same design as for the switchboard, OL 45, and junction traffic takes place in the same manner as already described, that is with open discriminating digits.

As with other switchboards of Ericsson manufacture, automatic switchboards of the system OS require a 24 V operating current. Normal telephone instruments, such as DBH 1101, DBK 1101 or DBN 1101 can be used. The telephone instruments are connected to the switchboard by two-wire lines.

Automatic Network Groups

Like public telephone networks, railways are to an increasing extent introducing automatic junction traffic between the various automatic exchanges in their telephone networks. Consequently, railway administrations are being confronted by the same problems as were the telephone administrations during the automatizing of trunk traffic, *i. e.*, the grouping together of telephone exchanges within the network into network groups; the improvement and, if possible, the re-arrangement of the junction circuits; the choosing of a suitable numbering scheme for the junction traffic between the exchanges, and to define the requirements to be met by the junction equipment.

In telephony, automatic network groups are understood to mean a number of telephone exchanges generally grouped around a larger main exchange and between which all junction is automatically performed. Although it is customary, in manual network groups, to erect direct lines between sub-exchanges and the main exchange, and often also between adjacent sub-exchanges, in order to reduce the number of operators required to establish a connection, in automatic network groups — on the other hand — junction network is given a radial structure. A network lay-out of this kind permits a considerable reduction in the total number of line bundles in the network group, this, in turn, permitting a more efficient use of the constituent circuits, the efficiency of a circuit being greater the larger the bundle in which it is located. A network group of this type, Fig. 5, consequently contains a main exchange, located in the principal community within the group, and to which a number of center exchanges and end exchanges are radially connected. Other end exchanges and, in certain cases, some center exchanges are in turn connected to the center exchanges.

Naturally, it is a very difficult enterprise to construct a telephone network for a railway along these ideal lines. That which is of basic importance for a railway must always be the railway system itself, to which all other features within the operation of the railway must adapt themselves. Any telephone system must consequently — in order to obtain any degree of popularity with the railroad — permit of the building up of a network of practically any arbitrary form; consequently, the Ericsson network group system has been devised so as to permit of its use even when the network is not radially constructed. It is desirable, however, to have the radial form of a network in mind also when planning the railway itself, as this will permit a great saving in the cost of the network. Should it be found desirable, however, there is nothing to prevent the building of direct junction circuits between certain exchanges as, *e. g.*, between *K 1* and *K 3*, in Fig. 5.

It is very difficult to determine the size of the automatic network groups, as this depends to a large extent on the arrangement of the railway system. If possible, the extent of the network groups should correspond to the administration areas of the railway, *i. e.*, districts or sections; if these are very large, however, they should be divided up into several network groups. It is often recommended that the network group be planned so that conversations within one network group can be carried on without the aid of an amplifier, thereby simplifying the junction equipment. In certain cases, however, sub-dividing cannot be carried on along these lines, especially if the junction network consists of cables.

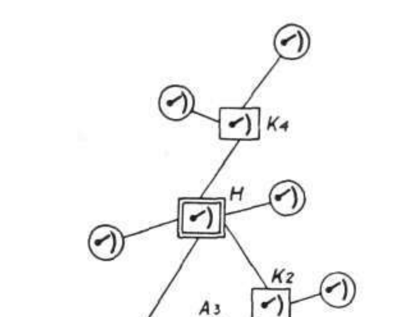


Fig. 5
Automatic network group

main exchange

center exchange

end exchange

If automatic operation is provided for the junction traffic between different telephone exchanges within a network group, traffic between adjacent network groups should also be automatically handled. The greater part of the traffic between the network groups should be carried over the main exchanges of these groups. Direct traffic between sub-exchanges belonging to different network groups can be arranged, however. For traffic between network groups, amplifiers are generally required for the connecting circuits, requiring special arrangements for the repeating of the impulses and the signals.

It is of the utmost importance for the speedy development and efficacy of the telephone traffic that the exchanges within the network are numbered in a manner which is both simple and natural and so that the numbers of the most commonly occurring connections contain as few digits as possible. Two numbering schemes, based on different principles, can be used, *i. e.*, with open or closed numbering. In order to understand the difference between the two numbering schemes, it is necessary — for the identification of a certain

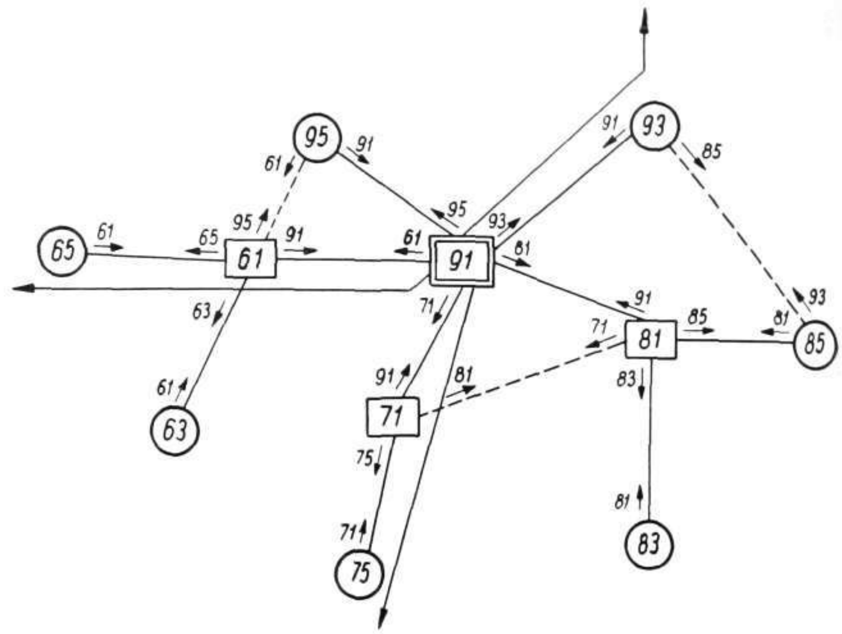


Fig. 6 X 5455
Automatic network group
with open discriminating numbers for the junction lines

telephone connection within the network group — to first determine to which automatic exchange and thereafter to which line within the exchange the telephone is connected. In all network group traffic, the calling number must consequently consist of two parts, namely the *discriminating number,* which indicates the exchange, and the *subscriber's number,* which indicates the subscriber's line. The difference between the two numbering schemes lies in the fact that with open numbering the discriminating number is denoted separately from the subscriber's number and is dialled only when traffic occurs between the automatic exchanges, while with closed numbering, on the other hand, the discriminating number is combined with the subscriber's number and is always dialled. Although closed numbering has been largely adopted within commercial networks, the open numbering is of decided advantage for railways where the exchanges are located at great distances from each other and the number of local calls is usually large as compared with the junction calls.

Open numbering can be arranged in two different ways. According to one of the numbering schemes, each bundle of junction lines is given a certain number, chosen so that all of the bundles entering a certain automatic exchange are given the same number. The advantages of this system are the relative simplicity and cheapness of the junction equipment, the fact that the discriminating numbers for the most common connections have only two digits, and that all advance occupation of the junctions is avoided, see Fig. 6. For instance, if a subscriber belonging to one of the exchanges *61, 71, 81, 93* or *95* wishes to originate a call to a subscriber within main exchange *91,* he only needs to dial the number *91* and then the subscriber's number. For traffic in the opposite direction, the main exchange subscriber dials the number of the desired exchange followed by the subscriber's number. This simple process can only be used, however, when the exchanges in question have direct junctions between each other. Should this not be the case, the subscribers must dial the discriminating numbers of the intermediate exchanges before dialling the discriminating number of the desired exchange. Such connections are not of such common occurrence, however, since the largest numbers of calls are exchanged between adjacent exchanges. In actual practice, it has been found that this method of dialling is very quickly learned by the staff and does not occasion any mistaken dialling. Since this junction traffic system can be obtained with simple and low-priced equipment, it can be recommended for telephone networks which are not too complicated and with only a small number of junctions between the exchanges.

With the numbering scheme using open discriminating numbers, each automatic exchange within the network group is given a three digit number, which constitutes the discriminating number of the exchange and by which it can be called from any other automatic exchange in the network group. These discriminating numbers must always begin with the same digit, *e. g.*, *9*, which consequently must not occur as the first digit in the subscriber's number. Also, the discriminating number can start with the digit *o*; according to what has previously been stated, however, this digit should be reserved for public main exchange traffic. The numbers *1—8*, *10—89*, *100—899* etc. can be suitably used as subscriber's numbers. By dialling the digit *9*, the subscriber indicates that he has a junction connection in mind and his call is immediately connected through to special junction equipments which perform the necessary switching operations.

Fig. *7* illustrates the schematic lay-out, of the network in a portion of a railway telephone network comprising two network groups, each with a main exchange and radially connected center and end exchanges. It is presumed that all switching within the network group as well as between the network groups is automatically performed. Junction traffic between the larger stations is handled over automatic exchanges at these stations and automatic junctions lines between them; junction traffic to the smaller stations is carried over selective calling lines, selective calling exchanges or railway telephone circuits. For all junction traffic between the automatic exchanges, open discriminating numbers are used according to a numbering scheme in which each automatic exchange is called by means of a certain definite number irrespective of the identity of the originating exchange. The exchanges may then be numbered as shown in Fig. *7*, all the exchanges having three-digit discriminating numbers beginning with the digit *9*. In order to obtain uniform numbering for the traffic between the exchanges in spite of the fact that the connections to the different exchanges are established over different routes and over a varying number of intermediate exchanges, one of two solutions on varying principles may be chosen. Either all calls beginning with the digit *9* are immediately connected to the main exchange of the network group from where the remaining switching procedure is controlled forwards or backwards depending on the dial number; or repeating

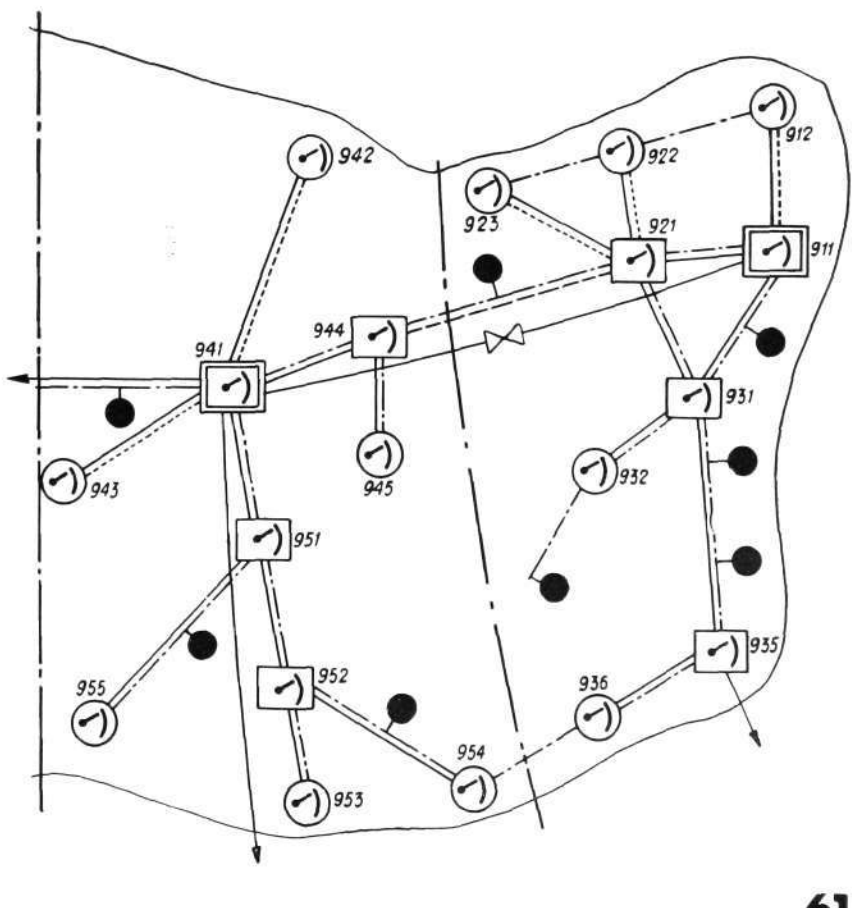


Fig. 7 X 5454

Automatic network group

with open discriminating numbers for the automatic exchanges

- main exchange
- center exchange
- end exchange
- selective calling switchboard
- automatic junction line
- selective calling line
- railway telephone line
- tie line
- 911 discriminating number

registers, or group registers — which control continued establishing of the connection to the desired subscriber —, are introduced in the center and main exchanges. With the first-mentioned system, certain parts of the line — not required during the conversation — must consequently be subjected to advance occupation during certain calls, this being avoided in systems with registers. Another advantage with register controlled network group traffic is that the numbering of the exchanges within a network group does not have to be on the decimal system, thereby permitting a more efficient use of the available number series *901—999* than with a direct controlled system. Also, in register controlled systems it is not necessary to introduce an extra network group number in the discriminating numbers for junction traffic between the network groups, but here also it is possible to use the same three-digit discriminating numbers as with traffic within a network group; this question has already been treated in the Ericsson Review No 3, 1937.

Ericsson installs systems with direct as well as register control, and is consequently in a position to advise as to the most suitable system for each network group. The most economical solution is often obtained by combining both systems, the direct controlled system being used for traffic within a network group, registers being brought into circuit only for traffic between the different groups. In such a case only the main exchanges need be equipped with registers.

Speaking connections are established in the same way in the direct controlled as in the register controlled systems; for local connections, only the number of the desired subscriber is dialled, and for main exchange connections, first, the three-digit discriminating number is dialled, followed — on receiving a new dial tone — by the subscriber's number. Selective calling lines and railway telephone lines can be connected to each automatic exchange as previously described. Traffic over these lines takes place in the same manner as the junction traffic between the exchanges with open discriminating numbers. If one wishes to obtain a connection with a certain remotely located selective calling telephone instrument from an automatic exchange, the discriminating number for the exchange to which the selective calling line is connected is first dialled, after which the discriminating number of the selective calling line followed by the number of the desired telephone instrument is dialled. Since selective calling lines are usually connected to two automatic exchanges, it is of no importance over which of these exchanges the connection is obtained. When calling a remote automatic exchange from a selective calling line, the selective calling subscriber must first obtain a connection to the nearest automatic exchange by means of a discriminating number, after which he occupies the same position as a subscriber on this exchange for subsequent switching operations. Calls to subscribers connected to the railway telephone lines take place in the same manner as calls to selective calling subscribers. For calls in the opposite direction, on the other hand, these subscribers require the services of the manual operator at the station exchange to which the railway telephone line is connected up.

Many railway administrations install manual switchboards at the largest stations in order to have recourse to manual switching in case of trouble at the automatic exchange, and the better to utilize the junctions during exceptionally heavy traffic. The possibility of cross-connecting all the automatic junctions to a manual switchboard when necessary is consequently desirable. Even when a call is automatically established, however, the operator should be able to cut in on the conversation and break the connection in favour of a more important call. If there is a manual board, the subscribers have also the possibility of ordering calls from the operator who then establishes the desired connection as soon as the required junctions are disengaged. Operators can also be used for the routing of calls to and from other railway districts that have not yet been automatized. In network groups with but few junctions, manual service is often applied between the most important stations during the busy hours, and automatic switching during the remainder of the day. Such an arrangement permits a reduction in the cost of the junction network without detrimentally affecting the service.

Single Channel Carrier Telephone System for Cables

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

In recent years carrier systems have been utilized to an ever increasing degree for the solving of telecommunication problems within different domains. Carrier transmission over wires was originally intended solely as a means of increasing the traffic capacity of aerial lines and open wire carrier systems still play an increasingly important part. In opposition to this development, there stood — where the requisite economic conditions existed — the building of trunk cable networks, tending towards the discontinuance of open wire lines and consequently also of carrier current communications. The situation is now changed, however, modern engineering practice having made possible the use of cables also for carrier transmission. This means of communication has been found to imply such great economic advantages that we find ourselves confronted by nothing less than a revolution within cable telephony, where carrier communications will play the leading role. Cable circuits can be utilized in various ways for carrier communication, and for this purpose Ericsson has developed different carrier systems, among them a single channel system for carrier current telephony over light-loaded cables.

With long four-wire cable circuits it has been found desirable to improve the transmission properties by reducing the propagation time of the cable circuit. This is obtained by raising the cut-off frequency of the loading. Medium light loading, with cut-off frequencies of about 5 800 c/s for the side circuit and 7 000 c/s for the phantom circuit, is being replaced by light loading with cut-off frequencies of about 7 800 c/s for the side circuit and 9 600 c/s for the phantom circuit, as recommended by the CCIF. A wide frequency range between the voice frequency band and the cut-off frequency is hereby obtained, however, which range offers itself for utilization. Already with medium light-loaded four-wire cables there existed an unused frequency range above the speech band, utilized by some administrations for a carrier telegraph channel by means of the super-audio telegraph system, the telegraph currents being amplified in the same amplifiers as the speech current. This system was described in the Ericsson Technics No 6, 1933.

An example of the utilization of the entire frequency range with medium light loading is the two-band telephone system used in Germany and intended for submarine cables with large repeater spacing. The width of the normal speech band in reduced sufficiently to make room for a superimposed carrier band used in the opposite speech direction.

With light loading there arises such a wide range between the voice frequency speech band and the cut-off frequency of the cable as to provide room for a telephone band of normal width, 2 400 c/s. This circumstance is utilized in the Ericsson single channel system for cables.

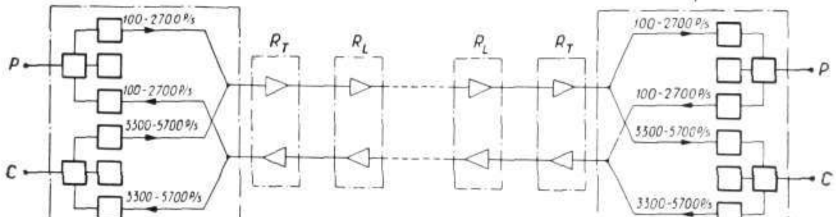


Fig. 1 X 5463

Diagram of single channel system ZL 500

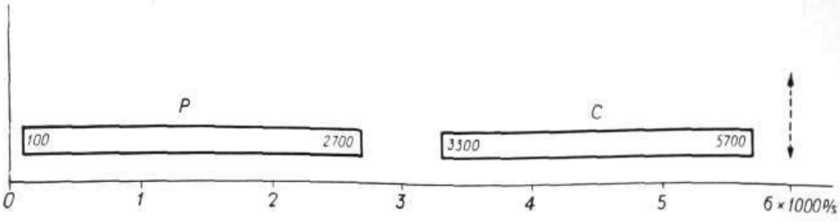
C input of carrier channel
P input of voice-frequency channel
R_L four-wire repeater
R_T four-wire terminal repeater
T terminal equipment

Fig. 2 X 5464

Frequency allocation of single-channel system ZL 500

C carrier channel

P voice frequency channel



General Characteristics

The Ericsson single channel system ZL 500 for cables is used on four-wire circuits with a cut-off frequency not lower than 7 500 c/s and allows — in addition to the regular voice frequency channel — a carrier four-wire circuit, see Fig. 1. The frequencies below 2 700 c/s are used for the voice frequency channel band, those for the carrier channel being from 3 300 to 5 700 c/s, with 6 000 c/s as carrier frequency, see Fig. 2. Consequently, the carrier band corresponds to the speech band 300—2 700 c/s. The carrier frequency and upper side band are suppressed. The voice frequency and carrier channels are amplified in common line repeaters. Due to the existence of non linear distortion in these, there arise modulation products of each of the channels, which fall within the frequency band of the other channel, causing non-linear cross-talk. This latter is unintelligible and does not endanger the secrecy of telephone communications, but it does cause a disturbance in the rhythm of speech and should consequently be held down to the same level as common cross-talk. This places requirements on the repeater linearity, generally not met by regular four-wire repeaters unless special measures are taken. The non-linear cross-talk can also be reduced through a cutting off of the peaks of the voice frequency voltage by means of an amplitude limiter. This causes a certain distortion but investigations have shown that the syllable articulation is not sensibly reduced even with a reduction of the greatest amplitude in the ratio 2.5 : 1.

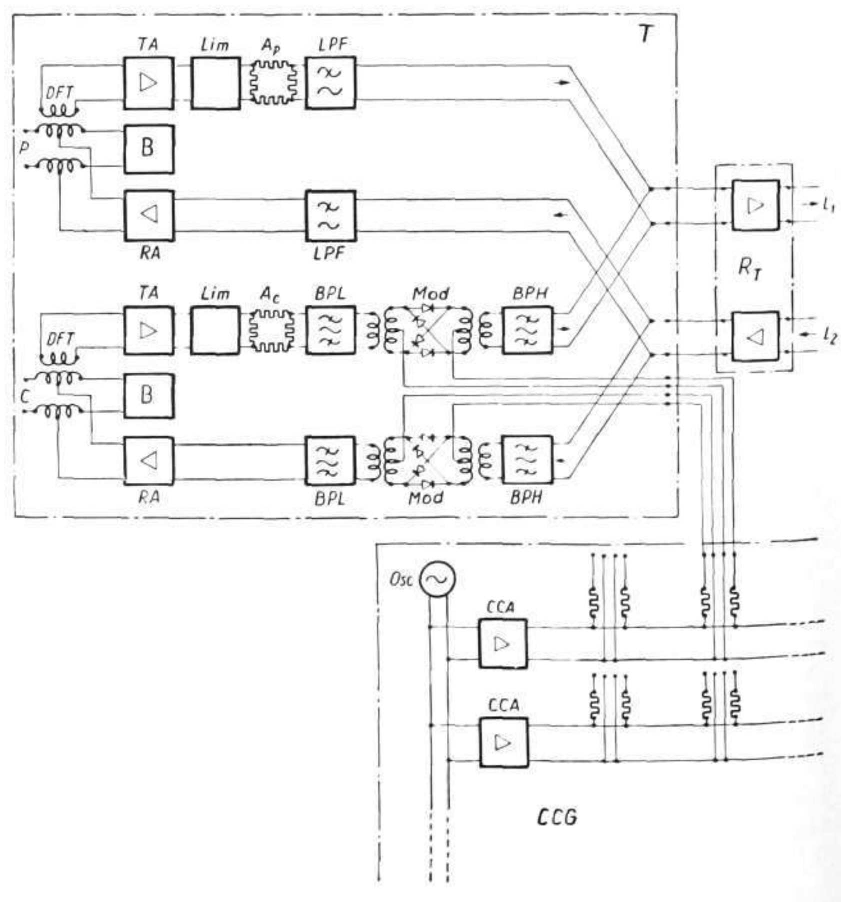


Fig. 3 X 5465

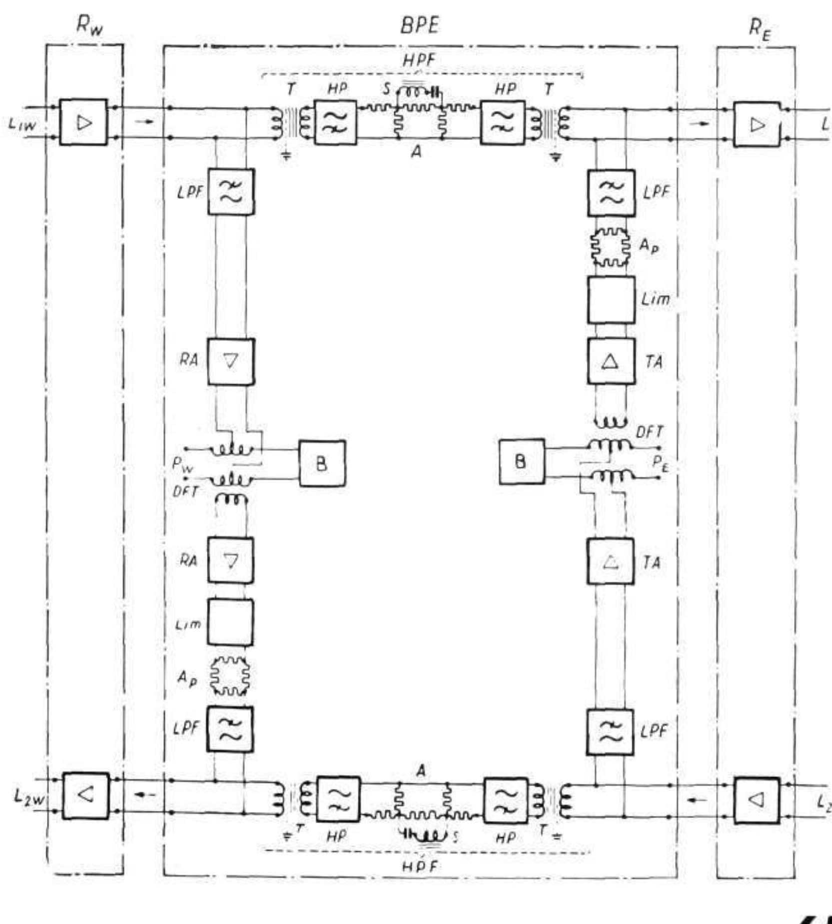
Circuit diagram for terminal equipment

A_P, A_C	attenuation pads
B	two-wire balancing network
BPH	high frequency band-pass filter
BPL	low frequency band-pass filter
C	input of carrier channel
CCA	carrier amplifier
CCG	carrier generator
DFT	differential transformer
Lim	amplitude limiter
LPF	low-pass filter
Mod	rectifier modulator
Osc	carrier oscillator
P	input of voice frequency channel
RA	receiving side of fork amplifier
R_T	four-wire terminal repeater
T	terminal equipment
TA	transmitting side of fork amplifier

Terminal Equipment

A terminal equipment comprises two main parts, *viz:* the terminal equipment of the voice frequency channel and of the carrier channel respectively, see the diagram, Fig. 3. The differential transformer *DFT*, which shifts over from the two-wire to the four-wire circuit, is a constituent part of the fork repeater which has two parts, the transmitter amplifier *TA* and the receiver amplifier *RA*. In the transmitter side are included an amplitude limiter, *Lim*, an attenuation pad A_P, followed by a low pass filter *LPF* which admits frequencies of up to about 2 700 c/s, thereby preventing the disturbing of the carrier channel. The output side of the low pass filter is connected to the outgoing four-wire branch L_1 through the terminal repeater R_T, which does not form a part of the carrier equipment. The speech currents arriving over the four-wire branch L_2 are amplified in the terminal repeater R_T and meet two filters *LPF* and *BPH*, which are connected in parallel. The first one is a low-pass filter of exactly the same kind as the one which forms a part of the transmitter side of the voice frequency channel, and only admits frequencies lying below about 2 700 c/s, while the band-pass filter *BPH* blocks such frequencies. The receiving part *RA* of the fork repeater follows after the low-pass filter.

The fork repeater and the amplitude limiter of the carrier channel are the same as in the voice frequency channel. On the transmitter side there then follows an attenuation pad A_C, and a low frequency band-pass filter *BPL* which admits the frequency band 300—2 700 c/s. The carrier frequency 6 000 c/s is modulated with the speech frequency in the rectifier modulator *Mod*. Only the lower of the side bands formed during modulation is filtered through the high frequency band-pass filter *BPH*, namely 3 300—5 700 c/s, and pass over the outgoing branch L_1 of the four-wire circuit. In the receiver of the carrier channel there is a modulator *Mod* with filters *BPH* and *BPL*, all identical with the corresponding elements in the transmitter. Here the incoming carrier band of 3 300—5 700 c/s is demodulated and reduced to



X 5466

Fig. 4
Circuit diagram for by-pass equipment

- A, Ap attenuation pads
- B two-wire balancing network
- BPE by-pass equipment
- DFT differential transformer
- HP high-pass filter
- HPF high-pass filter panel
- Lim amplitude limiter
- LPF low-pass filter
- P_E input of voice-frequency channel, east
- P_W input of voice-frequency channel, west
- RA receiving side of fork amplifier
- R_E four-wire repeater, east
- R_W four-wire repeater, west
- S equalizing network
- T transformer
- PA transmitting side of fork amplifier

300—2 700 c/s. The carrier currents for the modulators are generated in a valve oscillator *Osc*, driving a number of carrier current amplifiers *CCA*, each one of which is sufficient for feeding ten terminal equipments.

Protectors and switches for the various valve groups are mounted on current distribution panels, which are also provided with jacks for the measuring of the filament and anode voltages of each valve, and relays and lamps for alarm signals of various kinds. A measuring panel is provided with one voltmeter and one milliammeter for checking the voltages of the current sources and the condition of the valves. The instruments are connected to plug cords. The line and other jacks are assembled on a jack panel.

By-Pass Equipment

Should it be desirable to terminate a number of connections at an intermediate station it is suitable to use the voice frequency channels for this purpose and permit the carrier channels to pass by. In order to make this possible, a by-pass equipment ZL 550 is used for each terminated circuit. The principles are shown in the diagram, Fig. 4. Each four-wire channel is provided with a high-pass filter panel *HPF*, consisting of two transformers *T*, two high-pass filters *HP* connected by means of an attenuation pad and equalizing network *A*. On each side of *HPF*, the voice frequency channel is tapped off through the low-pass filters *LPF*; the transmitters and receivers being in all other respects built up in identically the same manner as the VF part of the terminal equipment. Consequently, the switchboard terminals P_W of the left differential transformer give connection to »west», as compared with the intermediate station terminals P_E giving a connection to »east». Four-wire repeaters R_W and R_E are connected on both sides of the by-pass equipment. The attenuation pad *A* in the high-pass filter *HPF* causes the carrier currents to come in the correct level as compared with the voice frequency channel after having passed the high-pass filter.

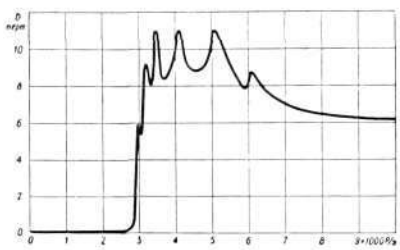


Fig. 5 X 3847
Effective attenuation of low-pass filter

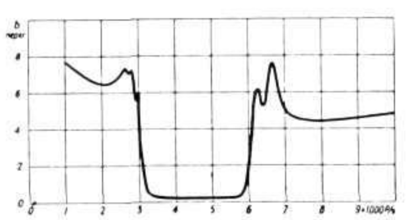


Fig. 6 X 3848
Effective attenuation of band-pass filter
on high-frequency side of modulator

Fig. 7 X 3849
Effective attenuation for high-pass filter
in by-pass equipment

Current Consumption

Marconi-Osram valves with a filament input of 0.15 A are used. The filaments — not more than four in number — are connected in series, these filament chains being fed from a source of current with a nominal 24 V tension. It is suitable to use a voltage of 21 ± 0.5 V, regulated by means of carbon pile regulator. The amplitude limiters obtain their grid bias from the filament current battery relays, alarm lamps etc. obtaining their current from the same battery. The grid voltages are generally tapped off at suitable points along the filament circuits. However, the carrier current amplifier *CCA* requires larger grid voltage than can be obtained from the filament circuit; consequently part of the carrier effect is rectified and used for generating the required additional voltage, thus dispensing with grid batteries. The anode voltage for the valves is obtained from a source of current with a tension of 130 V, which also should be regulated within the normal limits 130 V ± 2 %. The current consumption for each terminal equipment, carrier amplifier (common for ten terminal equipments) and by-pass equipment is 0.15 A, 24 V and 35 mA, 130 V, and for each oscillator panel (of which two are required for each terminal station) it is 0.15 A, 24 V and 15 mA, 130 V.

Details of Design

In the cable single channel system ZL 500, the frequency bands of the voice frequency channel and the carrier channel lie very close to each other and the demands on the selectivity of the *filters* are consequently high. The attenuation curves must have a very steep rise at the cut-off frequencies without bending upwards too much already within the transmitting band. Due to the fact that only coils with iron dust cores — and consequently with low losses — are used in the filters, the desired results are obtained, as is shown in Fig. 5, 6 and 7. In most cases mica condensers are used in the filters.

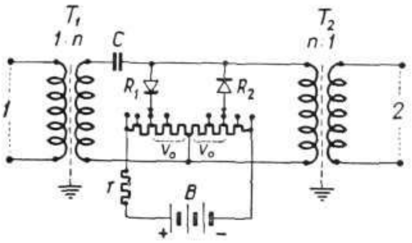


Fig. 8 X 3852
Circuit diagram for amplitude limiter

1	input side
2	output side
B	bias battery
C	condenser
P	potentiometer
r	resistance
R_1, R_2	metal rectifiers

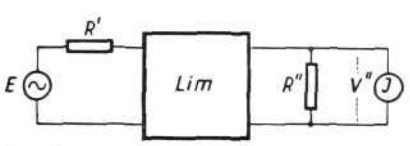


Fig. 9 X 3853
Device for determining of amplitude limiting curve

E	electromotive force
I	impulse meter
Lim	amplitude limiter
R', R"	loading resistance
V"	secondary voltage

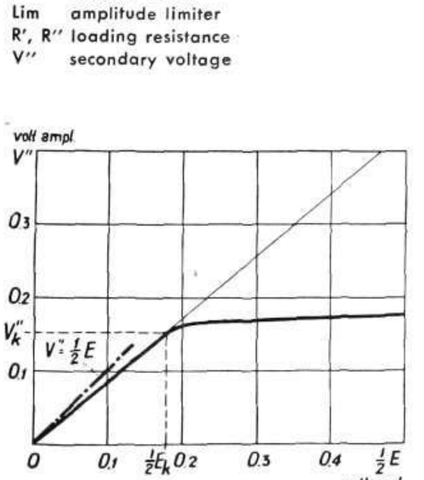


Fig. 10 X 3856
Amplitude limiting curve

The last curve shows how the high-pass filter *HPF* of the by-pass equipment sharply cuts off the frequency band at the cut-off frequency; this has been obtained with the aid of the equalizer in the attenuation pad *A*.

The *rectifier modulators* used in this system are all connected as shown in Fig. 3. The mode of operation of this modulator has previously been described in the Ericsson Review No 2, 1936.

The carrier frequency of 6 000 c/s is generated in an *oscillator panel* comprising an oscillator valve and an amplifier valve. The oscillator output from the oscillator panel is distributed among a number of carrier current amplifiers the input terminals of which are connected in parallel. Each carrier current amplifier contains a pre-amplifier valve and two power amplifier valves working in push-pull. An amplitude limiter is connected between the pre-amplifier and the push-pull stage resulting in a voltage with almost rectangular curve shape being applied on the grid of the push-pull valve. The voltage which governs the modulators then obtains the same shape. This is accompanied by a number of advantages, among others the fact that the shape of the voltage curve cannot be altered by the modulators in spite of the fact that their resistance varies with the current; the form is consequently uninfluenced by the number of modulators which are connected to the carrier current amplifier.

Each carrier current amplifier can furnish sufficient power for twenty modulators, *i. e.*, ten terminal equipments. In order to avoid a common voltage drop as much as possible and resulting cross-talk between different modulators, the circuits from the modulators are permitted to branch out from busbars as close as possible to the output terminals of the amplifier. The series resistances in the modulator leads also help to reduce cross-talk. Furthermore if the full number of modulators is not connected to the carrier current amplifier, this latter is loaded with a resistance corresponding to the resistance of the missing modulators.

A carrier oscillator feeds a large number of carrier current amplifiers, and a spare must be provided for such an important item; also, there is one spare amplifier for a certain number of carrier current amplifiers. In case of oscillator break-down, the spare oscillator is automatically connected up instead of the faulty one by means of a relay arrangement; should trouble occur in an amplifier, this is replaced by a spare amplifier in the same manner. The alarm bell of the system is simultaneously operated and signal lamps indicate the character of the fault. Faults are indicated by means of sensitive relays fed with rectified current from each distribution system. At the same time the relay current is a measure of the voltage on the respective busbars and is measured in a jack, connected in series with each relay.

In the *amplitude limiter*, Fig. 8, two rectifiers R_1 and R_2, with opposite polarity, are connected in shunt between the two identical transformers T_1 and T_2 with the voltage ratio 1:*n*. Both obtain a negative voltage V_0 from the potentiometer *P* which is connected to the poles of battery *B* over resistance *r*. Speech power is assumed to be transmitted from terminals *1* to terminals *2* on the amplitude limiter. As long as the amplitude of the secondary voltage in transformer T_1 is less than the voltage V_0 of the rectifiers, the resistance of the rectifiers remains very high; no AC energy is consumed in the rectifiers and the amplitude limiter has a small attenuating effect on the speech power. As soon as the amplitude of the secondary voltage of transformer T_1 exceeds the voltage V_0, the rectifiers R_1 and R_2 exert a very strong shunting effect during either half period of speech voltage. If the potentiometer resistance and the rectifier resistance in the forward direction were zero, the amplitude of the secondary voltage of transformer T_1 would not be able to exceed voltage V_0. Since the conditions are not fully met, this result cannot be quite reached, as is apparent from the curve, Fig. 10. By varying the voltage V_0 one can obtain different levels of limitation. The purpose of the condenser *C* is to reduce the attenuation caused by the transformers T_1 and T_2 at low frequencies and small amplitudes.

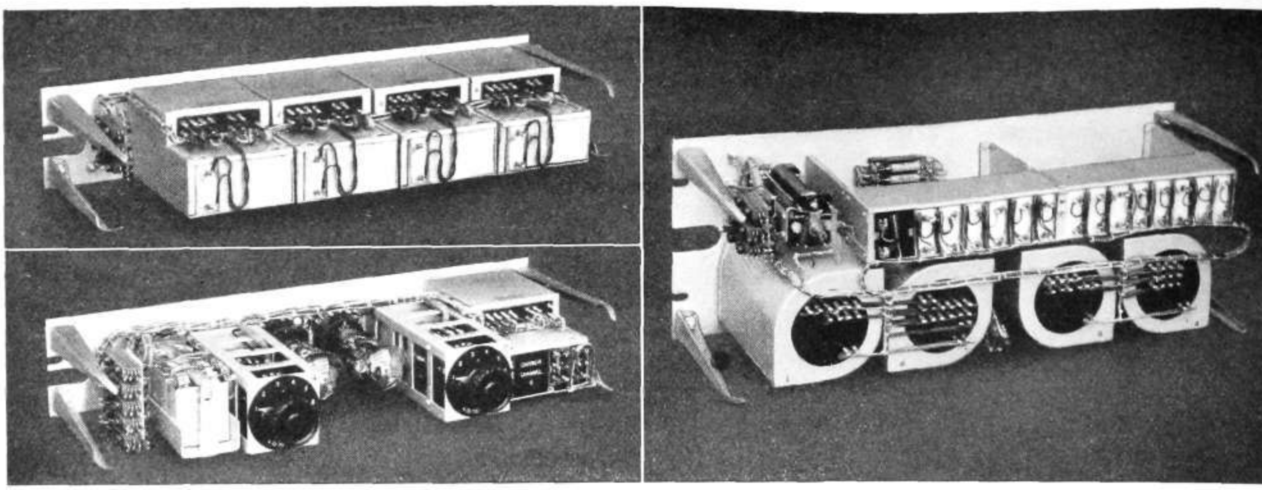


Fig. 11 X 7153
Panels
left top, low-pass filter; left bottom, fork amplifier; right, modulator

In order to investigate the limiting power of the amplitude limiter, a connection, the principle of which is shown in Fig. 9, is used. A source of current, the sinusoidal EMF of which has the amplitude E, and which has an internal resistance R', delivers energy to the load resistance R'' through the amplitude limiter *Lim*. The voltage amplitude V'' over resistance R'' is measured by means of an impulse meter I. We assume that the resistances R' and R'' both have the value R and that the amplitude limiter has the attenuation zero for small amplitudes. As long as the amplitude limiter does not come into function, the equation $V'' = \frac{1}{2}E$ will be valid. In a diagram with $\frac{1}{2}E$ as abscissa and V'' as ordinate, this will be a 45°-line, Fig. 10. If the effective attenuation of the amplitude limiter is b_D nepers, V'' will be smaller, namely $V'' = \frac{1}{2}E \cdot e^{-b_D}$, which, in the diagram, Fig. 10, is a straight line from the point of origin but with a smaller slope than 45°. When the EMF has reached the critical value E_k with the rectifiers just beginning to be conductive, the linear proportion between V'' and E ceases and the curve is deflected.

Mounting

All of the apparatus are mounted on one side of iron panels 482.6 mm wide, see Fig. 11. These panels are screwed on both sides of an angle steel

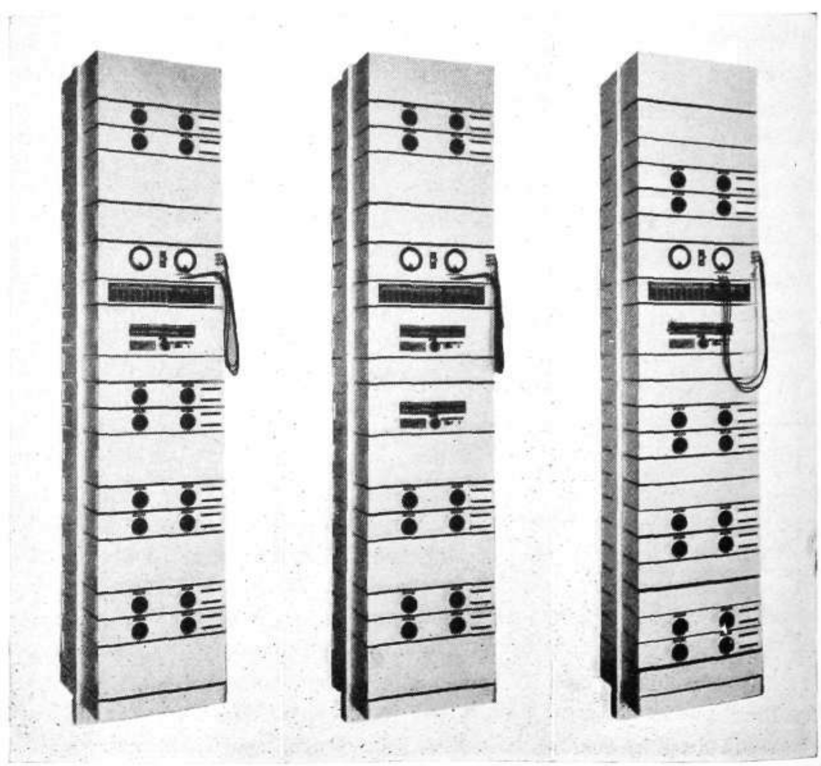


Fig. 12 X 5461
Terminal bays
at left, with four terminal equipments; in middle, with three terminal equipments, two carrier oscillators and four carrier amplifiers; at right, with four by-pass equipments

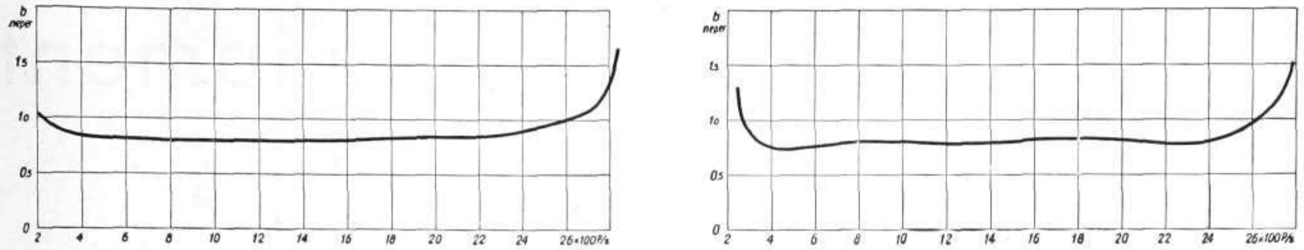


Fig. 13 x 7152

Overall attenuation

left, for voice-frequency channel; right, for carrier channel

frame. The width of the frame is 514 mm and the normal height above the floor is 2 400 mm. The rack cabling is carried inside the frame, between the front and back panels. The components on the panels are protected by removable covers. Jack strips, switches and instruments are mounted on bridges back of the covers and are visible in windows in the covers. When underlying parts must be easily accessible, these bridges are made to swing out. All metal surfaces are sprayed with aluminium gray enamel.

The racks can be mounted in different ways, see Fig. 12. A regular terminal rack is equipped with four terminal equipments and the common equipment for these. On the lower part of the rack are mounted three terminal equipments, above these the common panels with distribution equipment, jacks and measuring instruments, and at the top the fourth terminal equipment together with the common connecting panel. Each terminal equipment comprises two modulator panels, two fork repeater panels, two low-pass filter panels and one amplitude limiter panel. Also, one terminal equipment can be replaced by a carrier generating equipment comprising one carrier distribution panel, two oscillator panels and four carrier current amplifier panels, of which one oscillator panel and one amplifier panel are intended as spares. Finally, four by-pass equipments with common equipment can be mounted in one rack. Each by-pass equipment consists of two high-pass filter panels, two fork amplifier panels, four low-pass filter panels and one amplitude limiter panel. In all types of racks the measuring panel need only occur in every third rack, since the plug cords permit measuring in the two adjacent racks, where the measuring panel is replaced by a blank panel.

Transmission Characteristics

Both channels of the system are intended to work with an overall attenuation of zero from fork to fork. Such a channel can then be linked up to another trunk circuit without changing the overall attenuation of the entire circuit. When the channel is to serve as an independent trunk circuit, however, a pad of 0.4 neper is connected to each terminal, the overall attenuation then being 0.8 neper. This system is known as pad control system. By shifting the solderings, the pads A_C and A_P can be varied in steps of 0.1 neper. With their aid it is possible to adjust a suitable level difference between the voice frequency channel and the carrier channel. If these channels have the same level it will be found that the non-linear cross-talk caused by the repeaters will be greater in the direction from the carrier to the voice frequency channel than in the opposite direction. This difference in cross-talk disappears if the level for the carrier channel is reduced by about 0.5 neper below the voice frequency channel level. The output levels from the terminal equipment proper are — 1.0 neper for the voice frequency channel and — 1.5 neper for the carrier channel. The input levels are + 0.5 and ± 0 neper respectively for the voice frequency and the carrier channels.

The overall attenuations for the channels which arise when two terminal equipments are connected through a repeater with constant amplification within the frequency band in question are shown in Fig. 13.

Distortion Testing Equipment for Telephone Repeaters

S. JANSON, LINE DIVISION, ROYAL TELEGRAPH ADMINISTRATION, STOCKHOLM
S. KRUSE, TELEFONAKTIEBOLAGET L.M. ERICSSON, STOCKHOLM

In a single channel system for carrier telephony over four wire cable circuits the carrier and voice frequency channels are amplified by means of common repeaters. The non-linear distortion in these is responsible for the creation from the speech current in each channel of modulation products which fall within the frequency band of the other channel and consequently cause interference if they are of sufficient strength. Repeaters of the same type as those hitherto used solely for the amplification of the voice frequency channel are often used; in order to reduce their non linear distortion, they are provided with a compensating device which must be set so as to obtain a minimum of distortion. Since the setting depends on the constants of the amplifier valves, readjustment must be made while in operation. In order to facilitate this adjusting, Ericsson has designed a special distortion testing equipment.

Principle

If two purely sinusoidal voltages with the frequencies f_1 and f_2 enter a repeater, the non-linear distortion in the repeater will cause the amplified voltage to contain other frequencies than f_1 and f_2, *viz:* harmonics and combination frequencies. The general expression for frequencies in the output voltage of the repeater is

$$f = |(m_1 - m_2)\ f_1 + (n_1 - n_2)\ f_2|$$

where m_1, m_2, n_1 and n_2 are positive integers or zero. The sum

$$p = m_1 + m_2 + n_1 + n_2$$

is called the order of the particular distortion product. The products of the first order are f_1 and f_2, *i. e.*, the original frequencies, those of the second order are 0, $|f_2 - f_1|$ $f_1 + f_2$, $2f_1$ and $2f_2$ those of the third order f_1, f_2, $|2f_1 - f_2|$, $2f + f_2$, $|2f_2 - f_1|$, $2f_2 + f_1$, $3f_1$ and $3f_2$. In general, the amplitudes of the distortion products decrease with increasing order.

When a repeater is used for amplification of one single communication over a certain frequency band, only those distortion products whose frequencies fall within this band are of any importance. As indicated by the name, they give the impression of a higher or lower degree of distortion of the original communication. These various kinds of distortion are of far less importance in commercial telephony than, *e. g.*, in the transmission of radio broadcast programs. For the first mentioned, intelligibility is the determining factor, while fidelity as such is of secondary importance. Tests have shown that in a speaking connection it is possible to introduce considerable non-linear distortion before the syllable articulation is appreciably lowered, which is indicated in the curve, Fig. 1, borrowed from Ericsson Technics No 5, 1933. Actually, the telephone instruments themselves, especially the transmitter, introduce considerable distortion, which is noticeable if a loud-speaker is operated with such a transmitter by means of a good amplifier. Consequently it is unnecessary to place especially high requirements on the linearity of the repeaters in a common long distance circuit. According to the CCIF, a four-wire repeater shall have an output of at least 50 mW with a distortion factor not exceeding 5 %. These requirements are met by quite common amplifiers.

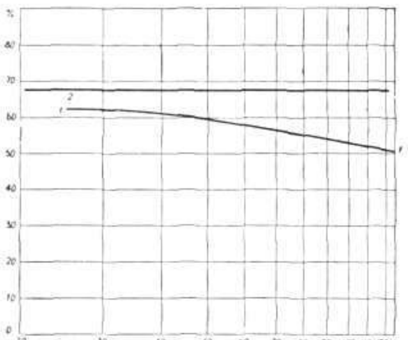


Fig. 1 X 3851

Syllable articulation as a function of the distortion

1 circuit with non-linear distortion
2 undistorted circuit

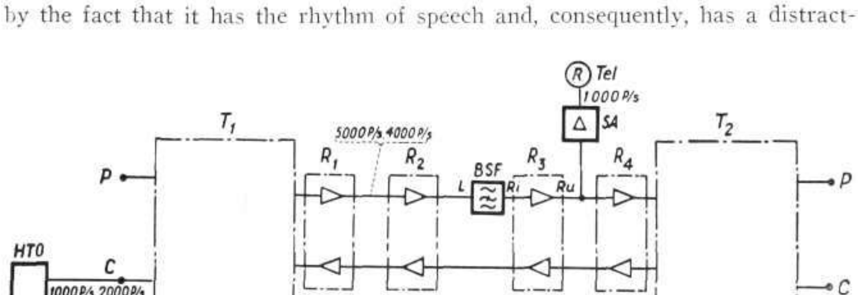
This matter takes on an entirely different aspect if several speech channels must be amplified simultaneously in the same repeater, as it is then quite possible that the distortion products generated by the currents of one of the channels fall within the frequency band of another channel and cause interference in this channel. In this manner, we obtain what is called *non-linear cross-talk*. Especially through combination frequencies of different orders of two or more simultaneous frequencies, for instance of the form $mf_1 + nf_2$ in the disturbing channel, there are large possibilities for the disturbances to enter into other channels. The combination frequencies are created by means of *intermodulation* between the original oscillations. Between two channels with frequency bands of 10 000—13 000 c/s and 15 000—18 000 c/s respectively, for instance, non-linear cross-talk is caused first of all through the intermodulation products of not lower than the third order, namely $2f_1—f_2$. Since the amplitudes of the distortion products decrease with increasing product order, it is necessary, in each separate case, to find out the lowest distortion order which gives disturbances within some considerable parts of the frequency band of the disturbed channel. In the Ericsson single channel system ZL 500 for cable circuits, the voice frequency channel with the frequency band 100 to 2 700 c/s and a carrier channel with the frequency band 3 300—5 700 c/s — arising through the modulation of the carrier frequency 6 000 c/s with the speech band 300—2 700 c/s — are amplified in common repeaters. In this case, the problem of non-linear cross-talk presents itself as follows: two frequencies f_1 and f_2 in the voice frequency channel form distortion products of the second order in the carrier channel only in case $3\,300 \leqq f_1 + f_2 \leqq 5\,700$. This condition is satisfied by all frequencies f_1 and f_2 lying within the range 600—2 700 c/s. The generated intermodulation products will then lie within the range 3 300—5 400 c/s, which — after demodulation — is 600—2 700 c/s. The greater part of the band of the carrier channel is consequently covered by distortion products of the second order from the voice frequency channel, for which reason it may be stated that the intermodulation of the second order in this case is the most serious one. The intermodulation of the second order from the carrier channel to the voice frequency channel can only arise in case $100 \leqq f_2—f_1 \leqq 2\,700$, which occurs in all frequency pairs f_1, f_2 in the carrier channel. The entire voice frequency band is covered by these products, for which reason intermodulation of the second order dominates also in this case. The strongest oscillations emitted by the transmitter in a common telephone instrument have frequencies between 600 and 1 000 c/s. A weaker amplitude maximum lies between 1 500 and 2 000 c/s. The strongest intermodulation products from the voice frequency to the carrier channel arise through a combination of frequencies from the latter range and fall within the range 3 300—4 000 c/s after demodulation from 2 000—2 700 c/s; in this case the disturbances will have a lighter acoustic colour. With disturbances from the carrier channel to the voice frequency channel it is possible for two strong oscillations to combine into a disturbing note falling within the range 100—500 c/s; the disturbances then have a dark timbre and are stronger than for disturbances from the voice frequency channel to the carrier channel.

The non-linear cross-talk is unintelligible and is consequently devoid of the injurious effect of the linear cross-talk through the betrayal of telephone secrecy; on the other hand, it differs from common inductive disturbances by the fact that it has the rhythm of speech and, consequently, has a distract-

Fig. 2 X 5457

Diagram for distortion compensation of four-wire repeater

BSF	band-suppress filter
C	carrier channel of single channel system
HTO	oscillator
L	line side of band-suppress filter
P	voice frequency channel of single channel system
R_1–R_4	four-wire repeaters
R_i	input side of repeater
R_u	output side of repeater
SA	selective amplifier
T_I, T_2	terminal equipments of single channel system
Tel	telephone receiver



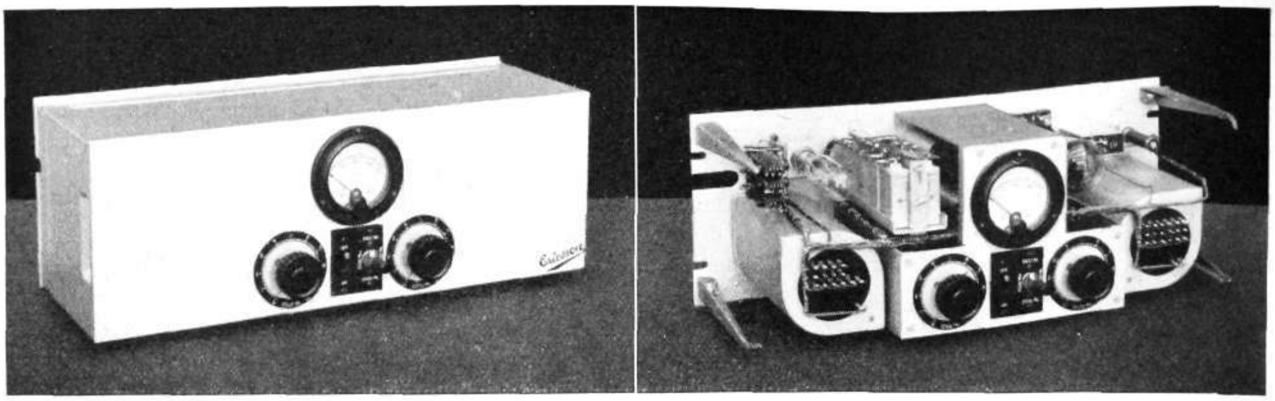


Fig. 3
Oscillator ZD 160
for distortion tests

X 7148

ing effect on those carrying on a conversation over the disturbed channel noticeable before its psophometric value has yet reached the permissible noise level. For this reason, the same limit has been set for the non-linear cross-talk as for the linear one.

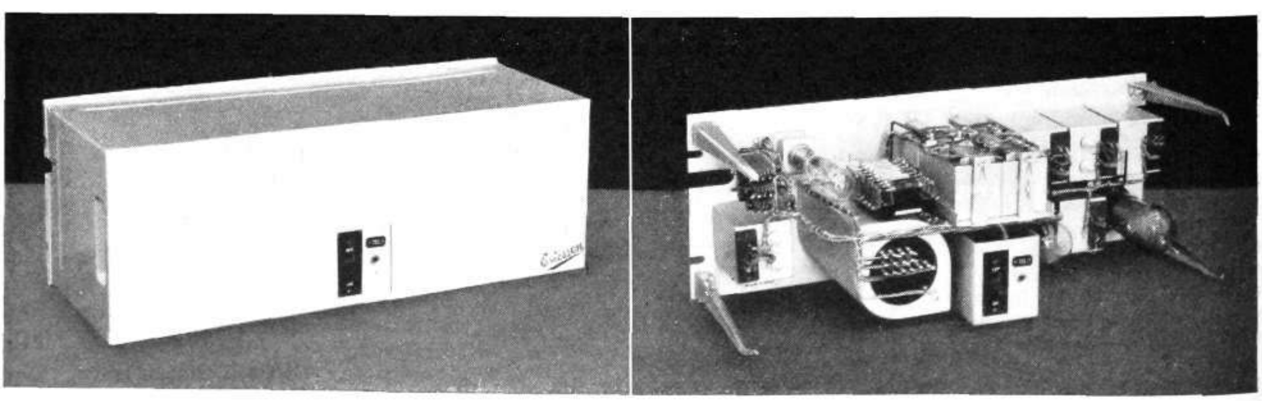
In general, the non-linearity of the common four-wire repeaters is too great to permit direct use of them for simultaneous amplification of two telephone channels unless the levels of these are lowered to impracticable values. With a single channel system for cable circuits the difficulty is all the greater, as distortion products of even the second order enter the disturbed channel. For this reason, the repeaters have been provided with arrangements which reduce the non-linearity of the second order. A compensating method is used for this purpose, for instance by the introduction in the repeater of a non-linear element in the form of a metal rectifier, so adjusted and connected that the distortion products of the second order generated in the rectifier will be equal in value but opposed to those created in the amplifier. The non-linear distortion in the repeaters originates chiefly in the electronic valves, and consequently varies with the valve characteristics. From time to time, especially when replacing valves, it is therefore necessary to readjust the compensator. An organ is consequently necessary for regulating the strength of the distortion products which are generated in the distortion compensator. The compensating process is empirical: the repeater is furnished with a suitable frequency or frequency mixture and some of the distortion products of the second order are filtered out after the repeater and listened to in a receiver. The adjusting organ of the compensator is then adjusted until the strength of the disturbing note has reached a minimum.

Design

In order to facilitate compensating, Ericsson has designed a special distortion testing equipment, see the diagram, Fig. 2. The frequencies 4 000 and 5 000 c/s are used as disturbing frequencies, these being generated in such manner that a valve oscillator *HTO* gives 1 000 c/s power, part of which is doubled in frequency, after which the two frequencies of 1 000 and 2 000 c/s are mixed and led into the carrier channel, where they are brought to 5 000 and

Fig. 4
Receiver ZF 570
for distortion tests

X 7149



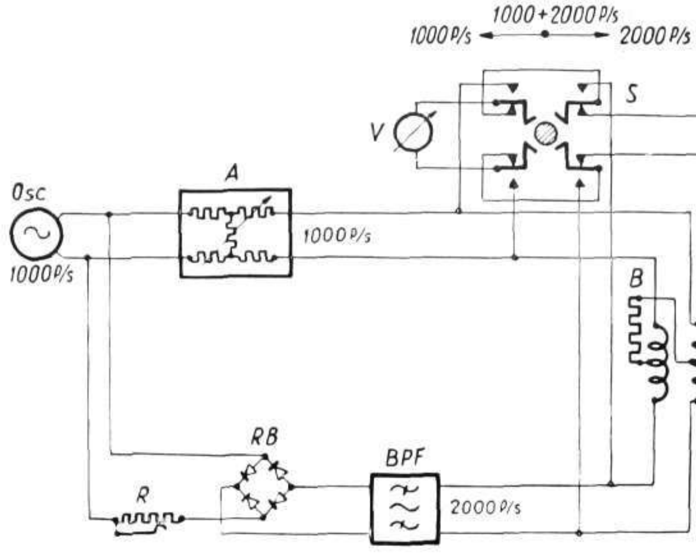


Fig. 5 X 5458
Circuit diagram for oscillator ZD 160

A	artificial line
B	balancing network
BPF	band-pass filter, 2 000 c/s
DFT	differential transformer
Osc	valve oscillator, 1 000 c/s
R	variable resistance
RB	rectifier bridge
S	switch
TR	terminal resistance
V	voltmeter

4 000 c/s respectively by means of modulation and are admitted to the line. On the output side of the repeaters the difference frequency of 1 000 c/s is filtered out, amplified and listened to. At each repeater station it is consequently necessary to have a selective amplifier *SA* for 1 000 c/s. In the repeaters located between the terminal station and the repeater to be tested, intermodulation products of 1 000 c/s are also generated, however, and enter the repeater under test and give a wrong impression as to its non-linearity. In order to avoid this, a band-suppress filter *BSF* which suppresses the frequency 1 000 c/s is connected on the input side of the repeater R_3 which is to be compensated; on the output side of the repeater the selective amplifier *SA* which filters the difference note of 1 000 c/s which is heard in the receiver *Tel* is shunted to the line.

Consequently, the distortion testing device comprises two units, an *oscillator* ZD 160, Fig. 3, mounted at the terminal station and generating the disturbing frequencies, and a *receiver* ZF 570, Fig. 4, which is mounted in the repeater stations and comprises a band suppress filter and the selective amplifier. The oscillator and receiver are mounted on one side of steel panels 177 × 482.6 mm and intended for mounting on a rack. They are equipped with one or two Marconi-Osram valves Type LS7, requiring a filament voltage of 20—28 V DC and a filament current of 0.15 A; this is held constant by means of a ballast lamp. The anode voltage is about 130 V and the anode current 8 and 16 mA respectively. The sources of current are switched on by means of a switch on the panel.

The oscillator, Fig. 3, consists of a valve oscillator *Osc* which generates a current with the frequency 1 000 c/s. Part of the AC power receives the double frequency in the rectifier bridge *RB*, the note 2 000 c/s being separated

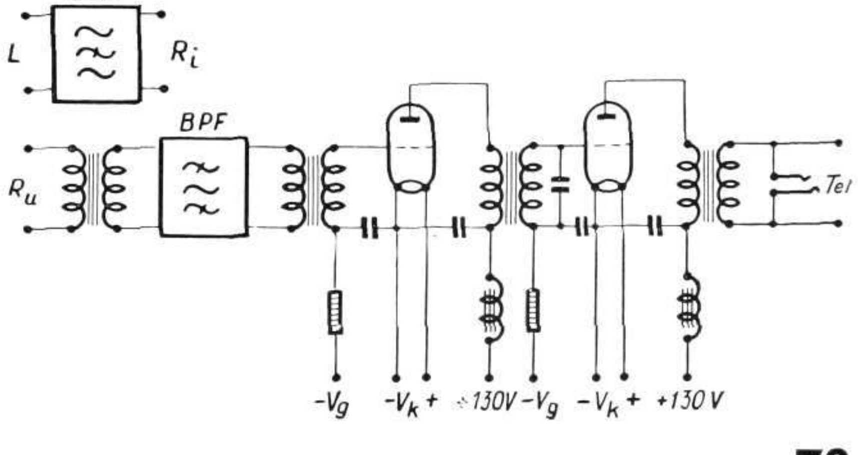


Fig. 6 X 5159
Circuit diagram for receiver ZF 570

BPF	band-pass filter, 1 000 c/s
BSF	band-suppress filter, 1 000 c/s
L	line
R_i	input side of repeater
R_u	output side of repeater
Tel	telephone receiver

in the band-pass filter *BPF* and mixed with the 1 000 c/s note in the differential transformer *DFT*. As a result of this connection, the powers of the 1 000 c/s note as well as the 2 000 c/s note can be regulated independently of each other by means of the attenuation *A* and the regulating resistance *R*, while the levels are checked by means of the built-in rectifier voltmeter *V*. The voltmeter can be connected to one or the other side of the differential transformer by means of the switch *S*. When the switch is in center position the voltmeter is connected to the outgoing circuit and measures the sum of 1 000 c/s and 2 000 c/s power. Since half of the equally large single frequency powers which are put into the differential transformer is dissipated in the balancing resistance *B* the total output will be the same as each single frequency power. With a correct adjustment of the powers, the voltmeter will consequently give the same deflection for the different positions of the switch. The total power in the outgoing circuit is in the order of 1 mW. When the oscillator is not connected to any circuit, the terminating resistance *TR* serves as load and permits of testing the power by means of the rectifier voltmeter *V*.

The receiver, Fig. 4, consists essentially of a two-stage selective amplifier for 1 000 c/s. In front of the first valve there is a band-pass filter *BPF* for 1 000 c/s with a narrow transmission band, and between the valves a transformer tuned to the same frequency. The input impedance of the amplifier is about 10 000 ohms and practically real, so that it can be shunted to the cable circuit on the output side of the repeater to be compensated, without influencing the transmission to any appreciable extent. Also, the receiver contains a band-suppress filter *BSF* for 1 000 c/s, intended to be included in the circuit on the input side of the repeater under test. The panel is also provided with a jack *Tel* for connecting up a high resistance telephone receiver. Since the receiving equipment contains no adjustable elements the connecting leads L, R_i, R_u and *Tel* are suitably multiplied in the jack fields of the repeater bays.

Intermediate Telephone Station for Automatic System

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

The Ericsson series of modern bakelite telephone instruments has now been augmented by still another, the intermediate telephone instrument, intended especially for use when two telephone instruments are to be connected to the same circuit so that conversations carried on from one of the instruments cannot be overheard in the other one; also this arrangement permits of intercommunication between the two instruments.

Due to its compact and attractive form and simplicity of operation the Ericsson intermediate telephone instrument is an excellent exponent of modern telephone design.

An intermediate subscriber's station consists of a main set, connected to the main exchange, and an extension set connected to the main set. The characteristic feature of this arrangement is that both of these instruments can obtain connections with the main exchange as well as call each other. For this latter purpose, it is necessary that both of the telephones be equipped with intercommunication signalling devices. Both telephones must also be equipped with dials, if the main exchange is automatic. If the distance between the telephones is short, intercommunication can be arranged with battery signalling between the telephones, in which case, however, there will be quite a large number of circuits between the telephones. With the model here described, magneto current is used for making the local calls, the instruments being consequently equipped with magnetos; this permits the use of a two-wire circuit between the telephones. Where large distances occur between the telephones, this is a necessary condition to permit of providing such installations without considerable extra cost for the intermediate lines.

Telephone instruments previously marketed for this purpose were generally very bulky and not very pleasing in appearance. With the introduction of the Ericsson intermediate subscriber's set, however, these drawbacks have

Fig. 1 X 5474
Main instrument DBH 40
for automatic system

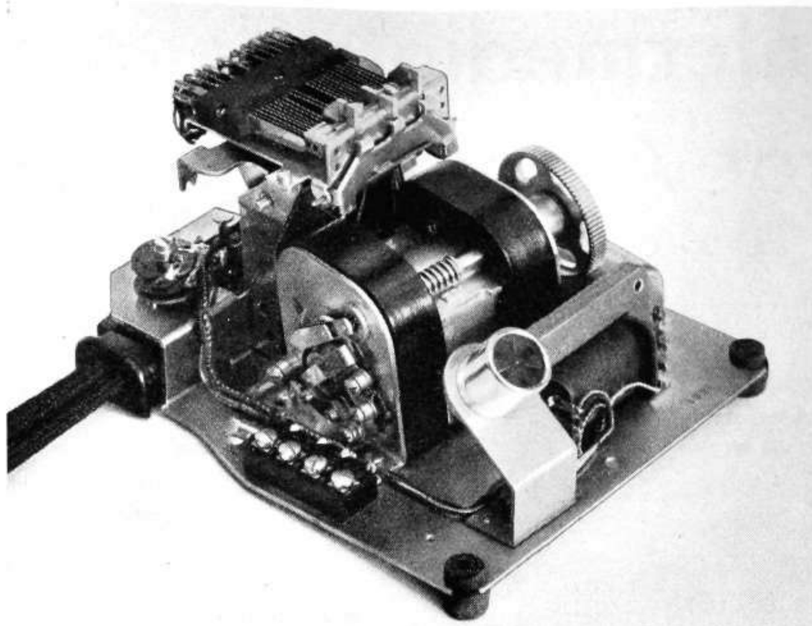


Fig. 2 X 5462

Inset for main instrument

at top, spring group for push buttons; at center, magneto; in foreground, star indicator and induction coil

been successfully eliminated, the same housing having been used as for the regular Ericsson telephone instruments. The lever switch used in the previous types of main sets has been replaced by push buttons, thereby greatly simplifying operation as well as giving this detail less prominence in the design of the instrument.

Use

The Ericsson intermediate subscriber's station is especially serviceable when two telephone instruments are to be connected up to the same circuit. In general, secrecy for conversations from either of the telephone instruments is of paramount importance. A simple connecting up in parallel of the telephone is consequently out of question. Furthermore, intercommunication between the two telephones is often desirable. Intermediate installations are especially suitable for business men who wish to have a telephone in their place of business as well as in their residence. Since only two-wire lines are used the telephone instruments can be placed at a considerable distance from each other without making the lines too expensive. This type of installation is suitable also for small offices, where the requirements for intercommunication are not so large as to require a private branch exchange. By substituting for the regular subscriber's instrument an intermediate subscriber's station, the cost of a new subscription can often be avoided and a better utilization of the existing subscriber's line obtained.

Design

A main instrument DBH 40, Fig. 1, for connection to an automatic exchange is — in addition to the usual equipment for a subscriber's dial set — provided with a set of three push-button keys, used for obtaining the different connection combinations required by this arrangement of telephone instruments. Also, the instrument is equipped with a star indicator for busy indication of the main exchange line. Two signalling devices are provided, *viz.* a polarized bell located in the wall box, and a buzzer mounted inside the telephone instrument. The two signals are consequently of entirely different character, preventing all misinterpretation of the same. The inset consists of a base plate on which the various components are mounted, these latter being easily accessible after the removal of the casing, see Fig. 2. In order to facilitate the changing of the cords, the base is provided with a special small, removable plate under the cord terminal block, permitting the cord of being changed without opening the instrument. In order to provide the greatest possible

Fig. 3 X 5475
Extension instrument DBH 41
for automatic system

ease and freedom for the turning of the magneto crank, the magneto has been given a somewhat sloping position by sinking it down into the base.

The extension instrument DBH 41, Fig. 3, is used together with the main instrument and is practically similar in appearance; it lacks some of the equipment of the main instrument, however, such as the push buttons and the star indicator.

Operation

In the diagram, Fig. 4, are schematically indicated the different connections possible with these telephone instruments.

For a *main exchange call*, Fig. 4 a, the red button is depressed, connecting the main instrument to the exchange line. The exchange is called by removing the handset. A calling signal from the exchange is received by the bell of the main instrument. The extension is connected to the buzzer of the main instrument and can call the main instrument by means of the magneto. By making the function of the red push button independent of that of the cradle switch, the red button can remain depressed as long as the main telephone instrument is to keep watch over the exchange line; when used for exchange calls, the function of the main telephone instrument is consequently the same as for an ordinary subscriber's set.

For an *inquiry call* from the main instrument to the extension during the course of a main exchange conversation, the white button, Fig. 4 b, is depressed, the red button meanwhile remaining in depressed position. The main instrument is now connected to the extension line and can call the extension by means of the magneto. The exchange line remains connected over a resistance in parallel with the bell, which is in circuit in order to receive new calling signal from the main exchange (such a condition may arise if the existing exchange call is a local call which may be broken in favour of an incoming trunk call). Conversation can now take place between the main instrument and the extension, but this conversation cannot be overheard over the exchange line. After obtaining the desired information, the main instrument can re-establish the exchange connection by pressing the red button, causing the white one to return to normal.

Should it be found desirable to *transfer a call* from the main instrument to the extension, the black push button is depressed momentarily, Fig. 4 c, causing the two other push buttons to return to normal and providing a through connection for the exchange line to the extension. The black button returns to normal as soon as it is released. The extension is now connected to the

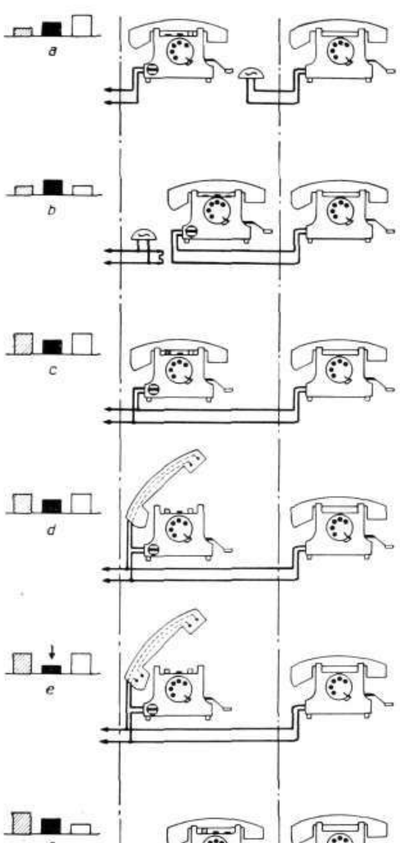


Fig. 4 X 3860
Diagram of intermediate subscriber's station

- a main exchange call to main instrument
- b information call to extension instrument
- c transfer of call to extension instrument
- d through connection to extension instrument
- e through connection to extension instrument (main instrument takes part in conversation)
- f intermediate connection between the two instruments

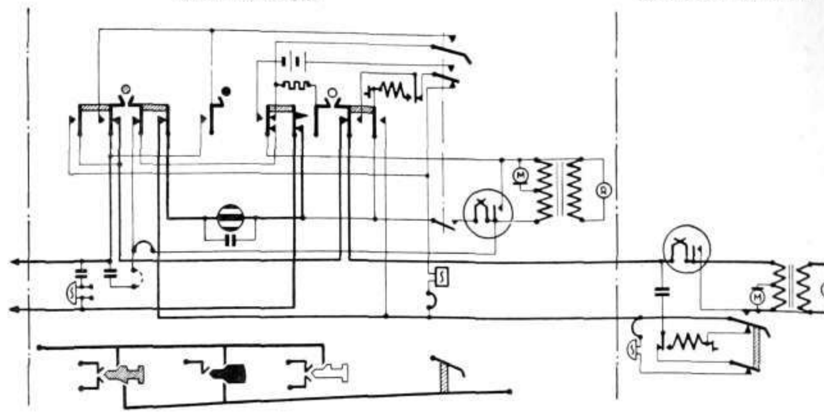


Fig. 5 X 5470
Circuit diagram for intermediate subscriber's station
left, main instrument; right, extension instrument; below, functions of push buttons

exchange line and can speak over the same. During the conversation the star indicator on the main telephone instrument indicates that the exchange line is busy.

This *through connecting* feature is used also when the extension is to stand at attention for calls from the exchange line. Calling signals from the exchange are received directly by the bell of the extension. The party at the extension answers the call and can also call the exchange without the aid of the main instrument. The depressing of the black button, Fig. 4 c, on the main instrument — whereby the microphone is brought in circuit — will, however, permit this instrument to take part in the conversation. When the button is released, the conversation over the exchange line from the extension can still be overheard from the main instrument, Fig. 4 d.

An *intercommunication connection* is obtained by depressing the white button only, before the handset is lifted, Fig. 4 f, causing the red button to return to normal in case it should have been depressed. The main instrument is then connected to the extension and can call the latter by means of the magneto. The bell of the main set remains in circuit to receive calls from the exchange line.

Technical Data

These telephone instruments are made for automatic as well as manual CB systems and for all existing feed conditions. The transmission characteristics are the same as for the Ericsson regular telephone instruments for CB and automatic systems, see Ericsson Technics No 2, 1934. For all switching combinations the cross-talk attenuation is greater than 9 nepers.

The magneto has two magnets of cobalt steel. At 20 c/s the idling voltage is about 90 V and the maximum effect 2 W, which is quite sufficient for the lengths of circuit to be reckoned with. The polarized bell is connected in series with a 1 μF condenser and rings for 15 V at 20 c/s. For dial system working, the bell of the main instrument is provided with a direction spring so as not to function during impulsing with the dial. The sensitivity can then depend upon the spring tension, which must be suited to the feed system and circuit length. The buzzer in the main instrument works for a tension of 25 V at 20 c/s.

A 3 V dry cell is required for intercommunication. Since the current consumption is low such a cell generally lasts for several years.

Automatic Routine Tester with Impulse Machine

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

Automatic telephone exchanges are generally provided with testing devices for supervising of the functioning of the installation, whereby faults in the automatic switching equipment are often detected before causing serious trouble. At smaller exchanges the time of the staff is not always fully occupied, and here it is consequently well motivated, from an economic point of view, to install manually operated testing devices, first of all line testing equipment, a testing device for the automatic switches and a traffic supervisor's desk. Larger installations must also be equipped with supervisory arrangements for the testing of all the vital phases in the switching procedure and indication of all detected faults. In order to facilitate the work of the staff, these devices must be easily operated and of simple design, while expert training should not be necessary for their operation. An automatic routine tester meeting these requirements is now being offered by Ericsson.

The purpose of the Ericsson routine tester with impulse machine is to carry out a large number of tests in the form of repeated test connections, and to attract the attention of the staff in case of faults. The tester is designed for the Ericsson automatic telephone system with 500-line selectors, but the fact that the control and supervisory signals are quite general in character and not individual for any definite system makes the tester adaptable to other systems as well. The group of switches to be tested is connected with the routine tester over two line pairs. Over one of the pairs the tester performs the same operations with reference to the automatic exchange as would a regular subscriber when making a call and obtaining a speaking connection. Over the other pair, which is connected to a line which has not been allotted to any subscriber, the calls are directed back to the tester. The calling number for this second line is set on the tester by means of dials, after which the corresponding combination of digits is automatically transmitted in the form

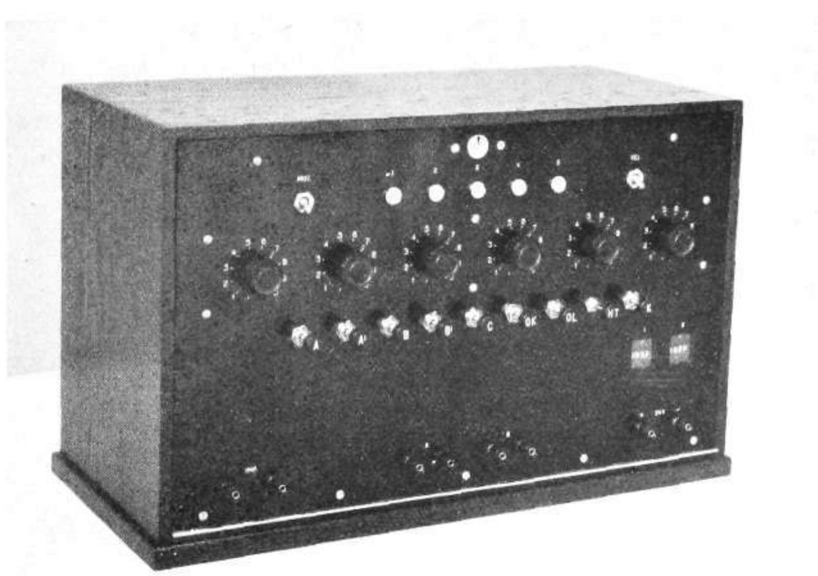


Fig. 1 X 5431

Automatic routine tester

top row, connecting keys and alarm lamps; second row, dials for setting number of test line; third row, switching keys and counting registers; bottom row, jacks for test line and battery connections of impulses; the calling number can be composed of one to six digits. The tester is designed for a 24 V operating current, but can be made or provided with auxiliary units for other tensions.

Since the routine tester works automatically and repeats the testing operation until it has been disconnected or has found a fault, it constitutes a considerable load on the group of switching devices under test, and the test should consequently not be carried out during traffic peaks. A choice of two methods is available, one can either let the tester work entirely without supervision during a considerable time, thus testing all of the switches, or else the testing is carried out under supervision so that every switch, *i. e.*, line finder, group selector and register to be tested is disconnected and does not fulfil its regular functions while being tested; this should be applied to a certain extent also in the subsequent switching stages. This latter testing procedure can only be carried out on condition that it takes place during the night, however.

The dimensions of the tester, Fig. 1, are as follows: height 350 mm, length 560 mm and width 225 mm. The front panel is equipped with two keys for battery connection and for starting the impulse transmitter, five signal lamps for indicating faults, six dials for the setting of the calling number, a number of push-button keys for making connections under different conditions, and counters which register the number of test connections and detected faults. At the bottom of the panel are jacks for making connection with the impulse machine, which can consequently be utilized for other purposes also. The impulse ratio and impulse frequency can be checked by connecting a measuring instrument to these jacks, in addition to which are jacks for the connecting up of the calling and the called line, as well as for the battery. In addition to the necessary relays, the tester contains a rotary step-by-step switch for the successive setting of the different phases of the switching process, an impulse machine and a voice frequency receiver, which are used for starting the impulsing — when a dial tone is sent out from the exchange — as well as for the supervision of the speaking connection.

The voice frequency receiver consists of a valve, the grid circuit of which is connected to the incoming rectified voice frequency AC. A relay in the anode circuit of the valve is then actuated. In spite of the fact that only 24 V anode tension is available, it has been possible to use valves of regular design, due to the fact that an electrolytic condenser has been inserted in order to double the voltage. This condenser is given a charge of 24 V at suitable moments, and then connected in series with the 24 V battery tension,

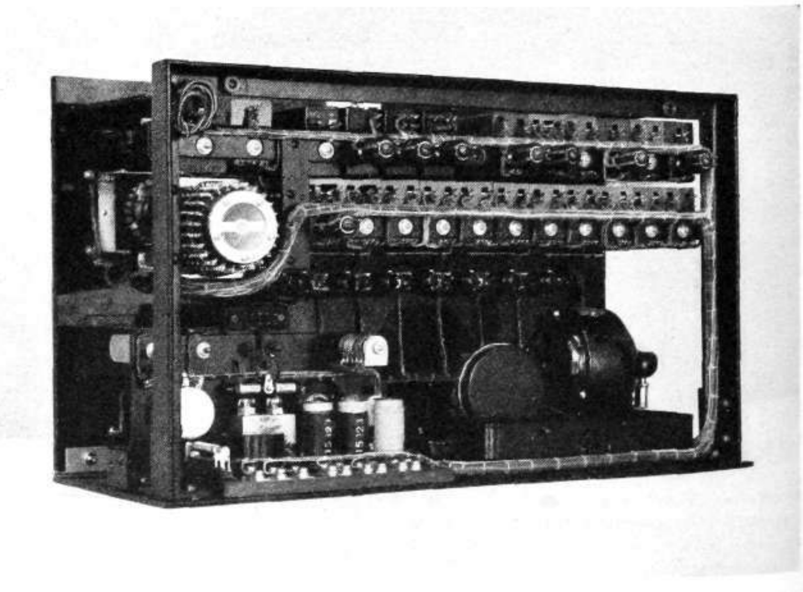


Fig. 2 X 5432
Chassis of the routine tester
showing relays, condensers and resistances; at upper left, rotary switch; at lower right, impulse transmitter

thereby giving 48 V for anode voltage. As an added precaution, a rectifier has been connected in series with a relay, which can consequently be energized only for the right direction of current, thereby preventing any damage occurring to the electrolytic condenser should the battery connections be reversed. The impulse machine consists of an impulse wheel with motor drive which, under normal conditions, makes ten breaks per second in two separate circuits. One of the circuits consists of a line loop to the exchange and the other is for the stepping forward of the rotary switch.

The testing process commences after the two test lines and the battery voltage have been connected up and the number dials have been set to the number of the called line and the required number of push button keys has been depressed. The calling and the called line have each two push buttons, one for closing their own circuit and one for the insertion of a 1 500 ohm resistance in the line loop. One of the push buttons is intended for the testing of systems with common battery supply for both subscribers, another button being for systems without repeated ringing signals. A special button is intended for the insertion of spark quenching devices during impulsing.

Faults are indicated by means of five lamps and one bell, which latter can be disconnected by means of a push button. These lamps obtain current over a ring of contacts in the rotary switch. If the testing process has not been completed after a certain time, a thermic relay is actuated, this relay being connected to another relay, which is energized under normal conditions. A thermic contact is thereby heated, which closes an alarm circuit to the bell and one of the five signal lamps. Each time the rotary switch reaches the first position, the above mentioned relay is shunted so that it cannot energize anew until the thermic contact has returned to normal. Should the switch during the testing process remain too long in one position, an alarm signal is given after some time. The first lamp glows if the dialling tone is not obtained from the automatic exchange. The fifth lamp is put in circuit if the testing arrangement does not function properly. The other three lamps when in circuit indicate that the switching route under test does not function correctly. The second and third lamps indicate that the ringing signal has not been sent out; thus, if the switching route has not been connected up to the intended testing line, the second lamp is lit. When the rotary switch is in a certain determined position, the fourth lamp will glow in case the ringing signal has not been disconnected; this causes a breaking of the connection to the voice frequency receiver. The same lamp glows in case the battery connection is broken, preventing the rotary switch from operating, or in case of a break in the speaking connection between the feed coils of the switching route, for instance at the connecting wires to the condensers; in this case the dial tone sent out over one of the lines does not influence the voice frequency receiver connected to the other line, and the switch of the testing apparatus ceases to rotate. The level of the emitted dial tone can be regulated by means of a dial, so that the tone will with absolute certainty influence the voice frequency receiver during testing with a maximum line resistance, without being so loud during testing without an inserted line resistance that the voice frequency receiver is influenced, for instance, when a single-wire connection is used for the switching route.

Sound Amplifier

O. ARNTYR, ELEKTRISKA AKTIEBOLAGET SKANDIA, STOCKHOLM

In quite a number of fields of activity, it is often desirable to increase the intensity of the sound above the primary level, for instance when transmitting music and speech or when making announcements to large assemblies. By utilizing modern amplifying practice, Ericsson has designed a sound amplifier intended for a hundred or so telephone receivers, or for a couple of loudspeakers.

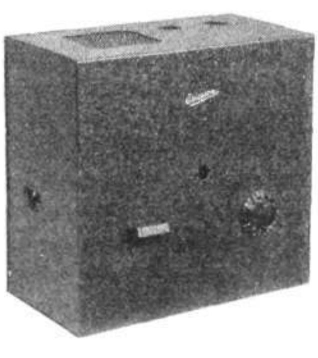


Fig. 1 X 3810
Sound amplifier PK 300

In order to permit persons hard of hearing to listen to lectures, church services etc., appliances of many different types have been constructed. The oldest permanent installations for this purpose were simply speaking-tube installations, a funnel being placed in front of the speaker, and connected to a system of tubes terminating at the seat of each listener in a couple of rubber tubes with suitable ear plugs. The first electrical listening installation consisted of a transmitter and battery, and a distribution network with telephone receivers at the seats of the listeners. This system was a considerable improvement over the earlier one. The greatest disadvantage remained, however: it was impossible to obtain such a strong sound that persons decidedly hard of hearing were given any appreciable relief. In order to remove this disadvantage mechanical amplifiers were constructed, which gave quite a good volume of sound, although of inferior quality, and the arrangements were complicated and not very efficient. In order to meet these essential requirements, and aided by their long experience in the construction of modern radio receivers, Ericsson have designed an amplifier giving a large sound volume and with an excellent quality of tone rendition. It also is of a very sturdy and reliable construction.

The amplifier PK 300, Fig. 1, is a convertible AC—DC model, *i. e.*, it can be connected to either DC or AC mains as well as for the most common occurring voltages. The amplifier is equipped with two amplifier valves and a rectifier valve, microphone and output transformer, volume regulator, fuse, terminal base etc. The main switch is combined with the switch for the microphone battery, thereby eliminating all danger of neglect in the disconnecting of the microphone battery. When the amplifier is in circuit, a red signal lamp glows, visible through an opening in the front of the cover. The amplifier is connected to the mains by means of a flexible cord. The current consumption amounts to 46 W with 220 V, 50 c/s AC. The output has the same voltage and a power of 2.4 W.

The sound is generally transmitted by means of carbon microphones. Naturally, other types, such as crystal or electrodynamic microphones, may be used, but the carbon microphone has the advantage of being relatively insensitive from a mechanical point of view, it gives a large volume of sound and is inexpensive. In order to meet varying requirements as to mounting, Ericsson has constructed three different designs, Fig. 2, especially adapted for use with the amplifier. The microphone RC 1860 is designed for table use, microphones RC 1855 and RC 1850 being designed for screwing against a wall or on a bracket. The microphone housing is of bakelite and contains a 40 ohm insert. The holder is provided with a terminal block and protecting cover. Two dry cells in series generally serve as microphone battery, this latter being connected directly to the amplifier.

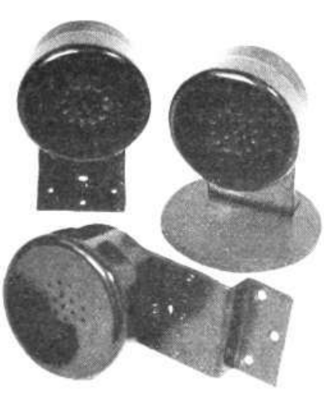


Fig. 2 X 3811
Microphones RC 1855, RC 1860 and RC 1850

As a substitute for the earlier telephone receivers, a new type RF 1810, Fig. 3, has been designed, this receiver being mounted on an extra long handle in order to be held with ease and without causing undue fatigue. It is provided with a vulcanized connecting cord with plug, the cord being vulcanized into

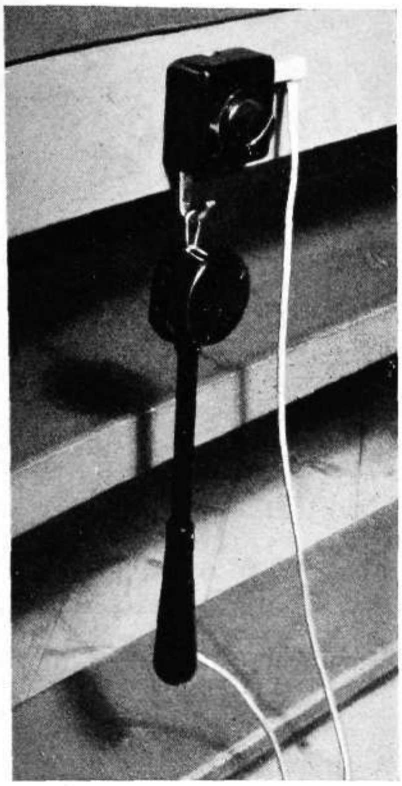


Fig. 3 X 3812
Receiver RF 1810 with suspension terminal PR 600

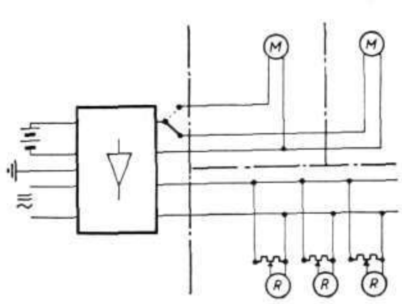


Fig. 4 X 3813
Circuit diagram for sound amplifier system

the plug as well. The magnet system of the receiver is amply dimensioned, and can consequently stand a heavy load without causing distortion. Thanks to its construction and to the vulcanized connecting cord, it is possible to clean the receiver with a wet sponge or the like without damaging the same.

The new hook terminal PR 600, Fig. 3, is provided with a volume regulator, thereby enabling each listener to regulate the sound volume to his personal requirements. It is also provided with a jack for the plug of the connecting cord, as well as a suspension hook for the receiver. The hook is combined with a break contact which automatically disconnects the receiver as soon as it is suspended from the hook. This is necessary in order to prevent persons sitting near a receiver not in use from being disturbed by the strong sound issuing from the same, in case the volume dial should not be in zero position. The volume dial is of bakelite and the protecting cover of pressed sheet iron. Due to its small dimensions, the hook terminal is quite inconspicuous when mounted.

An installation with the above described units, see Fig. 4, is very simple to maintain. This system has consequently been very widely adopted, especially in churches, where the microphones can be practically invisibly mounted on the altar, the altar rail and the pulpit. Thanks to the powerful amplification, speech and singing can be plainly and clearly heard at all times without the speaker having to place his lips close to the microphone. Also, the hook terminals can be very discreetely mounted in the pews, see Fig. 3. In churches, it is especially necessary that the hook terminal be provided with a suspension hook which automatically disconnects the receiver when this latter is not in use, as otherwise persons sitting in the vicinity of the receiver would be disturbed in their worship.

The amplifier has also been put to use in restaurants, bars and cafés where the dining room etc. and the kitchen lie on different levels. A microphone, which can be switched over to the amplifier by means of a push button, is mounted in the dining room, while a loudspeaker, connected to the amplifier, is mounted in the kitchen or in some other suitable place. On placing an order, the waiter or waitress depresses the microphone button, thereby connecting up the microphone to the amplifier. The waiter then gives his order in the microphone and it is repeated in the kitchen through the loudspeaker.

The amplifier has also been used to advantage in large store rooms. An amplifier with microphone is mounted in the office, with loudspeakers in the different store rooms. If some member of the staff is to be paged, a communication is to be made to the store-room staff, this can easily be accomplished by talking directly in the microphone, the message being broadcast wherever loudspeakers are mounted.

Distribution Pillars

E. JENSEN, SIEVERTS KABELVERK, SUNDBYBERG

Sievert's distribution pillars have gradually been adapted to a distribution system for mounting above ground level and intended for the cable networks of power and industrial installations. They are noted for their great flexibility, being easily adapted to different requirements; they are easily erected, have been designed with foresight and are of an attractive appearance. They can be used individually or combined with shrouded units.

When electrical power plants began some ten years ago to replace their old open-wire distribution networks with underground cable networks, there arose the question of suitable distribution units. At that time it was customary, in the larger cities, that cable mains, protected at the power station or substation, were drawn to buried cable boxes from which, in turn, protected distribution cables were drawn. The unprotected service cables were branched off from these in underground junction boxes. In smaller communities, the most common method was to lead the distribution cables direct from a station or substation.

This system had its disadvantages, however. Thus, the jointing chambers were very inconvenient for the replacing of fuses; two men are required to open the jointing chamber, and this work takes too much time when city blocks deprived of light are clamouring for restoration of the mains current. Under no circumstances is it a very pleasant job to change fuses in the narrow jointing chamber, with its more or less bare conductors; neither are underground junction boxes and unprotected service lines always so attractive.

In order to offer power plants a more attractive system, Sieverts Kabelverk took up the manufacture of distribution pillars for placing above ground — in general against the wall of a building —, to which all the cables were drawn and in which they were connected to a busbar system, with or without protectors. To begin with, a difference was made between distribution pillars and jointing chambers. The pillars were used for branching off the distribution cables from the mains. These cables were generally over-protected, fuse handles being used for this purpose. The jointing chambers were intended especially for service branchings and were calculated to serve two houses each, see Fig. 1. The service cables were under-protected, D-fuses being used for this purpose. The distribution cables were connected directly to the busbars by means of sweating lugs. Sometimes the jointing chambers were used merely for joining cables together over busbars without any protection whatsoever.

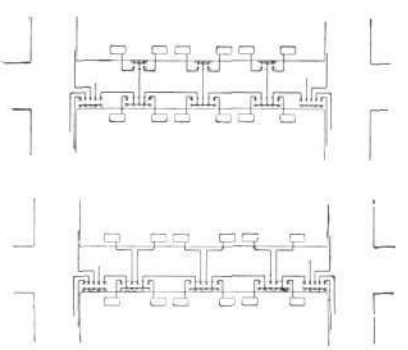


Fig. 1 X 3858

Former and present distribution systems

the first service boxes were fitted with fuses for two service cables only, thus requiring one box for every two houses; with the new distribution pillars, an arbitrary number of service cables — within certain limits — can be branched off at the pillar

The rational use of distribution pillars offers a number of advantages. The ease with which the fuses are tended, the saving in time and the greater personal safety accompanying this method during breakdowns in the network are so self-evident as not to require more detailed explanations. Each cable is terminated in a separate junction unit in the pillar, the different conductors being connected to fuses or to busbars, and one can consequently say that the network — to a certain extent — is constantly sectioned. This greatly facilitates inspection or measurings which are necessary during breakdowns or otherwise. When building a cable network, the pillars offer the advantage that the cables can be laid and connected up individually. The hindrance to traffic caused by the laying of cables can consequently be reduced to a minimum. The termination of the cables and their connection to the pillars can then be taken care of without unduly forcing the work and without obstructing the traffic. Faults occurring in a cable network are generally due to damage caused by street work or to trouble in the junction boxes. In the latter case it is naturally an advantage that the junction box is directly accessible above ground. The fault can be located and remedied without having to tear up the pavement and excavate the street, *i. e.*, without in any way obstructing the traffic. The service cables are protected in the pillars, where the fuses are always accessible to the power plant staff, and effectively protected against tampering. Extensions to a cable network can also easily be made from a distribution pillar.

One advantage ascribed to the jointing chambers is that, when they have once been installed underground, they are out of the way once and for all and cause no trouble in case the adjacent building should be torn down and rebuilt. This is quite true, but it should be emphasized, however, that the streets — especially those of large cities — are very encumbered under as well as above the pavement. A jointing chamber occupies so much space that it is perhaps difficult to find room for the same, and once in position it may seriously obstruct street repairing work. The space occupied by a distribution pillar is negligible. If the pillar — as is common practice — is placed against the wall of a building, it can be stated without exaggeration that it causes no obstruction, see Fig. 2. In certain cases modern show windows can cause difficulties in the placing of distribution pillars, as they are often so low that the base under the window is lower than the pillar. Also, the windows may be so closely spaced that the room between them is insufficient for the placing of the pillar. With the smaller pillars, however, this matter offers no difficulties, since the pillars are only opened — except for the connecting of the cables — for the replacement of fuses and inspection. For this purpose, the shell is opened only in front of the fuses, and as this opening is only about 400 mm high, there is really no reason why the pillar should not be placed so deep down that only the removable cover is above ground.

As far as the larger pillars are concerned, it does not go without saying that this type must be placed against a wall; it can also stand detached. This method has also been largely adopted in England, where one often encounters pillars placed in the footway, right on the edge of the curb. Even though this method is not always practicable, there is no doubt but that it is quite serviceable if carried out with discrimination.

Design

It is now some years since Sievert's original types of pillars and boxes were entirely replaced by a uniform system of cast iron pillars. These pillars are

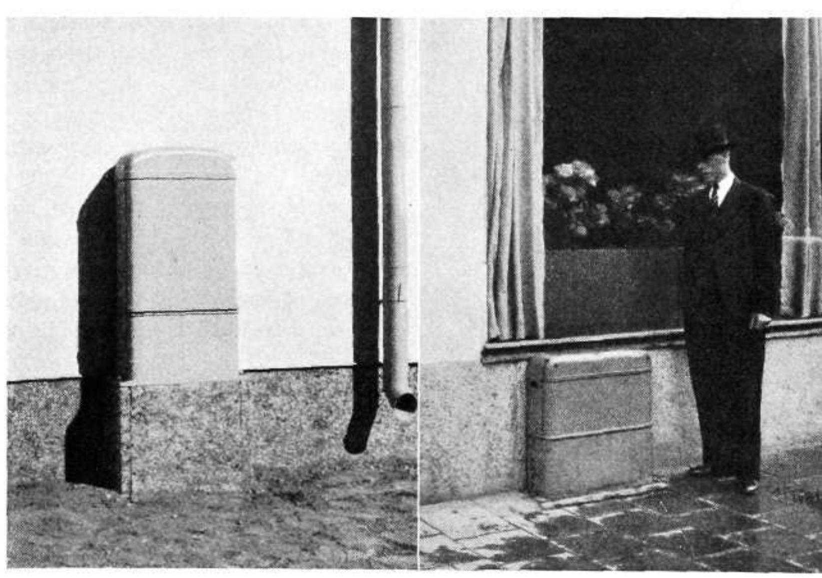


Fig. 2 X 5469
Distribution pillar
left, placed on high base to prevent damage in case of floods; right, placed beneath a store window

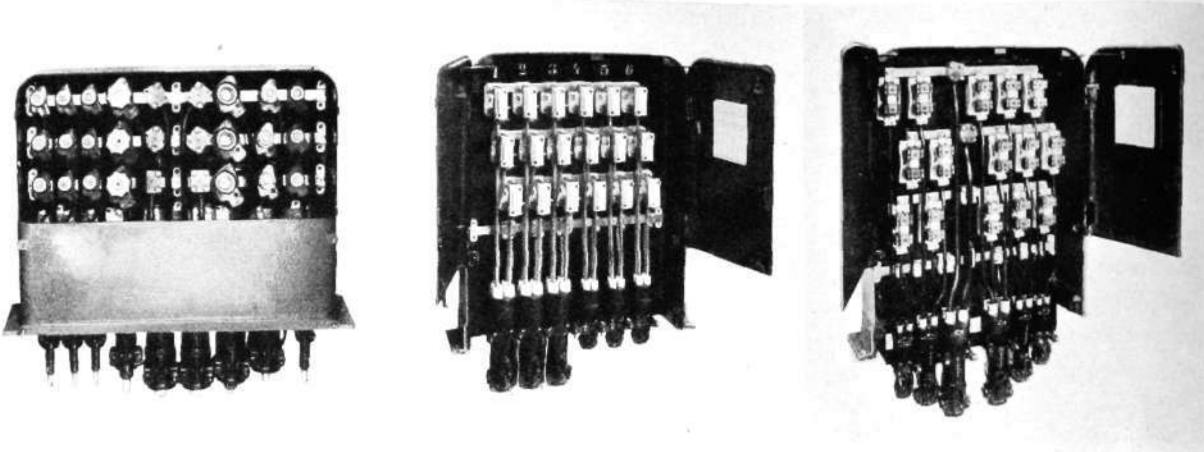


Fig. 3 X 7151

Regular types of distribution pillars

left, type KSD with D fuses for seven cables and terminals for two cables; middle, type KSH for six cables, all connected over H fuses; right, type KSV for six cables, of which five are connected over V fuses and one to busbars direct

made in three different types, Fig. 3, one smaller, Type KSD, fitted primarily with D-plug fuses, and two larger ones, Types KSH and KSV, fitted with fuse handles.

The smallest type of distribution pillar is equipped with a system of sturdy busbars, which support the protectors. The busbars are fitted on two or three porcelain supports. The protectors as well as the connections are constructed so that they may be attached to a busbar at any point, no holes for fixing screws being required. There are no bottom contacts in the fuse bases, but the base can be provided with a gauge ring in order to prevent the use of over-size fuses; thus, the cartridges are screwed in and make a direct contact with the busbar without any additional intermediate resistance. The fuses are made for 25, 60 and 100 A, the two first ones with the usual Edison threading, the last one with a fine threading. Standard connections for the cable conductors will accommodate a section of maximum 150 mm², but can be provided for larger sections as well. The system adopted permits the connecting up in the same pillar of a number of cables of varying sections in arbitrary sequence, either direct to the busbars by means of connections or over plug fuses of varying sizes up to 100 A.

Two types of jointing units are made for the pillars, the one to be filled with common insulating compound and the other pressure-tight. The first type will accommodate three- and four-conductor cables of up to 240 mm², the latter being for single conductor cables of up to 500 mm², and for three and four-conductor cables of up to 185 mm². The jointing units are manufactured in whole multiples of $33^1/_3$ mm, *viz.* $66^2/_3$, 100 and $133^1/_3$ mm. They are fixed to the back side of the pillar by means of strong pin bolts, holes for these bolts — with a spacing of $33^1/_3$ mm — being provided along the whole width of the back. It is possible to fit jointing units of different widths in the same pillar and in an arbitrary sequence from one side to the other. To the uninitiated this system appears somewhat puzzling, which it also may be, but it is quite a simple puzzle to lay. The catalogue gives information as to the space required by every group of fuses and connections, also, the free width of the busbars. The widths of the jointing units are indicated in the number of spacings of $33^1/_3$ mm, amounting to 2, 3 and 4 spacings respectively for the different sizes. Information as to the available space for jointing units, also expressed in spacings, is given for each pillar. The determining of the number of devices and jointing units which a pillar can accommodate is really nothing more than a simple addition.

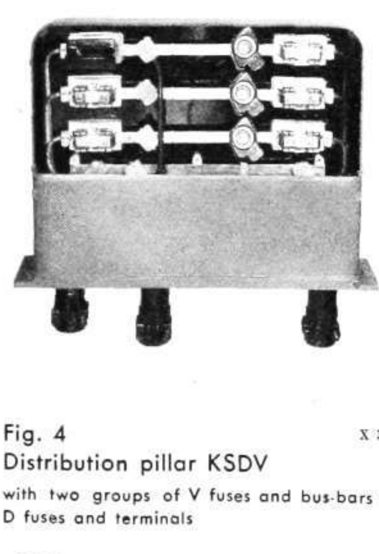


Fig. 4 X 3859

Distribution pillar KSDV

with two groups of V fuses and bus-bars for D fuses and terminals

It sometimes happens that, in a pillar intended chiefly for light cables, it is found desirable to connect one or two heavy cables over fuses. Also, it may be found desirable to connect an incoming cable in such manner as to permit the opening of all circuits when carrying on work in the pillar. Both of these requirements can be met with the aid of fuse handles for maximum 200 A, since it is possible — by placing the fuses horizontally — to obtain

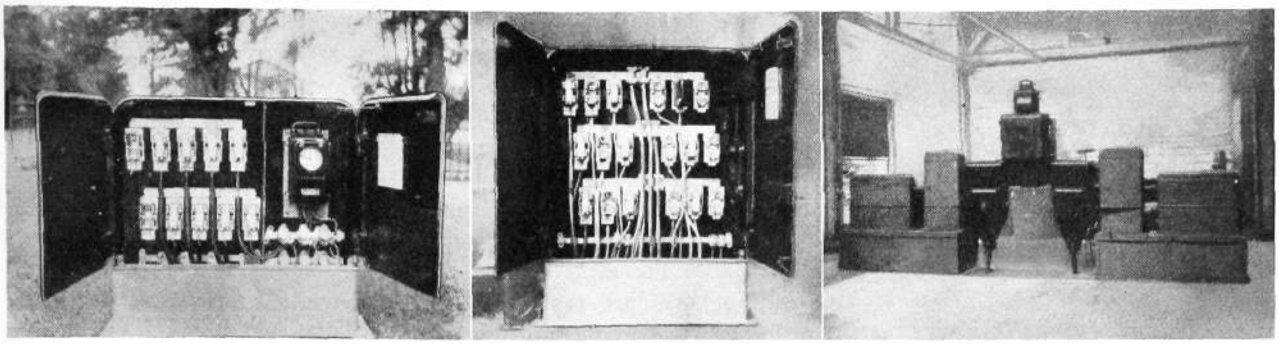


Fig 5 X 7150

Special types of distribution pillars

left, type KSV with D fuses for street lighting and time switch; middle, type KSV employed as distribution central in large machine shop; right, distribution central for large industrial plant, assembled of shrouded units, two pillars KSH for heavy cable and two pillars KSD for lighter cable

room for two groups of fuses, one to the left and one to the right, in the pillar, see Fig. 4. The cables are connected to the outer ends of these fuses: the inner ends of the fuses being connected by means of busbars, to which D-fuses and connections can be fitted in the customary manner. If the fuse handles are to be used only for opening the circuits, they are fitted with knife contacts, otherwise they are provided with cartridges in the usual manner.

High capacity fuse handles for 500 V of two different kinds are used in the large pillars, *viz.:* H-fuses and V-fuses, both of which are obtainable in standard sizes up to 350 A. The H-fuses contain an element, consisting of a porcelain base and two knife contacts. At each end of the cartridge are metal contact plates which grip the knife contacts of the elements. Each cartridge is inserted in a porcelain handle provided with screw terminals, with which the metal contacts can be forced against the knife contacts. After placing the cartridge in position, these screws are tightened by means of an insulated screw driver, furnished with every pillar. The cartridges are to be had in a smaller type, from 60 to 200 A, and a larger type, from 150 to 300 A. The elements have correspondingly smaller and larger knife contacts, which can be exchanged at will. Besides the fact that the elements are the simplest possible, the H-fuses have the advantage of requiring very little space, the 350 A fuses not requiring more space than 200 A fuses. Also, both 200 and 350 A fuses can be fitted in the same pillar without requiring any special arrangements. The V-fuses have larger and more expensive elements, but the cartridges are cheaper, due to the fact that they can be handled with the same handle. The elements are provided with powerful spring grips, into which the cartridges are pushed. In this case, since the cartridges need not be locked, they are somewhat easier to manipulate. The fuses are supplied in a series for up to 200 A, and another series for up to 350 A. The smaller series is already larger than the corresponding H-series, but it can nevertheless find room in the same size of pillar as these latter. The larger V-series, on the other hand, requires considerably more space and, consequently, a larger pillar.

Pillars of standard construction are provided with fuse handles for 4, 6 and 8 fuse groups, and are consequently provided with the full number of fuses. However, there is nothing to prevent the elimination of one or more groups of fuses, either because they are superfluous for the moment or because it is desirable to connect the corresponding cables direct to the busbars. The pillars are always in such a finished state, however, as to permit the fitting of the full number of fuses at any time.

All of the various pillar models are made, not only in standard types, but also in special types for different purposes, Fig. 5. It is quite common, for instance, that electric power plants wish to combine cables for the common distribution and cables for street lighting in the same pillar, so that both of the groups are electrically isolated. A busbar system is then fitted for each group. Also, in the above example, it is often found desirable to install a switching clock and, eventually, a contactor for the lighting and extinguishing of the street lights. This can generally be arranged without difficulty, even though comparatively large pillars may sometimes be required. If the distribution system is too large for one distribution pillar, it is possible to combine two or more. Openings for interconnections are then provided on the side of the shell, and the pillars are mechanically joined together by means of standard extension flanges. The electric connections between the pillars are accomplished by means of vulcanized wire.

Power plants often wish to measure the voltage at certain points in the network, for which purpose they use cables with one or more insulated measuring wires laid in the cable conductor. Special jointing units for one or two measuring wires are provided in order to permit the separation of these measuring wires in the pressure tight terminal units. When jointing units with insulating compound are used, this can be arranged very simply with the standard units.

Due to their construction, the cable pillars require comparatively little space in width. Thus, the space required for each cable is barely 100 mm in pillars with cartridge fuses, and a trifle more than 100 mm in pillars with fuse handles. Due to this fact, these pillars are in great demand for industrial plants and installations in general where space is limited. As previously described, they are then sometimes fitted only with fuses and connecting terminals. In industrial plants, however, it often occurs that circuit breakers, measuring instruments and so forth are required in a distribution central. Also, these requirements are sometimes encountered in electric power plants, for example for the underground transformer stations. The central is then best arranged by combining regular shrouded material with one or two distribution pillars. Industrial concerns often require the fitting of a cable pillar with a main circuit breaker for the feed cable. With smaller intensities of current, this is best arranged by mounting a shrouded switch on one side of the pillar. With larger intensities of current special constructional features may be required.

Ericsson Technics

Ericsson Technics No 2, 1938

N. Svartholm: Distortionless Transmission on Inductively Shunted Transmission Lines

The first of the present paper, which is closely connected with an earlier work by *S. Ekelöf* published in Ericsson Technics No 5 & 6, 1937, gives some variant solutions of the transient problem of an inductively shunted smooth line. Some conclusions concerning the transmission properties in general of such lines have been drawn, particularly a new possibility of distortionless transmission, a closer investigation of which with regard to a lumped distribution of the shunting impedances is given in the latter part of this work, at the instigation of and in collaboration with *H. Sterky*. Furthermore the properties of lines loaded with series inductances besides the shunt impedances *(Pupin-Thompson* lines) have been discussed.

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Latvija W. Endel	*Riga,* Doma laukums 7; P. K. 86
Lietuva T. Witte	*Kaunas,* Gedimino gatvé 7 a
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Chile Flaten, Royem, Anker y Cía, Ltda	*Santiago,* Morandé 230; cas. 2168
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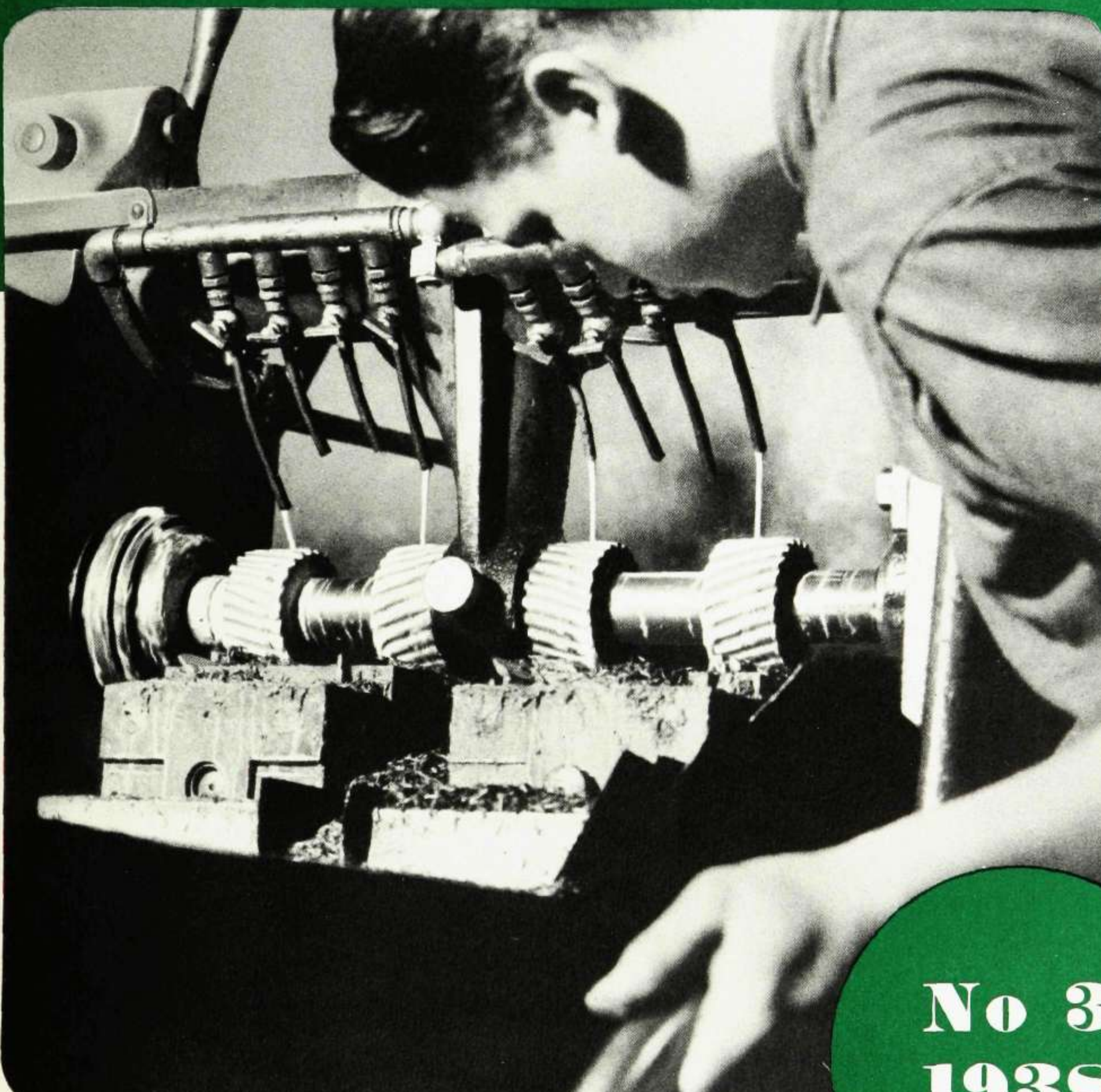
Ericsson Review



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ERICSSON REVIEW

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CONTENTS

How the Ericsson System Came into Being

H. LINDBERG, SECRETARY OF THE ROYAL TELEGRAPH ADMINISTRATION, STOCKHOLM

On 8th April 1938, the seventh Stockholm automatic exchange on the Ericsson system was put into operation. With that the telephone network of Stockholm proper was completely automatized and was thus fully comparable from the teletechnic point of view with the most outstanding that could be displayed in other quarters.

This provides a suitable occasion to recall briefly the pioneers of automatic telephony. The review here given, however, is far from being complete, being designed merely to show how the idea of automatization developed stage by stage, with the object mainly of bringing out the chain of circumstances and the lines of deveiopment which led to Ericssons's automatic telephone system with 500-line selectors.

The description is taken from the souvenir publication published by the Royal Telegraph Administration in connection with the automatization of the Stockholm network.

Automatic telephone technics has in its more essential parts been developed in America. In reading its history one is amazed by the rapidity with which it has made its way. During a period of 25 years practically all the ideas were born and worked out, which hold good today even though in renewed and improved form.

Some three years after *Alexander Graham Bell* invented the telephone, application was made by *M. Daniel Connolly* of Philadelphia, *Thomas E. Connolly* of Washington and *D. E. Thomas J. McTighe* of Pittsburg on 10th September 1879 for patent which constituted the first attempt to connect up telephone circuits automatically. The device from the constructive point of view was very imperfect but the idea had been aroused and the foundation laid on which a long line of speculative inventors were later to build.

Ten years later, on 2nd November, 1889, *J. G. Smith* applied for patent for an automatic selector system for telegraph circuits. The invention is noteworthy to the extent that it introduced principles which were later developed to form the fundamental bases of modern automatic telephone technics. Thus Smith was the first to observe that all instruments did not carry traffic at one and the same time. He therefore arranged for each instrument a preselector, but restricted the telegraph circuits and the final selectors to the number required for the maximum traffic needs. He likewise introduced, among other things, lines for traffic in both directions.

With the name of *Strowger,* three of the great men of automatic technics appear in history, the brothers *Almon B. Strowger* and *William Dennison Strowger* and the son of the latter, *Walter S. Strowger*. The two first-named were born and grew up in New York and attended University together. Almon displayed pronounced mathematical talent, but he also was imbued with other ambitions. At the outbreak of the American Civil War he interrupted his university studies to become — a trumpeter. After the conclusion of peace he trained for the teaching profession.

The history of the origins of the Strowger selector contains a number of interesting points. Almon Strowger, who was irritable and evidently one of the pioneers of the guild of telephone complainants which later became rather extensive, could not abide telephone operators. He was constantly losing his temper at their »wrong connections, long delays, snappy answers, off-handedness and unwarranted cutting off». The result of this obviously rather compact dislike was that he devoted himself to making the operators superfluous. In conjunction with his nephew he constructed an automatic selector, patent being applied for on 12th March, 1889. The first demonstration of the selector principle which took shape in this patent is stated to have been made with the help of a circular collar-box. Walter Strowger who witnessed it thus got the idea of how his uncle conceived a selector unit which by means of lifting and rotating movements would produce the adjustment of a wiper in a field on the inner wall of a half-cylinder.

The first Strowger selector was completed in 1890 and exhibited to the Bell Company at the Kansas and Missouri Telephone Company. On 30th October, 1891, there was formed the Strowger Automatic Telephone Exchange which on 3rd November 1892 was put into operation at La Porte, Indiana, the world's first automatic telephone exchange. The exchange was well received by the public but was superseded in two years. Those responsible for the new exchange at La Porte were three men of Swedish origin, *John* and *Charles J. Erickson* and *Frank Lundquist*, who at that time were associated with the Strowger Company. Working on their own account, they had some time earlier constructed a 100-line selector with two directions of movement at right angles to each other, one movement along the periphery of the field to hunt for the tens and one movement inside the field to hunt the units. It was a later selector design, however, which was employed at La Porte, the »piano wire board». It was the first to contain banks of contacts with wires, patent applied for 7th November, 1894, and has been described, not without reason, as extraordinarily ingenious. It is also the fact that a number of its component parts have been adopted in selector designs of very much later date. From the patent application it may be indicated: the multiple consists of a device with parallel wires, which are traversed by all the selectors and are common for them. The contact shaft has several wipers which are varied in relation to each other. The wiper shaft moves in its direction of length and around its axis.

The next step of importance was recorded on 16th December, 1895, under number 638249, as the most revolutionary patent of the Strowger Company, including the selector design through which the Strowger name has come down to posterity.

For controlling the setting of the selectors there had hitherto been employed press-button impulsing from the subscriber instruments. This device was for a long time a standing objection against automatic systems, which may be understood when it is realized that to get into connection with subscriber *199* no fewer than 19 button-pressings were required. In 1896 patent was applied for in connection with the first telephone dial, though Conolly and McTighe already in 1883 and Strowger in 1891 had made experiments with similar devices for impulse transmission.

All the exchanges constructed up to this time were of very limited capacity so that the problem of augmenting the connecting possibilities came more and more to the fore. In the summer of 1896, therefore, there opened an interesting phase of development. It was then that the engineers of the Strowger Company began to cherish the idea of primary and secondary selectors instead of a single selector, with such a large bank of contacts that its wipers could reach every subscriber connected to the exchange. This idea, however, was not entirely new. As early as 21st May, 1891, *J. W. McDonough* of Chicago had hinted at it in a patent, in which may be observed also the fundamental idea of a much later event — the automatization of network groups. Others too, such as *J. G. Smith* mentioned above and the Parisian *Moïse Freudenberg* had touched on the problem. However, it was *A. E. Keith* and the brothers *Erickson* of the Strowger Company who constructed the first automatic telephone exchange with group selectors and final selectors. It was installed during 1897 at Augusta, Ga.

This paved the way for large automatic exchanges and the first plant för 1 000 subscribers came into existence in December 1900 at New Bedford, Mass. It was followed the next year by a similar but improved exchange at Fall River, Mass.

Call meters came into use in 1902 at a 10 000 line exchange in Chicago. The device was necessitated by the telephone charge being reckoned per call. The meters employed recorded all connections established, no matter whether answer was obtained or not. On the other hand calls were not counted in the event the called number was busy.

In 1904 the Strowger Company introduced the pre-selector, the Keith pre-selector, at an exchange in Wilmington, Del. In earlier plants there had been a first group selector for each subscriber's line. Thanks to the pre-selector it was now possible for 100 subscribers to make use of ten first group selectors in common. This meant a saving of 90 % in the cost of first group selectors. Of course, there was the expense of pre-selectors, but the final gain was still considerable.

Up to the years 1904—1905 local batteries were employed at all automatic exchanges for microphone feed. The advantages of the central battery system were becoming more and more recognized and it was therefore quite natural that the question of its adoption also for automatic exchanges became more discussed. It was done for the first time with the exchange at South Bend, Ind., completed in May 1905, this being moreover the first exchange which had pre-selectors, first and second group selectors, final selectors and call meters, that is a connecting scheme in which even the automatic technician of our day would be quite at home.

The machine-driven automatic systems were due to the brothers *George, James Hoyt* and *Egbert S. Lorimer*. The middle of the three was originally a lawyer, but a lawyer in the predicament that his life interest was electrical experimenting. He quickly abandoned the law — his employer not being the least to encourage the change — and sought contact with *Romaine Callender* who had already given proof of his inventive talent by a design for organs. These two along with the other Lorimer brothers established in 1896 the Callender Telephone Exchange, which company — Callender having by then quitted it — made application on 24th April, 1900, for patent relating to the first machine-driven automatic system.

Clement in 1910 constructed the first automatic relay system.

Naturally it was the United States which first gained the benefit of the new technics. It was only in 1898 that Europe came into close contact with it, when A. E. Keith demonstrated a trial plant at London before a representative gathering of telephone technicians. In the summer of 1899 an exchange of 400 numbers was ordered for Berlin. It was put into service in 1901. It was not, however, until around 1910 that any large automatic telephone plants came into existence in Europe and then it was at Graz and Munich.

By 1912 there were 131 automatic telephone exchanges in the United States. The largest were Los Angeles with 24 000 subscribers, San Francisco with 16 500 subscribers, Columbus with 14 000 subscribers, Portland with 12 000 subscribers and so on. At Chicago there was at that time an exchange for 20 000 subscribers under construction.

In Europe in the same year the number of automatic exchanges was comparatively small. Within the German Empire postal union there were automatic or semi-automatic exchanges at Hildesheim, Altenburg, Dalgow, Raesen, Dornarp, Neudietendorf and Durrheim. Exchanges at Posen and Dresden for a fitted capacity of 10 000 and 100 000 subscribers respectively were under construction. Both these exchanges were arranged for semi-automatic switching. In Bavaria there was an exchange at Munich-Schwabing arranged originally for 3 000 subscribers. There were in England an automatic exchange at Epsom for 500 subscribers and another of the same size under construction at Caterham. Austria had automatic exchanges at Graz and Cracow and one under construction at Vienna. In the Netherlands a semi-automatic exchange had been put into operation at Amsterdam.

Fig. 1 X 3869
The Betulander and Pehrson automatic exchange, manufactured in 1900

First Automatization Experiments in Sweden

Thus Europe at the beginning took up a rather waiting attitude and a similar attitude was adopted by Sweden's representative at the »Electrical Congress» in Chicago in 1893. At the world exhibition held the same year at Chicago, he made acquaintance with automatic telephone technics and the following is what he wrote on the subject: »Automatic switchboards are still only ideas, in view of the fact that nobody has yet succeded in constructing a practical one. At the Chicago exhibition such a switchboard was exhibited by Strowger, along with a telephone instrument connected to it. On the subscriber instrument there were four press-buttons, one for units, one for tens, one för hundreds and one for thousands. Thus, if it is desired to call, say, *365* then one would have to press five times on the unit key, six times on the tens key and three times on the hundreds key. In this way is brought about at the central exchange by means of step-by-step mechanisms that subscriber *365* is put into communication with the caller. It would take too long to describe the various devices in detail, since all experts were unanimous that the main apparatus was far too often out of order to be of practical utility, though the problem would appear to have been thoroughly worked out theoretically. It has been put into use very little up to now. At La Porte, Ind., there is said to be an exchange of 50 subscribers where such an automatic plant exists. As it too is constantly getting out of order the company is obliged to keep an engineer at the exchange to supervize the apparatus and put right the faults as they arise. This constant duty by an engineer will naturally be more expensive in salary than the telephone operator who would otherwise be required.»

There was no excess of enthusiasm there. Nevertheless the new technics found supporters even in Sweden. As early as the establishment of the Stockholm Private Telephone Company in 1883 cheaper subscription had been promised by the employment of »an automatic switching apparatus invented by Messrs. *Cedergren* and *L.M. Ericsson* and a common line for two or more subscribers». In addition, *G. A. Betulander* and *J. P. Pehrson* had

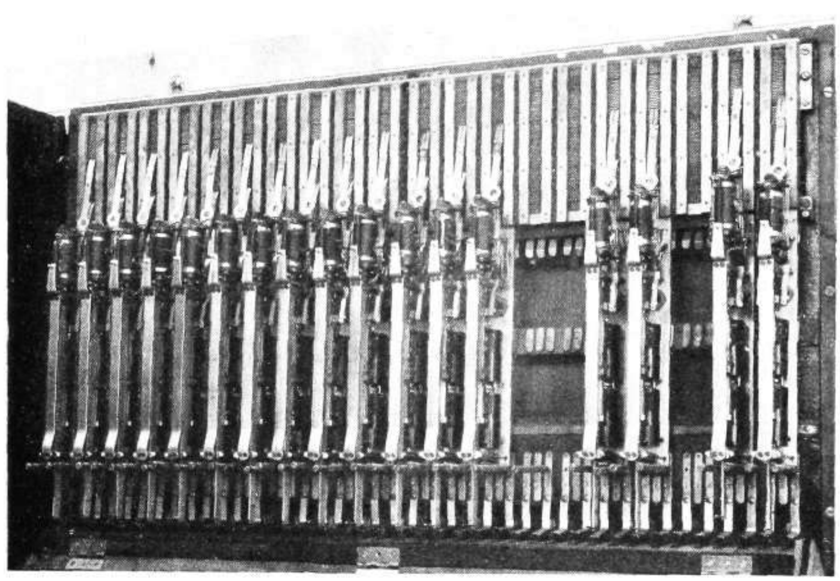


Fig. 2 X 5478
Betulander exchange, installed in 1909

in the nineties constructed small automatic exchanges, one of them having rotating selectors, Fig. 1, being exhibited by the Telegraph Administration at the Exhibition of 1900 and obtaining the gold medal. An exchange of this kind was put into service near Stockholm in April 1901 and this type of exchange had, in conformity with the assurance of the two inventors, also attracted such great interest abroad that »several concerns presented themselves as willing to negotiate for the exploitation of the exchange». Betulander also constructed exchanges with a connecting device working vertically. These exchanges were made at the workshops of the Telegraph Administration and came into use in the beginning of the 20th century at a number of exchanges — one such exchange at Östanbro, Fig. 2, was in operation right up to June 1936.

It was not until about 1910, however, that the question of automatization came under consideration for a large undertaking. That was the year when proposals for the automatization of the Stockholm telephone network were first put forward.

At this period the Telegraph Administration had four local exchanges in Stockholm, all arranged for local battery. To provide for anticipated increase in subscribers and to facilitate transition to the CB system a manual main exchange was planned on this system. Before the details for this exchange had been settled, however, the question arose whether it would not be advisable to build the exchange for automatic operation.

As up to then no automatic exchange of large size had been built in Sweden and consequently experience in the domain was lacking, the then Director of Telephones *Axel Hultman* and the Line Engineer *Herman Olson* were instructed by the Administration to investigate in America the economic conditions and the working reliability of automatic telephone plants. This voyage of investigation, undertaken during the first half of 1910, convinced the two envoys of the advantages of the new system from the points of view both of economy and operating reliability particularly as regards large networks. At that time, however, it was considered that the semi-automatic systems were to be preferred, partly because they were cheaper and more reliable in operation than the automatic (the number dials were expensive and functioned with less satisfaction), and partly because they made no demands on the subscribers either in the form of ability or inclination to carry out the impulsing themselves.

Both Hultman and Olsson commenced immediately on their return to work on the construction of automatic selectors, each with the Strowger selector as prototype. Olson subsequently changed over to a design in which the wiper was moveable around a fixed point, Fig. 3. Connection was obtained by the wiper being first turned vertically and then sideways along the arc-shaped banks of contacts in the field. The banks of contacts in the Olson selector, therefore, took on the form of a section of a sphere, while the banks in the Strowger selector were shaped as parts of a cylinder. The next system of Olson was based on small step-by-step driven selectors, 30 and 10-line, operated by DC impulsers from an impulse machine, and finally he settled on the coordinate selector, which the Telegraph Administration later developed further.

Hultman too soon abandoned his trials with selectors of the Strowger type and went over to the problem of designing a machine-driven selector. It was obviously the Western Electric Rotary System which gave the impulse for this aim, but the system which Hultman with, *inter alia, Mauritz Agrell* as collaborator, succeeded in designing differed so essentially from the Rotary System and indeed from any other system that it must be regarded as a new and independent invention.

The special feature of the Hultman system is the design of the bank of contacts. In other systems the bank consists either of a separate bank for each selector, the connecting device being moved in one or two directions along the surface of the bank, or of a bank common to several selectors,

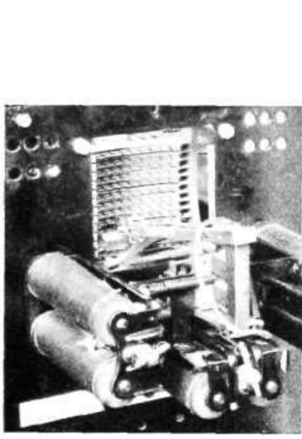


Fig. 3
The Olson selector of 1918

X 3870

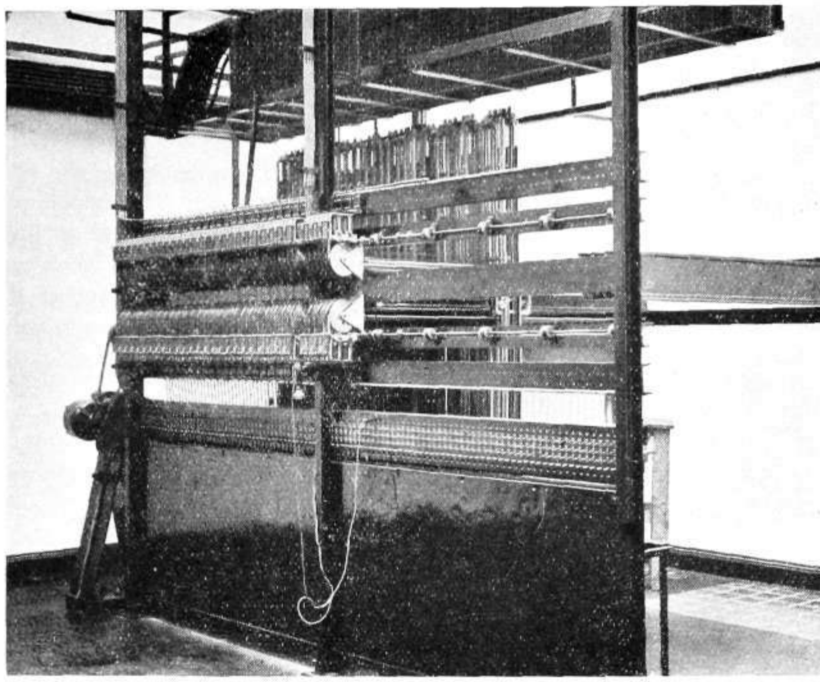


Fig. 4 x 5479
Final selector rack with 10 000 line selector of 1915
Hultman system

in which case the connecting device moves in one direction only. In the Hultman system, however, the bank is common for several selectors and the connecting device is moved over the bank in two directions. The difference in principle may therefore be stated as that in the Hultman system the bank has extension in three dimensions as against only two in other systems. It was thus the design of the bank which constituted the essentially new in Hultman's invention and which was therefore made the main point in the patent application, first made in Germany on 2nd June, 1913, and later in Sweden among other countries on 23rd February, 1915.

Even in its first execution Hultman's connecting bank consisted of bare wires running parallel with one another, supported and insulated from each other by a number of transverse discs of fibre or other insulation material, placed at suitable distances from each other, the wires being drawn through holes in the discs. While the bank has many times being altered since that time, yet this design still persists. The holes in the insulating discs were arranged in two rows, the holes being at equal intervals in each row but one row having double as many holes as the other. The distance between the two rows of holes was large enough for a wiper, provided at its end with three trailing contacts, two on one side and one on the other, to be inserted between the wires drawn through the holes, thus producing the contact connections necessary for switching, The number of wires was governed by the capacity of the bank and their length by the number of selectors which had to work in one and the same bank. A suitable number of bank units made up in this way, was combined to a frame and placed so that the wipers movably fitted on the selector could be inserted in any frame whatever of the rack.

The first selector constructed by Hultman, Fig. 4, was made for a multiple capacity of 10 000 subscriber lines, *i. e.*, the bank comprised $3 \times 10\,000$ or 30 000 wires. The selector consisted of an extended frame fixed on a carriage fitted with four castor wheels for sideways motion. At the top and bottom of the frame were placed two wheels between which the long, double-acting wiper was guided in its up and down movement. The wiper was moreover guided by four wheels fitted in the middle of the wiper and running on vertical tracks on the frame.

The selectors were fitted on horizontal beams, along which they could be pulled to right or left from the central normal position by means of cords, while the castors on the abovementioned carriage ran in tracks on the upper and lower sides of the beams. The vertical movement of the wiper was obtained by means of a rack fitted on the wiper and a toothed wheel engaging same, this being moveable along a shaft extending along the horizontal beams but rotating with the shaft when this was revolved. At the back of the beams, as also on the selector wiper, a number of contacts was mounted to control the movement of the selector horizontally. The connecting bank of this selector was divided into four sections, each with 2 500 subscriber lines, distributed in 50 frames of 50 lines to a frame. Of these four sections one was placed above and to the left of the selector wipers in normal position, one above and to the right of the wipers and the two others below the lower end of the wipers, one to the left and one to the right.

Trials with this system were carried out at L.M. Ericsson & Co's, with the collaboration of *Martin Löfgren* and *Sigurd Johanson*. A first trial plant was demonstrated on 26th January, 1915, for the head of the Telegraph Administration, Director-General *Herman Rydin*, and members of the Board of Telegraphs.

In 1910 Aktiebolaget Autotelefon Betulander was established, constructing automatic exchanges on a relay system designed by Betulander. It was later reconstructed as Nya Aktiebolaget Autotelefon Betulander and was finally taken over by Telefonaktiebolaget L.M. Ericsson. While Hultman and Olson were each working separately for the production of an automatic system, the same problem was also occupying Betulander and his collaborators, among whom may be especially mentioned *Nils Palmgren*, who along with Betulander appeared on a number of patent applications of those days.

The designing activity thus proceeding along three different lines led rapidly to appreciable results and by 1915 the Telegraph Administration considered it desirable to carry out comparative tests in practical operation. A little while before — in 1913 — the Administration had purchased from a foreign manufacture a semi-automatic exchange which was put into service in 1915 at Landskrona.

The first Hultman exchange, a semi-automatic exchange for 1 000 subscribers, was ordered from Aktiebolaget L.M. Ericsson & Co under contract dated 16/25th June, 1915, to be delivered and installed in Stockholm within twelve months. There was concluded on 20th August, 1915, an agreement with Nya

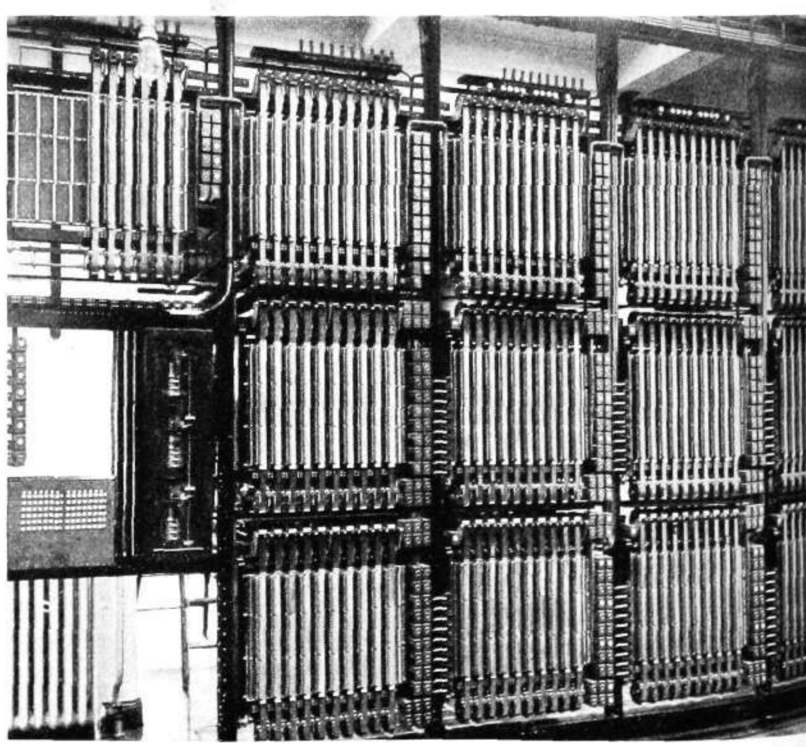


Fig. 5 X 5480
Line-finder rack with 100-line finders of 1915
Hultman system

Aktiebolaget Autotelefon Betulander for delivery within ten months of a semi-automatic telephone exchange on the Betulander relay system for 1 000 subscribers. An Olson exchange for 200 numbers was ordered later the same year from the Telegraph Administration workshops.

The Hultman exchange comprised in addition to the 10 000 line selector a rack with line finders and an impulse machine, a rack with sequence switches and registers, a keyboard position for the semi-automatic switching and a B-position for the incoming traffic. The line finders, Fig. 5, were mounted together in groups of ten, with a common bank consisting of bare wires laid horizontally, arranged in one plane on the front and one on the back of the frame common to ten finders. The line-finder bank comprised 100 subscriber's lines with four wires for each subscriber. The movable connecting organ consisted of an endless, flexible steel strip which by means of mechanical force was made to run over two discs one above and one below the contact bank. On the strip were fixed four studs of insulating material which as the strip moved acted succesively on springs located in front of the wires of the bank so that contact was made between the respective wires and the contact springs. The series switches consisted of a number of discs of insulating material fixed on a shaft, which as the shaft turned under machine drive produced the contact combinations necessary for switching. There were three sequence switches for each final selector. The step-by-step driven registers were operated by means of the impulse machine controlled by the keyboard and restored to home position by impulses from the final selectors.

The exchange was in service with about 300 subscribers from the spring of 1918 up to and including July 1920. It operated satisfactorily in the main, particularly when it is recalled that it was put into service practically without preliminary experiments. Hultman, however, even before the exchange was opened had realized that alterations should be made, as is clearly evident from a report of an inspection of the exchange in January. According to this report Hultman received the inspection committee with the following declaration: »finders of the design fitted should not be further employed; new sequence switches should be fitted, new registers, new keyboard positions and new final selectors are to be designed; the capacity of the multiple should be reduced to 2 000 lines, the impulse machinery could be dispensed with, a system of reports for fault signals should be introduced etc.» The inspection committee was convinced and recommended in its report that the system indicated by Hultman appeared in several respects to be »so simple and ingenious that the experiment should be proceeded with».

In the Olson trial exchange, which as stated was arranged for 200 subscribers, there was employed an unusual form of selector design, a kind of combined pre-selector and line-finder. Each subscriber line was connected to such a combined selector, which for outgoing call was used to hunt for a disengaged link circuit and for incoming call to hunt a reserved line in the group selector multiple. This last function was unique. These pre-selectors were 30-line selectors with two sections of contact points, one for outgoing and one for incoming traffic. The distribution might be done arbitrarily so that, for example, twelve numbers could be used for incoming and eighteen for outgoing traffic. For register selectors, group selectors and other devices required for building up the connection throughout the system there were employed both 10-line and 30-line selectors.

The selectors were rotary and had not more than 33 contacts in the multiple bank. On call from a subscriber his pre-selector was started, hunting a disengaged link circuit and afterwards obtaining connection over a register selector with a selector. Since the system was arranged for semi-automatic operation at the trial exchange, connection was made over the register to a keyboard operator who took the subscriber's order and set the register in accordance with it (the system could easily be converted to entirely automatic, in which case the register was operated direct by the dial impulses of the subscriber). The numerical group selectors were arranged on an intermediate selector system, *i. e.*, the selectors over which calls were exchanged were exceedingly simple and had no devices for impulsing and testing. Special testing selectors were employed for directing these intermediate selectors during the setting. These testing selectors were operated by the register and hunted for a disengaged outgoing line and then set the intermediate selectors both on the calling link circuit and the outgoing circuit selected to the succeeding selector. A testing selector was also actuated by the two last digits in the subscriber number, after which the desired connection was established through the testing selector starting the indicated subscriber's selector and stopping it on a selected circuit of the group selector multiple.

The object of Olson's two different types of selector was obviously to have the most frequently ocurring selector simple and inexpensive and to be able to restrict the occurrence of the more complicated and expensive switching devices to the extent determined by the maximum number of simultaneous connections in each selector stage. Only the pre-selectors were restored to their home position, while the other selectors might take up when at rest any position. The capacity of the system was with one group selector stage 3 000 subscribers, with two group selector stages 90 000 subscribers and with three group selector stages 2 700 000 subscribers.

One technical disadvantage in the employment of the system in large networks was considered to lie in the fact that it did not provide possibility of intermediate connection of subscribers, so that it became comparatively uneconomical in a network as large as that of Stockholm. During the years 1917—1920 there were connected to the trial exchange a number of subscribers, chiefly service telephones. The exchange was taken down in 1920 after it had been decided that the automatization of the Stockholm network should be done on another system.

The trial exchange furnished by Nya Aktiebolaget Autotelefon Betulander utilized relays exclusively for all functions. This procedure represented both a strength and a weakness. Mechanical wear in the system was very slight and it worked at exceedingly great speed. One trouble, however, was that the circuits in the exchange were comparatively complicated and comprised a considerable number of relay contacts in which fault might be anticipated on account of sparking and carbonizing.

The exchange remained in operation, however, from June 1917 up to an including February 1920, during which period it established 2 000 000 connections. Some 400 subscribers were connected to the exchange and these were served from three operator's positions provided with keyboards. The fact

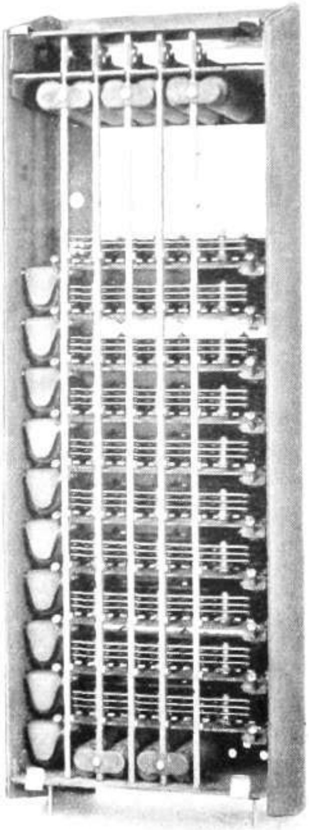


Fig. 6 X 3871
Coordinate selector of 1919

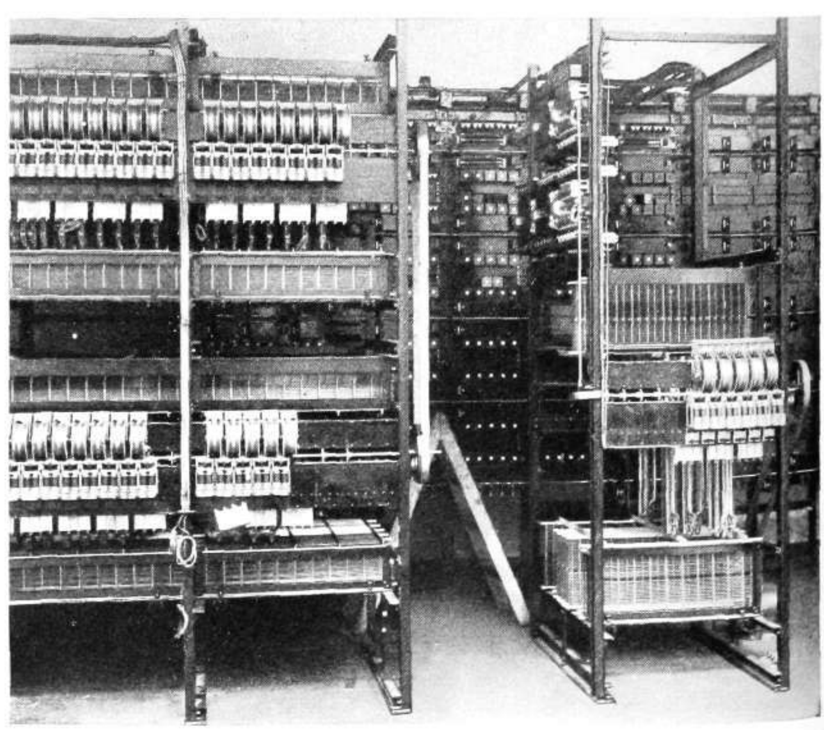


Fig. 7 X 5481
Racks with 1 000 and 2 000-line selectors of 1919
Hultman system

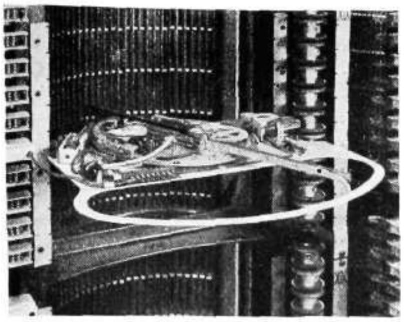


Fig. 8 X 3880
Racks with 500-line selectors
Ericsson system

that the system was not adopted for Stockholm was in part due to it being considered unsuitable in many respects for a network of the size of Stockholm. Thus, for example, the incoming and outgoing selectors were the same which rendered impossible a complete intermediate connecting, so that smoothing out of the load was made difficult.

The system has been developed since, however, in the Telegraph Administration under the name of coordinate selector system, Fig. 6, and in 1926 the first large exchange on this system was opened at Sundsvall. A number of medium-sized central exchanges and over 200 smaller exchanges have since been automatized on this system. The coordinate selector has now gained a footing in the world's largest telephone undertaking, the Bell Telephone Company of the United States. This company opened on 13th February, 1938, its first »cross-bar dial central office», that is, coordinate selector exchange, at Brooklyn.

Arrival of the Ericsson Automatic Telephone System

Besides the contributions to the discussion on an automatic exchange suitable for Stockholm, which found their expression in the trial exchanges, there soon followed a fourth and a weighty one — the system of Telefonaktiebolaget L.M. Ericsson with 500-line selectors.

When Hultman in 1913 had his first design shaped out in principle he sought collaboration for its manufacture with Telefonaktiebolaget L.M. Ericsson. So it was this firm that, under the directions of Hultman, executed and delivered Hultman's first trial exchange with 10 000-line multiple. The exchange, as stated, did not satisfy the designer and presumably not the supplier either. Hultman came out with new ideas and proposals: he designed a final selector with a capacity of only 2 000 lines and a line finder and group selector with a capacity of 1 000 lines, Fig. 7. The work on this new design proceeded during 1918 and in the summer of 1919 small trial installations were put up with the object of testing direct connection from the keyboard positions at the Norra Vasa trial exchange to subscribers in other exchange areas, *i. e.*, connections without recourse to junction operators. These installations, however, for various reasons were never used for traffic.

Before necessary adjustments could be made on the installations Telefonaktiebolaget L.M. Ericsson brought out their 500-line selectors. These proved, as will be seen later, the decisive word. Ever since 1918 comprehensive research work had been going on in this company under the direction of *Knut Kåell*, who had been commissioned to try and work out a competitive system based on Hultman's designs and proposals. A start was made with the selector, with the Hultman wire multiple as fixed point of departure. The question was raised whether multiples of the size suggested by Hultman were advisable from the economic point of view. The answer that Kåell obtained from his mathematical calculations indicated that the optimum lay between 600 and 700 lines. He therefore chose, taking into account the desirability of being able without too great difficulty to comprise the selector in a decimal system, a selector with a 500-line capacity, which though rather too small according to calculations yet was preferable on many accounts to the 1 000 line selector. *D. Lienzén* was responsible for the constructive shaping of the new selector. In the beginning of 1919 Ericsson's 500-line selector was completed, Fig. 8. It was then adapted to a system and in the spring of 1920 the first tenders were made for exchanges on the Ericsson automatic telephone system with 500-line selectors. By a contract dated 23rd April, 1921, the Telegraph Administration ordered the first automatic exchange, Norra Vasa at Stockholm, for 5 000 numbers. At this stage one point may be noted: Telefonaktiebolaget L.M. Ericsson had sold automatic exchanges to a value of 2 000 000 kronor before drawings of all the exchange parts had come from the drawing office to the factory and before there had even been opportunity to check up a complete connection in the test room.

The Telephone in the Service of the Railways IV

C. TH. ANJOU, TELEFONAKTIEBOLAGET L. M. ERICSSON, STOCKHOLM

In the Ericsson Review No 4, 1937, and No 1 and No 2, 1938, accounts have been given of the telephone systems employed for communication between telephone instruments connected to common two-wire circuits along the railway tracks, and of the joint traffic of these systems with local telephone networks within the station acres. Stress has been laid in these accounts on the many advantages of automatic telephone operation.

There is, however, with the railways a large demand for long distance communications, linking up the most important of the railway system's main stations. The large main centres, in fact, require convenient direct circuits both for the ordering of the railway traffic and for various administrative business. Railway administrations, therefore, have arranged long distance circuits along all main lines and are continually extending this communication network to meet growing requirements.

An account is given below of how these long distance circuits are built up and the systems applied.

Trunk Telephony

As is known, it became at one time a question for railway undertakings to change over from the slower telegraphy to the more appropriate telephone in order to satisfy the increased demands imposed by higher train speeds and traffic intensity. Gradually also the need for direct trunk circuits became more and more apparent both for the control of the rail traffic and for facilitating administration. The result was that the railways constructed their own trunk networks alongside the telephone networks already in existence.

The trunk telephone traffic may be handled either manually or automatically. The latter method of operation has up to now found small application, despite the fact that from the technical point of view it no longer involves any great difficulties. The reason is chiefly to be found in the fact that the number of circuits between places in a railway network is usually small so that the load on these circuits is large. With the introduction of automatic operation over small circuit bunches, the utilization per circuit falls considerably in comparison with what is the case with manual working and consequently the construction of new circuits has in general been avoided, the manual operation being retained instead.

There are, however, means with the aid of which it is possible to augment appreciably the utilization of the circuits. The number of call possibilities on a circuit may in fact be doubled even many times over by the application of carrier circuits. The principle of this procedure is the same as for wireless transmission, the only difference being that appreciably lower carrier frequencies are employed — i. e., much longer wave-length — than with wireless transmission, with the result that the high frequency energy emitted follows the telephone lines and does not as with wireless radiate out into surrounding space. Several such carrier systems have been developed by Ericsson, including a single-channel system for one carrier circuit and a three-channel system for three carrier circuits besides the ordinary voice-frequency circuits.

All the apparatus necessary for the operation and utilization of trunk circuits is designated by a common word, trunk equipment. It consists of terminal exchange equipment and, with long trunk circuits, also of repeater equipment, while with four-wire operation there are also terminal repeaters and voice frequency equipment. The nature of the trunk equipment is determined to a high degree by the question whether the connections go over bare wires on poles along the track or whether they are carried in cables embedded in the track embankment. The length of trunk circuits is generally so great that repeated amplification is necessary to bring down the line attenuation to an admissible figure, 1 to 2 neper. With aerial circuits of bare wire the repeater distances are relatively great, 300 to 400 km, while with cable circuits they stand at 100 to 200 km or less.

Aerial circuits can only be permitted with non-electrified tracks and in exceptional cases on tracks with electric operation, in which case they must be moved off from the track to an adequate distance to avoid the noises due to induction from the trolley lines. For electrified tracks, therefore, cables may be regarded as normal.

Cable circuits present the advantage over aerial circuits that they are considerably less exposed to damage and thus cause appreciably less interruption in working of the telephone communications. Both kinds of circuit allow of increasing the number of circuits by means of carrier systems. It is seldom or never a question of multi-channel systems with railway telephone networks, since two places are seldom linked together by a large number of trunk circuits even if these run parallel for long stretches. Mostly a single-channel system for cables is employed, utilizing the normal repeaters along the lines. Aerial circuits on the other hand are often equipped with multi-channel systems, chiefly three-channel systems.

Repeaters

To compensate for line attenuation on long circuits repeaters are inserted at regular intervals along the lines. For each bunch of lines these are assembled at fixed repeater stations. A distinction is made between terminal repeaters and intermediate repeaters, as also between through repeaters and cord circuit repeaters. The through repeaters are connected to definite lines and are thus comprised in the permanent trunk circuits always available for the establishment of calls between two places. The cord circuit repeaters are temporarily connected between two lines and thus serve as connecting devices with the requisite grade of amplification for the building up of trunk communications of a more occasional nature.

Repeater stations cannot be under constant supervision but are partially left unattended. They should therefore be built up on a simple system providing great reliability of working. This should also be done from the point of view that fault arising can be rapidly localized and easily remedied. It is advisable to build the repeater stations entirely mains-connected, the power being taken from the public mains, a 24-hour battery reserve being provided to cover any temporary interruption in the mains supply. The repeater station includes a test equipment, enabling amplification measurements to be made, as also attenuation and level measurements together with supervision and control of the repeaters and the ringing repeaters.

Repeaters are of two kinds: two-wire repeaters and four-wire repeaters. The former are the more frequent, since two-wire circuits are naturally less expensive. Two wire circuits, however, carry speech in both directions on the same pair of wires and two-wire repeaters must therefore be two-way. In order that the speech amplified in one direction shall not return through the repeater device for the other direction, causing self-oscillation in the repeater and announcing itself by a continuous howling on the line, the two amplification directions in the repeater must be connected to the line over a differential transformer, which in turn is connected to a balancing network, *i. e.*, an arrangement of coils, resistances and condensers which in electrical respect resembles the line. There still remains, however, a slight tendency to oscillation and this can never be entirely eliminated, how accurately the repeater may be built. When the two-wire circuits are still longer and the number of two-wire repeaters thus larger, these self-oscillation tendencies of the individual repeaters act in combination and in this way there is gradually reached the limit of two-wire circuit length when howling is heard and four-wire operation must be adopted. In most cases, however, railway trunk circuits do not attain this limit.

Four-wire circuits have one pair of wires for one direction of call and another pair for the opposite direction. Each pair of wires is equipped with one-way repeaters. Both pairs of wires are coupled to two-wire lines over differential transformers at both terminals of the circuit, the two-wire lines being balanced in the manner given above. As may be seen, the *whole* four-wire circuit works in the same manner as if it were a single two-wire repeater. There is, moreover, no surplus of amplification as in a two-wire repeater, which explains the good stability of the four-wire circuit.

Two-wire repeaters, and often four-wire repeaters, are provided with signal repeaters for transmission of ringing and clearing signals which the repeaters themselves cannot transmit. At times they are provided with relay repeaters for transmission of the automatic telephone operating impulses. In long four-wire circuits where many signal repeaters are required this causes the trouble that the mechanical retardation resulting with relay devices might considerable delay and even make impossible the transmission of ringing signals. This is avoided by sending out signals over the circuit at 500 or 1 000 c/s which, contrary to ordinary ringing signals, can go past the repeaters and thus without noticeable delay reach the other terminal station in the same way as the speech itself. Here the voice-frequency signals are converted by means of special voice-frequency receivers and relays to ordinary ringing signals. Voice-frequency signalling is of importance for very long circuits where normal ringing repeaters would give a total retardation of troublesome size, which seldom occurs, however, in railway telephony. As the voice-frequency signal equipments at terminal stations are expensive apparatus, they do not often provide any economic advantage over ringing repeaters.

Where the lines enter the stations they must always be first provided with safety devices to prevent injury both to the operating staff and material. With aerial lines damage may be caused by lightning in the country over which the lines pass and with cable lines along electrified tracks by the inductive tensions arising from the electric traction, which are often of considerable magnitude. Line transformers constitute a good protection against these. All trunk lines — with electrified tracks all lines in the main — must therefore be equipped at their entrance to the stations with line transformers. Besides, these prevent entry to the station of a number of troublesome noises for telephony, induced in the lines.

The balancing networks which as stated above are necessary with all two-wire repeaters and at the terminal points of four-wire circuits, are installed in the same rack as the line transformers. The balances are built up of coils, condensers and resistances, so that they give the same electrical characteristics as the line to which the repeaters are connected. The balancing network is so connected to the repeater that it forms the requisite balance against its line and thereby prevents selfoscillation in the repeater.

As is known, cable circuits are as a rule provided with induction coils, loading coils, inserted at fixed intervals to bring down the attenuation in the circuits as far as possible within the voice frequency band. For different frequency ranges the loading coils have different values and the balances for lines of different strength of loading are made up in different ways. Other factors too govern their composition, such as the line dimensions, capacitance between lines and — for aerial lines — the line material (copper or iron).

When the repeater stations comprise cord repeaters the lines are connected together over these in a manual telephone exchange. When a repeater is thus connected to a line, it is at the same time connected to the balance pertaining to the line. The cords with the necessary wires from the repeater terminate in double plugs each of which is connected to a line jack and the jack alongside for the line balance.

A repeater station consists, as stated above, of a number of repeater racks, a test rack, a transformer rack and a power rack. The lines go from the cable box via a distribution frame to the repeater rack jack panel or in case of cord repeater connection to the swichtboard. In either case the transformer rack is passed through. All passage of lines from one rack to another takes place at the rear of the racks.

The repeaters of the station are mounted one above the other in iron racks, four repeaters to each rack, see Fig. 1. Each repeater constitutes a separate panel and both repeater valves and dials for regulating the amplification are accessible from the front. Above each rack are resistance lamps and fuses, through which all valves, among others, receive their operating tensions, while approximately in the middle of the rack is a jack panel for incoming lines. For testing the ringing repeater there is a special test panel on one of the racks, just below the jack panel. The ringing repeaters are mounted at the bottom of the rack.

The connecting diagram for a repeater with ringing repeater is shown on Fig. 2. The diagram applies to two-wire repeaters and may naturally be modified for special cases, while the devices with four-wire repeaters are similar. Line L_A is connected to the differential transformer *1*, the other side of which is connected to the line balance B_A. The incoming telephone current, after bisection necessary because of the differential transformer's principle, passes through filter *2* on its way to ringing repeater RL_A—RF_A which has a signal receiving relay and a condenser *8* coupled in series between the branches. The ringing signal thus arrives here but is prevented from going further by a condenser in series in one branch, while the telephone current continues through the correction network *3* and the potentiometer *4*, which serves for adjusting the amplification, on to the valve's

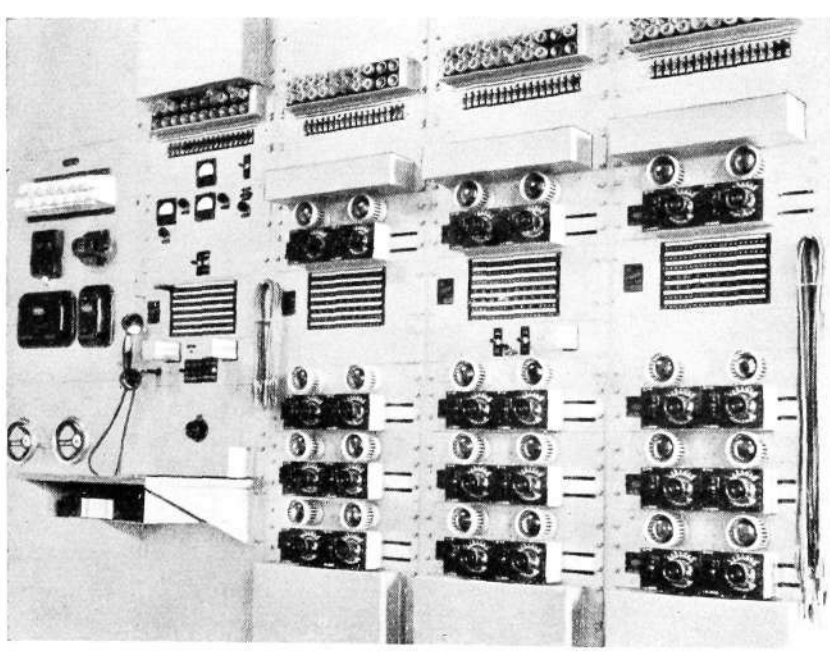


Fig. 1 X 5477
Repeater racks
right to left, three repeater racks, test rack and mains supply rack

input transformer *5* which is connected in the ordinary way to the valve grid circuit. The filters *2* and *7* limit the transmitted frequency band upwards, which is necessary to enable balancing of the repeater to be done, this being the more difficult the wider the frequency band to be transmitted. The correction network *3* has an attenuation falling with the frequency which counteracts the natural rise of the line attenuation with the frequency, so that the circuit gets a uniform transmission of all frequencies in the band.

The output side of the valve delivers amplified telephone energy over the output transformer *6*, filter *7* and the second differential transformer *1* to the other line L_B. Renewed ringing current is obtained from the ringing repeater at RF_B—RL_B over transformer *1* to the line L_B. For the reverse direction of speech the lower part of the repeater diagram applies, the ringing repeater then working in the opposite direction.

The test equipment included in the station may be seen on Fig. 3. Immediately below the resistance lamps and fuses at the top of this rack there is a voltmeter on a panel with the switch for testing the station's filament and anode tensions. Below this panel is located the level measuring device which consists in principle of an amplifier with known amplification and a voltage measuring instrument. In order that this may always show on measuring a definite deflection the incoming voice frequency tension must be more or less attenuated by certain potentiometer arrangements. The handwheels for these are directly graduated in neper in the level of the incoming tension. With this instrument attenuation, overall line attenuation, level and amplification may be measured. The lowest panel is a voice frequency generator, which delivers the voice frequency current necessary for the above tests. It can be adjusted for any for the frequencies 300, 500, 800, 1 000, 1 400, 2 000 or 2 400 c/s. The panel above the generator is a supervision panel enabling calls over the repeaters to be heard at the repeaters, cutting in for conversation with subscribers and ringing up other stations.

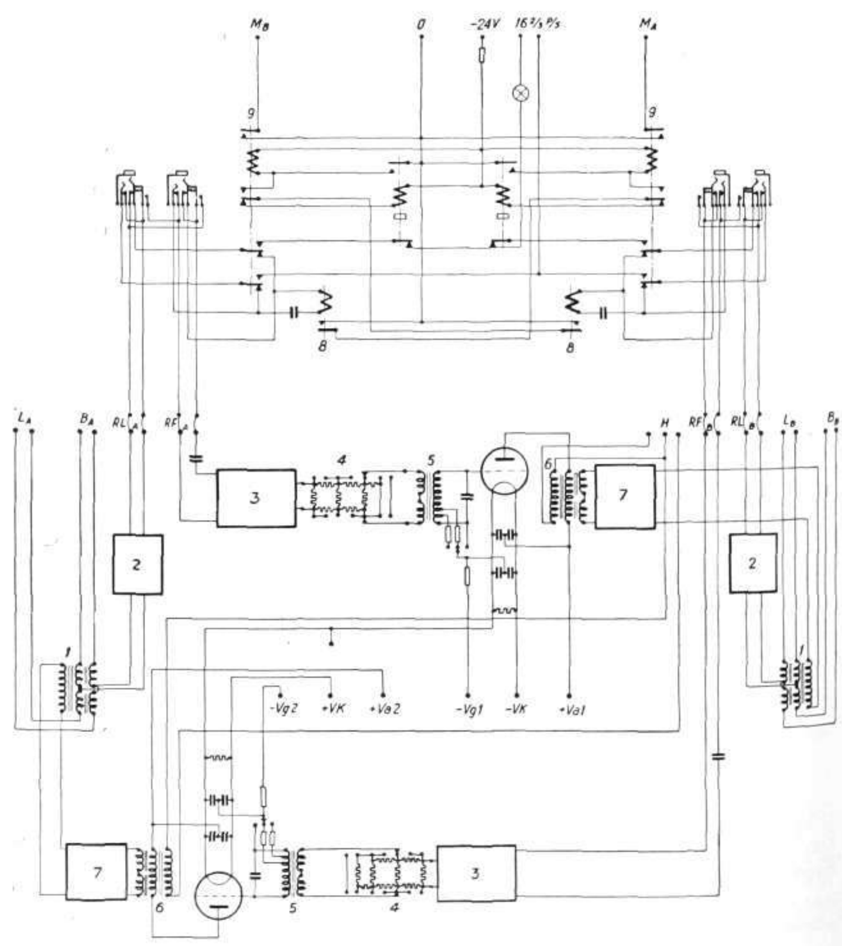


Fig. 2 X 5335

Connecting diagram for repeater equipment

above, ringing repeater; below, telephone repeater

1	differential transformer
2	filter
3	equalizer
4	potentiometer
5	grid transformer
6	anode transformer
7	filter
8	incoming signal relay
9	outgoing signal relay
B_A, B_B	balances
H	listening jack
L_A, L_B	circuits
RF_A, RF_B	ringing repeater's amplification sides
RL_A, RL_B	ringing repeater's line sides

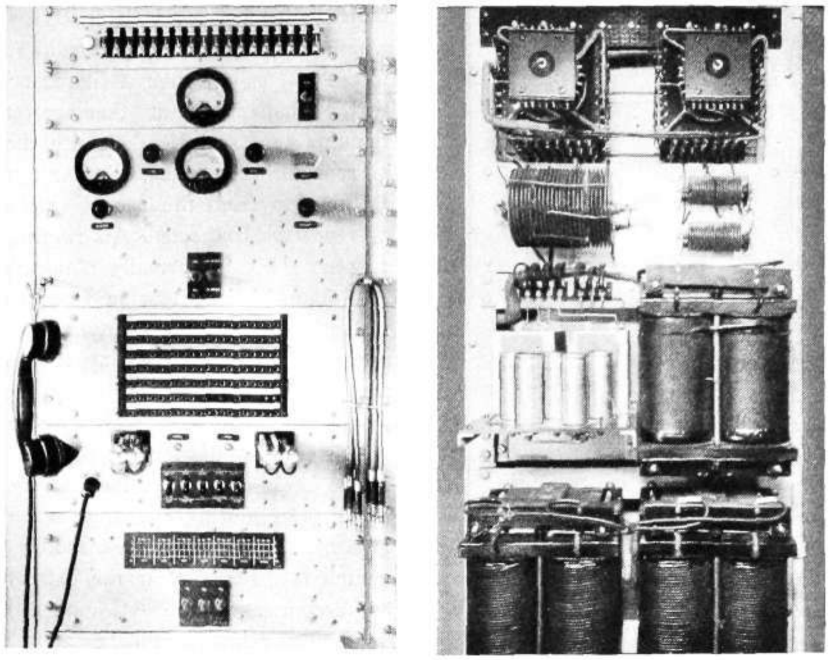


Fig. 3 & 4 X 3684 X 3669

Racks in detail

left, front of test rack with, from top to bottom: fuse panel, voltmeter panel, level measuring panel, jack panel, supervisory panel and oscillator panel; right, back of mains supply rack with, from top to bottom: regulating resistance, rectifier, condensers and chokes

There is a mains supply bay at the station for energy supply, Fig. 4. The incoming AC current, *e. g.*, 220 V, 50 c/s, is transformed to suitable tension for the rough regulating transformers *1* and *2*, see the diagram, Fig. 5, proceeding to the metal rectifiers arranged in full wave bridge circuit *5* and *6*. The former of these provides anode tension 130 V DC for the valve anodes, the latter filament tension 24 V DC for the cathodes. Fine adjustment of the tensions is done by the two resistances *3* and *4*, operated by two dials on the front of bay. From the rectifiers the anode and filament currents pass through filters for smoothing and are finally fed direct to the repeater valves after passing over a switching relay. The two filaments in a repeater are connected in series with a regulating lamp.

If for any reason the AC current fails, thus putting the rectifiers out of action, the switching relay couples in the reserve feed so that operation proceeds uninterruptedly. The reserve feed consists of an accumulator delivering 24 V DC to the filaments and a rotary converter delivering 130 V and driven by the battery. Each repeater consumes 0.25 A filament current, so that with mains supply the disconnection of a repeater signifies an appreciable

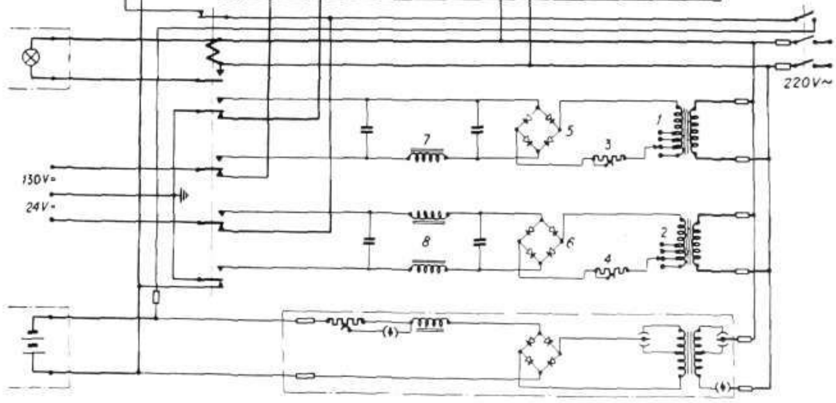


Fig. 5 X 5336

Connecting diagram for mains supply equipment

top, reserve converter and regular converter; below, left, switching relay, right, anode current rectifier, filament current rectifier and charging rectifier

- 1, 2 adjustable transformers
- 3, 4 regulating resistances
- 5, 6 rectifier bridges
- 7, 8 filters

increase in the 24 V field. To avoid this, there is an extra load resistance which is connected in by certain relays if the filament current for any reason is cut off, *e. g.*, when a filament burns out, and consumes the same current as the filament circuits that are out of action. In this way the 24 V rectifier remains constantly loaded with the same current, irrespective of the number of repeaters connected. Similar arrangements are also introduced to maintain the tension from the 130 V rectifier constant without regard to the number of repeaters connected. All ringing repeaters work with 16 to 25 c/s ringing current. This is normally obtained from a rotary converter driven from the AC mains. If the tension from the mains fails, ringing current is obtained instead from a reserve converter which in addition to 130 V DC also delivers approximately 80 V ringing current. For all the machine and battery circuits there is a number of fuses at the top of the power bay. Under these are located the regulating resistance for the reserve converter and a main switch which cuts off the tension for the whole station. Other equipment is mounted at the back of the bay. The battery usually consists of a regular train lighting battery, facilitating exchange when overhall is necessary. For charging there is a metal rectifier not exceeding 3 A, adjustable in three stages. The main switch is three-pole, as the battery circuit must be cut off at the same time as disconnecting the AC mains. If the mains alone were disconnected the switching relay would be actuated and the reserve converter would be started up.

Cord circuit repeaters are connected to the lines over cords in the exchange. The lines, however, are of different lengths and thus different attenuations and it would therefore be necessary to readjust the amplification for each case. This is avoided by the repeaters intended for the telephone exchange being set for different degrees of amplification. The operator then only needs to select with aid of the cords a suitable repeater for a certain group of lines and thus keep the overall attenuation within convenient limits.

Railways have often many weak telephone lines frequently of comparatively great length as also lines of inferior quality, *e. g.*, iron conductors. These lines, which as a rule constitute isolated connections between two places along the railway tracks with small traffic, often have far too high an attenuation to make it possible to carry on conversations unhindered over them. Nor would it pay to arrange any repeater station, as the number of circuits is too small and their importance not sufficiently great. For such circuits Ericsson has a simpler repeater, entirely mains supplied, with a lower degree of amplification, usually 1 neper, and mostly without ringing repeater. The ringing signal in such case goes past the repeater through a filter without being repeated. Starting is done by connecting a flex to a wall point in the public mains. If the mains current fails, the incoming circuit pairs are joined up automatically by a relay and the line can then operate without amplification. If a drop in the amplification is feared a receiver is plugged in to a jack on the repeater for each direction of speech and a switch pressed. If a tone is then heard in the receiver the amplification is satisfactory. Otherwise the amplification has fallen more than 0.2 neper and a valve requires replacing. The repeater is designed for fixing direct on a wall.

Carrier Circuits

Most telephone lines in a railway network consist of bare wire lines, carried on poles along the railway tracks. When there is need of increase it often occurs with surprising rapidity. This may be due to a certain tourist resort becoming suddenly popular, to a certain stretch of track being electrified or to some other reason. If the section of track is electrified this will necessitate replacement of the bundle of aerial wires by a telephone cable. If the railway traction remains unaltered and only one or two new circuits are required then carrier frequency circuits should be introduced instead.

Change-over to cable operation has already been touched on above and the requisite repeater equipment described. Carrier frequency may either represent a transition stage to the cable solution or may in itself constitute a more permanent solution of the telephone problem for a certain track section. Of particular importance in such event is the case where there exist along the railway line only a few wire pairs, one of which is equipped with a selector installation having a large number of telephone apparatus connected. It may often happen that the distance is considerable over which such a circuit links up two of the railway's main places. These usually have strong need of being in direct communication with each other over a more convenient plant than a selector line represents, with the large traffic and the high attenuation caused by the many selector equipments connected in. It should be observed that it is not possible to introduce repeaters on selector circuits on account of the difficulty in balancing their strongly variable line impedance. An exception is constituted by the case where a low amplification, not more than 1 neper, is introduced at one point only on the line. The attenuation due to the length of the line and the large number of selector equipments may be so great, however, that between two sections of the selector circuit it may be necessary to let an operator repeat in a conversation between two remote places. Moreover, the lines are frequently, particularly when several sections have to participate in the long distance circuit, engaged in one or more sections, which delays the establishment. A carrier circuit over the selector circuit provides in this case the desired convenient circuit. The great merit of the carrier circuits lies in the fact that it is possible rapidly and at appreciably less expense to obtain circuits often considerably better in all respects than by stringing a new pair of wires.

The carrier equipments which are before all suited for railway telephony are of two kinds: single-channel system which allows for one carrier circuit and three-channel system which allows for three carrier calls between two places. They work on frequency bands transmitted over the lines and lying above the voice-frequency band. In the main, frequencies under 30 000 c/s are suited to railway requirements in this respect.

For a carrier plant on a selector line there are required, in addition to terminal equipment, filter devices at each selector instrument, which prevent the high frequency calls being disturbed by the selector equipment. These filters are fairly simple and inexpensive devices.

Ericsson's single-channel system ZL 400, Fig. 6, works with entirely suppressed carrier frequency and only the one side-band is transmitted, which is of importance from the standpoint of disturbance. For speech in the one direction the frequency band of 3 500—5 900 c/s is used with 6 200 c/s as carrier frequency, see Fig. 7. In the other direction there is used the frequency band of

Fig. 6 X 7095

General diagram for single-channel system ZL 400 with auxiliary output amplifier

AUX MOD BP	auxiliary modulator filter
AUX RKI	auxiliary directional filter
B	balancing network
BPI	input band-pass filter
BPU	output band-pass filter
DEM	demodulator
DEM BP	demodulator filter
DFT	differential transformer
HP	high-pass filter
LDT	auxiliary amplifier
LP	low-pass filter
M	supervisory device
MOD	modulator
MOD BP	modulator filter
N	correcting network
PHYS	voice-frequency channel
RA	receiver amplifier
RI	receiver signal
RKI	input directional filter
RKU	output directional filter
RO	receiver oscillator
RR	signal receiver
RU	transmitter signal relay
TA	transmitter amplifier
TL	trunk circuit
TO	transmitter oscillator
VFC	carrier channel
XA	push-pull amplifier

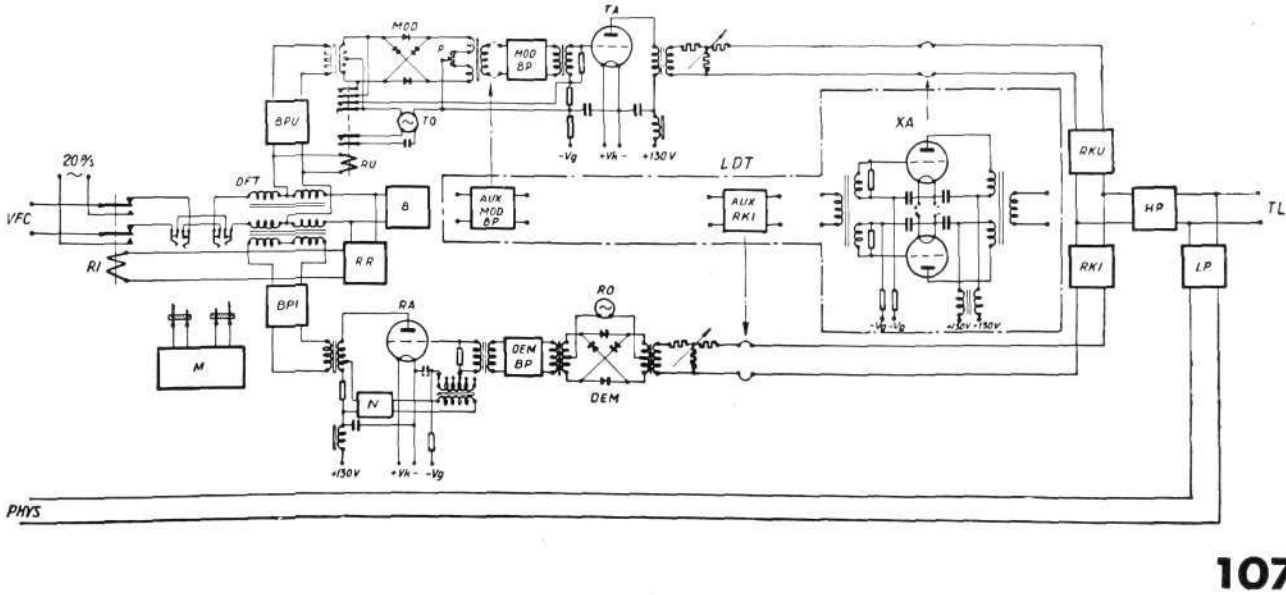
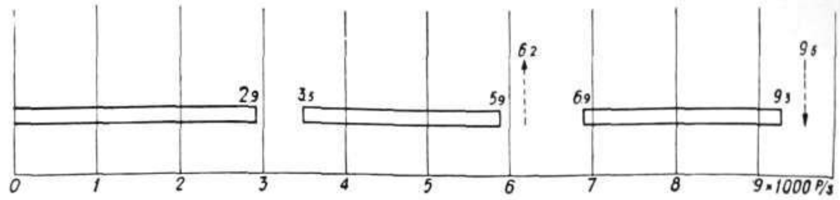


Fig. 7 X 5295
Frequency distribution for single-channel system ZL 400



6 900—9 300 c/s with 9 600 c/s as carrier frequency. The highest frequency transmitted therefore is 9 300 c/s; with automatic level regulation there is used for the one direction a rather higher pilot frequency. The relatively low frequencies are advantageous because short cable sections may eventually be linked into the circuit. The effective voice-frequency band transmitted is 300—2 700 c/s. The low-pass filter for the voice frequency circuit has an upper frequency limit of 2 900 c/s.

The level of the side-band delivered to the trunk circuit is + 0.75 neper. Having regard to line disturbance it is not generally possible to allow a lower incoming side-band level than — 1.75 neper. The largest tolerated line attenuation would then be 2.5 neper. By augmenting the system with an extra transmitter repeater and the requisite filter devices it is possible, however, to increase the outgoing side-band's level from 0.75 to 2.0 neper. The greatest line attenuation permitted then would be 3.75 neper. The extra transmitter repeater is used either when this greater range is required or when the single-channel system is to operate on the same pole line as a three-channel system. The normal overall attenuation on the single-channel system is 0.8 neper, but it can be brought down to zero.

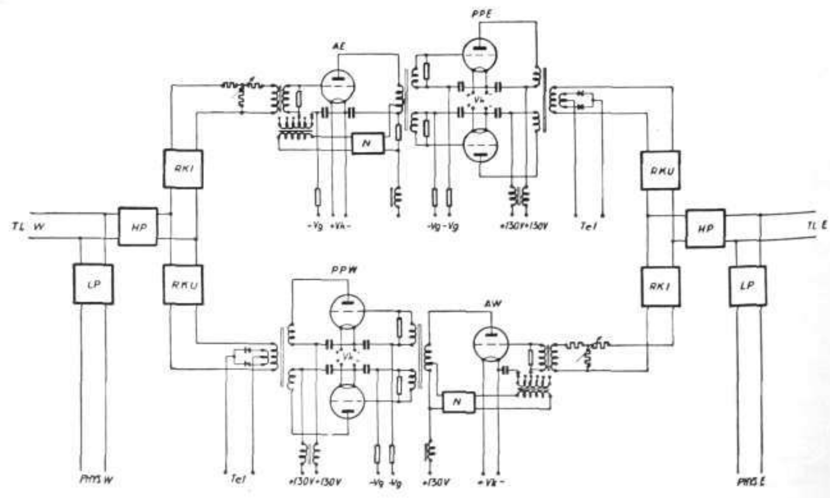
The signalling is done in such a way that the carrier frequency is altered by 500 c/s so that it will work within the transmitted frequency band. It will then act on the receiver as a side-band to a continuous tone with the frequency of 500 c/s. The 500 c/s tone formed in the receiver actuates a simple tone-signal receiver constructed on the normal Ericsson principle.

When the line attenuation is greater than can be overcome by the terminal equipment amplification, there is employed an intermediate repeater ZL 450, Fig. 8, comprised in the system. It is normally designed to amplify the side-band coming in with — 1.75 neper level up to a level at the outgoing side of + 2.0 neper. It thus has an effective amplification of 3.75 neper. The system may, when necessitated by too great attenuation variations in the circuit, be provided with automatic level regulator.

In the Ericsson system metal rectifiers are used as modulator and demodulator instead of electron valves. This provides an appreciable advantage: metal rectifiers constitute for these functions a much more stable constructional

Fig. 8 X 5296
General connecting diagram for intermediate repeater ZL 450

AE	amplifier, east to west
AW	amplifier, west to east
HP	high-pass filter
LP	low-pass filter
PHYS E	physical channel, east
PHYS W	physical channel, west
PPF	push-pull amplifier, east to west
PPW	push-pull amplifier, west to east
RKI	input directional filter
RKU	output directional filter
TL E	trunk circuit, east
TL W	trunk circuit, west

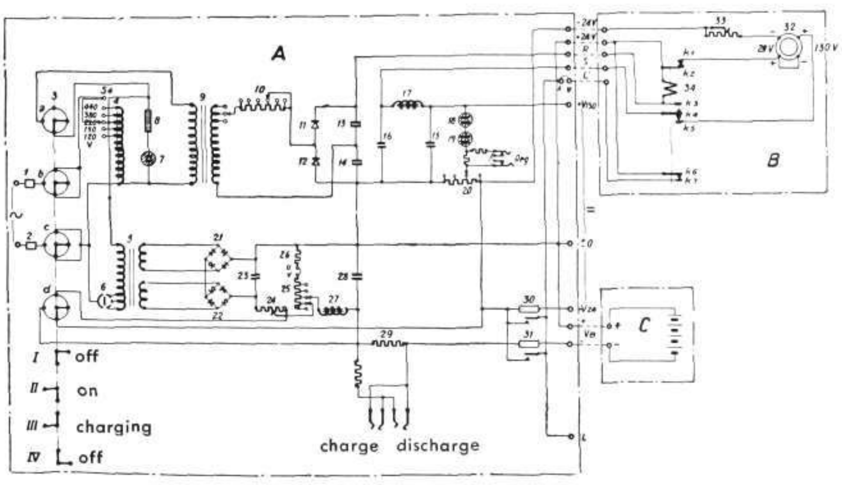


part than valves and contain important theoretical advantages over them. Dust-iron cores are employed in the system and the low losses thus obtained ensure good transmission properties in the filters.

The single-channel system requires a feed of 24 V for the filament circuits and 130 V for the anode circuits. These tensions may be taken from available batteries in a repeater station. If there is an AC main, the system may be fed from it over a mains supply unit with requisite anode-voltage converter, see Fig. 9. The mains supply unit may be connected to mains of various tensions between 110 and 440 V, 50 c/s, and is composed of two separate parts: the current distribution panel ZL 480 and the converter panel ZL 485. The former comprises two metal rectifiers for 24 V, 1.1 A DC and 130 V, 80 mA DC respectively. A 24 V buffer battery is connected as reserve in the event of interruption in the mains. The converter panel contains a single armature converter and a relay which on failure of the mains tension connects the converter to the buffer battery. This then starts and delivers 130 V DC for the anode circuits. Filament current is then received direct from the buffer battery. To maintain a constant filament current in spite of varying 24 V tension there are iron resistances inserted in the filament chains. The current distribution panel and the converter panel, Fig. 10, are normally designed for mounting on racks, *e. g.*, in the single-channel frame. They may also be fixed on the wall by simple attachments and used for other purposes. The parts and cabling of the panels are protected by removable covers. Any suitable 24 V accumulator may be used as buffer battery, this being placed entirely apart from the mains connection unit.

In the terminal equipment with auxiliary output amplifier, Fig. 11, certain panels, the supervision and test panel, the handset panel, the balancing filter, the auxiliary output amplifier, automatic level regulator and mains supply unit, have the character of auxiliary parts to the single-channel system proper and are thus not required in all cases. The single-channel system therefore is supplied in a large number of variants. Unrequired panels are replaced by blind panels. The intermediate repeater, Fig. 12, is like the terminal equipment made in different variants.

When an extension with only one carrier channel does not suffice it is possible, where the aerial line bunch comprises a sufficient number of wire pairs between the places to be connected, to add further single-channel circuits on pairs which prove suitable, taking cross-talk into account. Where the number of circuits or cross-talk difficulties do not allow of the introduction of several single-channel systems on the one pole line, the augmentation of the number of circuits may easily be carried out by adding instead a three-channel system on a wire-pair suitable for the purpose and moving earlier single-channel systems to other bundles.



X 5322

Fig. 9
Connecting diagram for mains supply unit

A rectifier panel
1, 2 fuses
3 switch
4 auto transformer
5 filament transformer
6 filament current adjuster neon
8 series resistance
9 anode transformer
10 anode current adjuster
11, 12 anode rectifiers
13, 14 smoothing condensers
15, 16 filter condensers
17 smooting coil
18, 19 neon lamps
20 potentiometer
21, 22 filament rectiers
23 smoothing condenser
24 filament rheostat
25 series and shunt resistances
26 shunt resistance
27 smoothing coil
28 smoothing condenser
29 measuring shunt
30, 31 fuses
u,v,x,y soldering tags
L alarm circuit

B rotary converter panel
32 single armature converter
33 regulating resistance
34 starting relay

C buffer battery

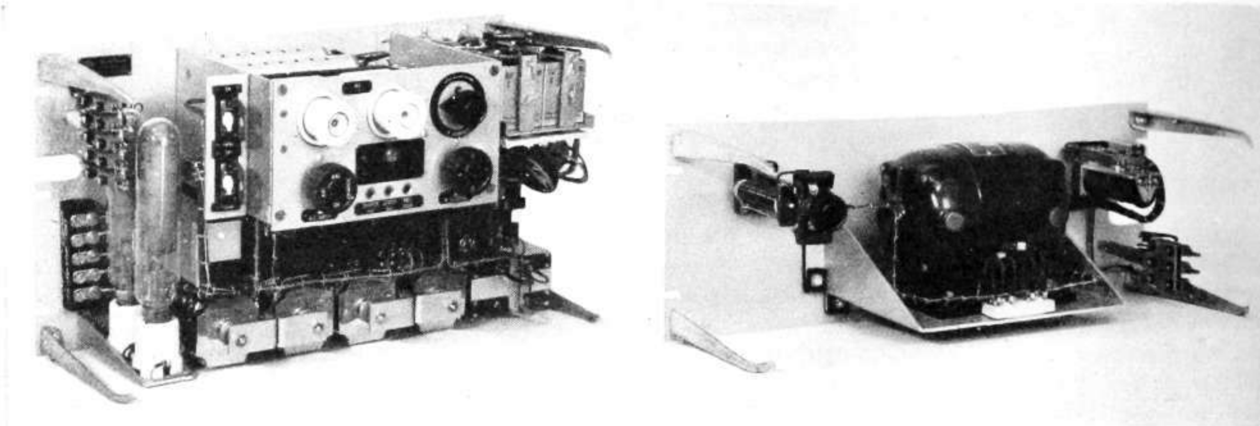


Fig. 10 X 7157

Mains supply unit

left, current distribution panel ZL 430, right, rotary converter panel ZL 485

A three-channel system consists in principle in combining three different carrier channels each with its own frequency range. The three carrier circuits and the voice frequency circuit thus lie one above the other in frequency and none of them can have a disturbing effect on the others provided they are furnished with filters of adequate efficiency. In other respects the three-channel system is constructed in the main on the same principles as the single-channel system. It is, however, normally equipped with several test possibilities and manual or automatic level regulating, while common equipments for power feed etc. have greater capacity and require more supervision facilities than are necessary with the single-channel system. The line filters are more complicated than with the single-channel system; while the single-channel has a simplified form of voice-frequency signal equipment the three-channel system has a fully developed voice frequency signalling system, constructed on the usual Ericsson principle.

With cables too it is now possible to obtain the benefits of the progress in carrier technics. Thus it is possible conveniently and cheaply to obtain one or more new circuits in a cable strand already fully taken up, with the aid of the Ericsson single-channel system for cables. This is in principle an ordinary single-channel system, though constructed for four-wire operation; it works on the same frequency band for both conversation directions. This

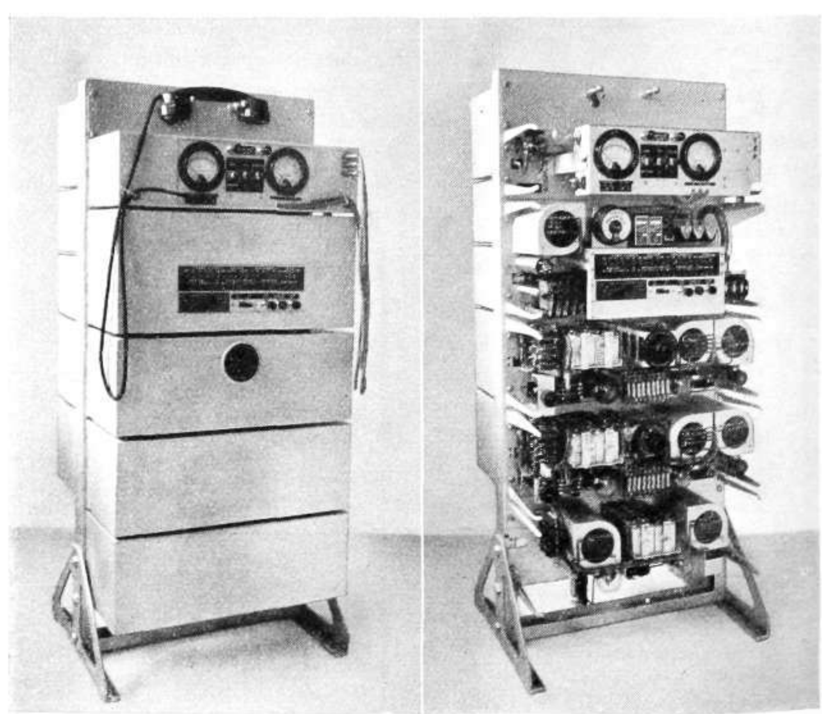


Fig 11 X 5486

Terminal equipment with auxiliary output amplifier ZL 420

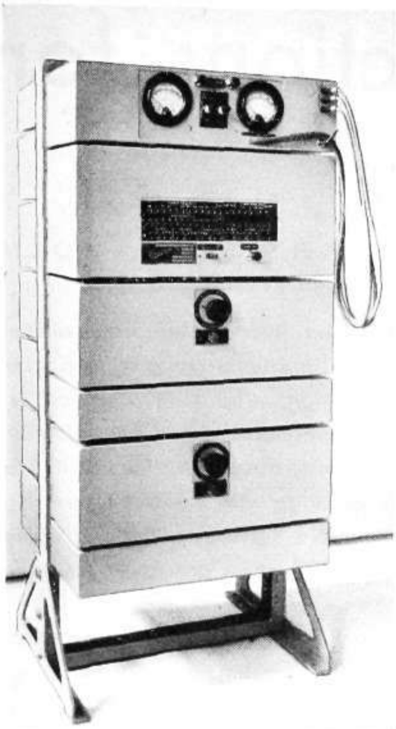


Fig. 12 X 3607
Intermediate repeater ZL 450

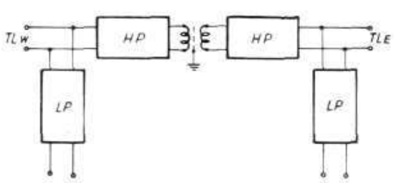


Fig. 13 X 3901
Diagram of by-pass
HP high-pass filter
LP low-pass filter

frequency band lies immediately above the voice frequency band and is amplified at the same time as this by the normal four-wire repeaters which are, however, built for the purpose to transmit frequencies up to around 7 000 c/s.

The cable circuits which must also transmit carrier frequency calls should be loaded in order to be suited for this. They are generally quads with the phantom circuit also utilized. Of two different quads the one is used for one direction and the other for the reverse direction. In this way it is possible in addition to the three voice frequency four-wire circuits to obtain up to three carrier circuits. By means of the above utilization of the quads there is avoided the cross-talk otherwise frequently troublesome in the quad at high frequencies and the resultant disturbance.

If on a line stretch, where a carrier frequency is installed, the low frequency band is to be taken out at an intermediate station while the carrier conversations are to be passed without hindrance, there is employed a carrier by-pass equipment. This consists of two high-pass filters, a screened transformer and two low-pass filters. The high-pass filters are connected in series through the transformer and the device is so connected that it divides up the traversing circuit, the high-frequency being allowed to pass unhindered while the voice frequency is blocked. The voice frequency goes instead over the two low-pass filters each joining a branch to the station and preventing the high-frequency from entering. There is thus obtained at the station a low frequency conversation in both directions.

If, however, it is necessary at the intermediate station to connect in a repeater on the traversing low frequency circuit, the high frequency must still be shunted past the station, since the normal two-wire repeaters do not transmit the carrier band lying above the voice-frequency band. The carrier by-pass equipment is employed here too, but in this case it must, so that the stability of the repeater shall not be endangered, be repeated in the repeater's balancing networks. This is most simply done by coupling in between the line balances and the repeater a similar device with two high-pass filters, analogous to the connecting in of the by-pass equipment between the circuits and the repeater.

The carrier by-pass equipment's attenuation from circuit to circuit at 10 000 c/s is only 0.07 neper. For voice frequency on the other hand it presents an exceedingly high attenuation. The by-pass equipment is provided with a jack panel and is fitted in a frame of U-iron intended for hanging on a wall.

Anti-Sidetone Connections for Telephone Instruments

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

The anti-sidetone connections have proved an appreciable improvement to telephone instruments in commercial use. To attempt to give in figures the gain which their introduction has brought about in practice is, however, exceedingly difficult, since both local conditions and physiological and psychological factors must be taken into consideration. The CCIF has for many years been occupied with this question and several interesting results have come out from the comprehensive tests executed. It would take up too much space to go into these results, which are to be found in the latest edition of the committee's reports.

The following article, however, gives a summary of the properties which characterize the anti-sidetone connections, now being introduced to an ever-growing extent in modern telephone instruments.

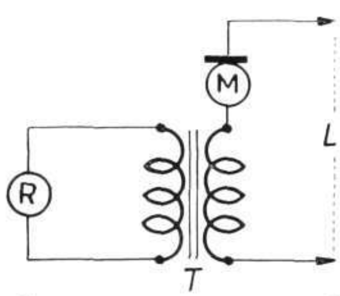


Fig. 1 X 3842
Ordinary connection for CB-system

The speech arrangement in a telephone instrument for CB system as generally made before the introduction of the anti-sidetone connections was in principle connected as in Fig. 1. The microphone and receiver are connected in series over a transformer, the induction coil, to separate the receiver from the line. The transformer has a two-fold purpose: to screen the receiver from the influence of the feed current to the microphone, by which the receiver magnet is less exposed to demagnetization; this is of special importance for older telephone constructions in which magnets of wolfram alloy steel with low coercitive force and therefore small stability against demagnetizing are used; and the sensitivity of the receiver may be increased by reducing the diaphragm distance since no DC current passes the receiver windings either in magnetizing or demagnetizing direction. Some part of the increased sensitivity must, however, be available for compensating the attenuation in voice frequency caused by the transformer.

In the corresponding connection for LB-instruments, Fig. 2, the duty of the transformer is to transmit inductively to the line circuit the voice-frequency current variations obtained in the microphone through resistance variations while at the same time an adjustment of the low-resistance microphone to the outer circuit takes place. The adjustment has the purpose of achieving the greatest possible efficiency in the connection through the most suitable balancing of the mutual amplitudes of the constituent impedances.

Both the connections just described are troubled by a substantial weakness. The speaker hears in the receiver his own speech with a strength which in unfavourable cases is many times stronger than the strength from the distant instrument. For example, with a conversation over a long line when the total overall attenuation between the instruments may amount to 2—3 neper, the ratio with non anti-sidetone connection between the sound strength in the receiver of the speaker's own and the received speech is in the range of 20 : 1. The accommodation which the ear then must make for each transition from speech to listening is highly troublesome. Moreover it results, as shown by experience and tests carried out, in a lowering of the voice, often unconscious, with a view to levelling out the difference in sound volume.

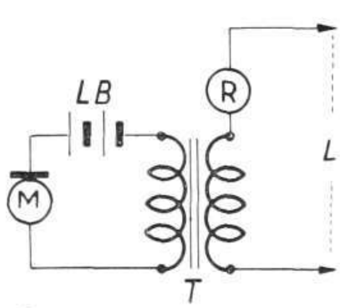


Fig. 2 X 3843
Ordinary connection for LB-system

There is in addition the trouble that the noises in the vicinity of the listener that are caught by the microphone are reproduced in the receiver with full strength. These noises may in certain cases make completely impossible the grasping of the speech from the distant instrument. The same applies to noises arising in the microphone on account of heating of the contact points between the carbon granules. This microphone noise is reproduced with undiminished volume in the receiver.

To eliminate these troubles anti-sidetone connections are now used. These are so executed that the speech current from one's own microphone does not act on the receiver. In a connection of this kind for CB-instruments, Fig. 3, the transformer has three windings: the receiver winding, the line winding and the balance winding. By appropriate selection of the resistance R_B it is possible to arrange that the current from the microphone does not affect the receiver. The condition for this to occur, provided the transformer is ideal, will be that

$$\frac{Z_L}{R_B} = \frac{n_2}{n_3}$$

where

Z_L = external impedance for voice frequency measured from the instrument terminals,

R_B = balance resistance,

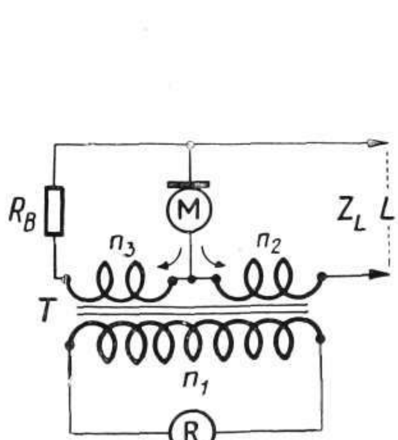
n_2 = turns of the line winding,

n_3 = turns of the balance winding.

In this way on sending, the currents in the two windings n_2 and n_3 cancel out each other's inductive influence on the telephone winding n_1. It should, however, be noted that the above conditions are only fulfilled in exceptional cases for all frequencies comprised in speech. In practice the line impedance Z_L varies in a manner often very irregular with the frequency due to the characteristics of the line and the devices at the exchange connected to it and also due to the instrument connected at the other end. For strict fulfilment of the above conditions, therefore, it would be necessary to introduce for R_B complicated line balancing. There is, however, another difficulty in that the line impedance Z_L may assume quite different values if the line is an aerial one or a cable. In practice, one is content to allow the line impedance to be compensated by an ohmic resistance. Full balance is not as a rule achieved in this way, but in practice this is not of so much importance. The main thing is that an appreciable reduction of the noise is achieved so that it is not noticeably greater than the speech received. It is obvious that this similarity in strength of noise is the more difficult to attain the longer the line connecting the two instruments is, in other words the higher the attenuation between the two instruments. As regards calls over trunk and toll circuits, however, the overall attenuation is usually regulated by repeaters to a value which does not come appreciably higher than for calls over the longest local lines. Even if this be not the case, yet the result obtained with anti-sidetone connection is considerably better than when such is not applied.

In this respect a misconception regarding the efficiency with the anti-sidetone connection should be corrected. From various quarters it has been declared that the transmission properties with this connection must be inferior to those of the older connection, Fig. 1, since only part of the microphone power goes out to the line while the other part is absorbed in the resistance R_B. It is overlooked, however, that in the older connection also a certain part of the power produced in the microphone is lost, namely that taken up by the receiver connected in series through the transformer, in the form of unutilized sound energy. The two powers are equally great in both cases, the difference is merely in the way in which they are absorbed in the two connections. This may easily be checked by calculation or measuring of the efficiency on transmission.

It remains now to see what effect the anti-sidetone connection has on the efficiency of speech reception from the remote instrument. The two windings n_2 and n_3 work in conjunction, so that no trouble on account of balancing can arise. It can be shown by calculation, however, that if the above-stated balance conditions are fulfilled the current in the receiver winding on reception is



X 3844

Fig. 3
Anti-sidetone connection for CB-system

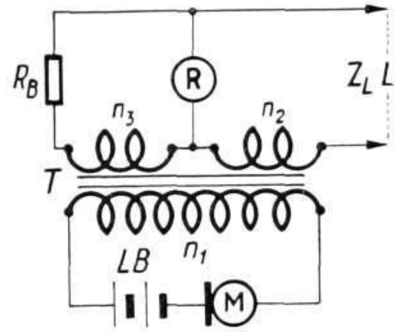


Fig. 4 X 3845
Anti-sidetone connection for LB-system

independent of the microphone resistance R_M. The efficiency of the instrument for reception is thus unaffected by variations in the resistance in the microphone inset. As is known, this resistance is highly variable, both with the feed current and also with the position of the inset. In the older connection, Fig. 1, these resistance variations made themselves apparent as a variation in the grade of reception. A high microphone resistance, *e. g.*, due to low current feed, gave rise to deterioration not only in the transmission efficiency but also in reception. This trouble has been eliminated by the introduction of the anti-sidetone connection, Fig. 3.

The addition of the balance resistance R_B in parallel with the microphone has moreover proved to prolong the life of the microphone appreciably. At the moment the handset is lifted and the microphone connected in, the current feed is zero and the microphone resistance high. In the connection of Fig. 2 the greater part of the tension of the exchange battery then falls on the microphone and its contact points may burn. As the current rises to a stationary figure the resistance in the microphone is reduced to the normal figure and the tension over the microphone falls. Through the shunting of the microphone by the resistance R_B the tension over the microphone is dropped at the moment of connection, by which the risk of the contacts burning is reduced and an increase of life is ensured.

For LB-instruments an anti-sidetone connection as in Fig. 4 is employed. The difference in principle compared with the connection of Fig. 3 is merely that the microphone and receiver change places. The same conditions for balancing as for the connection of Fig. 3 apply here; for the best arrangement, however, it is required that the transformer turns be selected in another manner. The characteristics with both connections are the same.

For certain feed systems it is better from the point of view of current feed to use another connection, Fig. 5, as is employed in certain Ericsson instruments designed for CB-systems and automatic systems of another system than Ericsson's. Here the balancing is done by the voltage field over the balance resistance R_B being reversed and cancelling the tension induced in the winding n_1. All three windings work in cooperation. Provided the transformer is ideal, the balancing conditions for this connection may be written

$$\frac{Z_L}{R_B} = \frac{n_2}{n_3} \cdot \frac{n_1 + n_2 + n_3}{n_1}$$

From this equation it may be seen that, compared with the one previously given, the balance resistance R_B may be made appreciably lower for a given external impedance Z_L. This connection is specially adaptable to systems with high line current. By suitable selection of the resistance R_B the microphone feed current may be so arranged that the most suitable working point is attained. In this connection method the only duty of the condenser is to prevent DC current passing into the receiver. There is no difference in principle between this connection and those described above, and the characteristics stated apply here also without reserve.

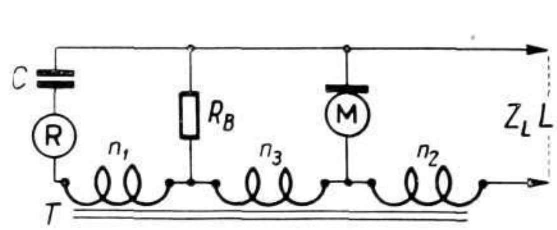


Fig. 5 X 5453
Anti-sidetone connection for CB-system

Portable Telephone Instruments

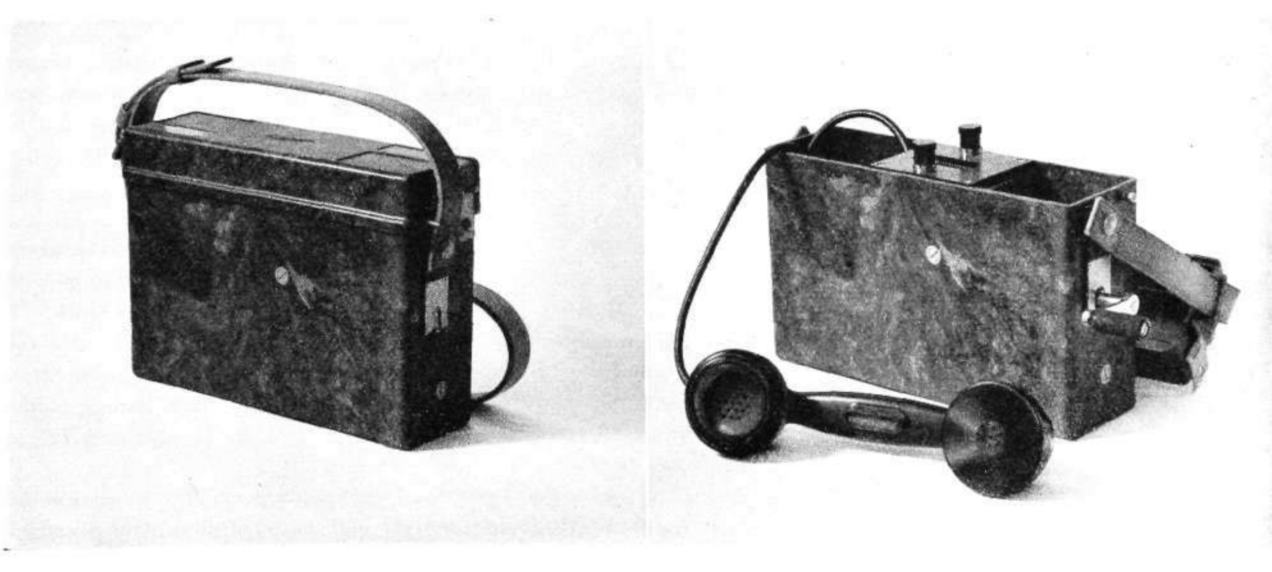
E. BERGHOLM, TELEFONAKTIEBOLAGET L. M. ERICSSON, STOCKHOLM

The portable telephone instruments as described in Ericsson Review No 2, 1935, and No 3, 1936, have recently been still further improved. Their durability has been increased by the employment of a new moulding composition which has an impact resistance many times greater than that of bakelite. By the use of light material with high efficiency it has been possible to bring the weight down below 4.5 kg, thus making the instrument in all probability the lightest of its kind in existence. The new instrument may be had in various executions, including ordinary magneto instrument for LB-systems, universal instrument for fault locating and line testing in telephone networks of various systems and finally as field service instrument for military use, constructed in consultation with military experts.

It is obvious that a portable telephone and particularly one to be used on active service must be constructed on principles entirely different from ordinary stationary instruments. It is especially important that the *strength* shall be such that the instrument can stand careless handling. When the instrument is to be employed in the field it is very important that it should be *light in weight, small in size* and of such shape and with such carrying devices that it does not hinder the bearer in carrying weapons and pack at the same time. In many armies field instruments are used which have a weight of 7 to 8 kg, constituting naturally an exceedingly cumbersome extra burden and it has aroused legitimate attention that it has been possible to bring down the weight of the Ericsson instrument to 4.1 kg. This has been possible through the employment of light but efficient material and has in no way been done at the expense of the strength and performance of the instrument. As an example it may be stated that a special bakelite material has been developed which is far superior in respect of strength to that previously used, that the generator is made of specially efficient magnetic material permitting of greater power despite the considerably smaller dimensions and weight.

Other outstanding features of the new instrument are convenience in use, connection to all existing telephone systems both manual and automatic, simplicity of assembly and easy interchange of the parts.

Fig. 1 X 7154
Portable telephone instrument DPA 1001



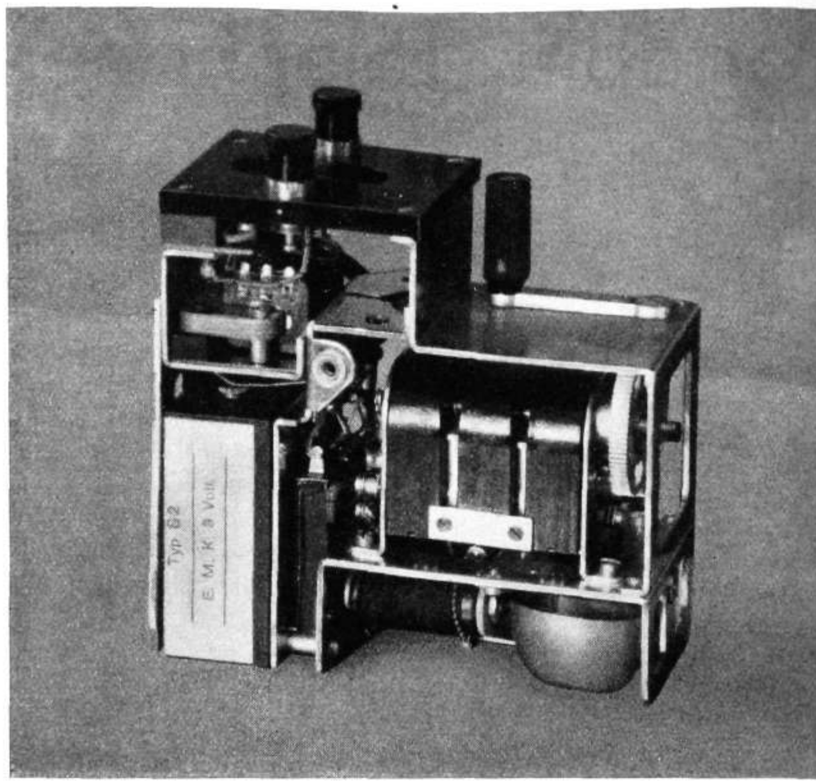


Fig. 2 X 5460
Portable telephone instrument inset
left, above, induction coil, below, battery; right, magneto, below, bell

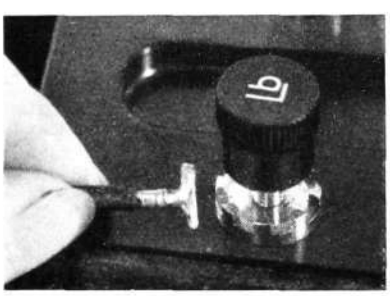
Design

The new portable instrument, Fig. 1, is mounted in a case of bakelite the composition of which has been specially tried out for this purpose. The impact resistance of this material is many times greater than that of ordinary bakelite. The greatest possible suitability for field conditions has been aimed at; the earth-brown colour matches that of the ground very well and the dull finish of the bakelite surfaces does not reflect sunlight. For the same reason all fittings have been given a matt finish.

The lid is held in place by two spring catches at the ends, these opening by pressure on two fittings on the top of the lid. The attachment is simple and strong and has proved both reliable and rapid in practical use. Along the side of the instrument there are no hinges or other projections to be injured in transport or with careless handling, the lid being attached to the carrying strap by mobile fittings in which the strap runs. When used as a fixture the strap may be removed from the instrument, first taking off the lid.

The *handset* is of bakelite and has a key of entirely new design with large pressure surface thus facilitating operation. The handle has cast-in connections. Microphone and receiver are easily replaceable. As the telephone generator is of high alloy cobalt-steel its stability is particularly great and demagnetizing practically eliminated. The handset is connected to the instrument by means of a vulcanized rubber cord.

The *inset*, Fig. 2, comprises all the other parts making up the instrument, magneto ringer, bell, induction coil, condenser and battery, these being mounted on a frame of strong brass plate which also carries the terminal block. The line is connected on connecting clips, specially designed for field cable connection; the terminal screws are toothed at the bottom with a view to firmly holding the ends of a cable with a TO joint, see Fig. 3. This joining method has proved particularly suitable for the purpose.



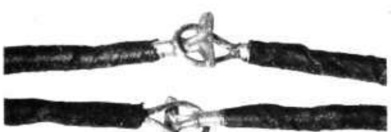


Fig. 3 X 3855
TO joint
above, connecting of T-end to terminal joint; below, TO joint before winding with insulating tape

The *magneto* is of a new type specially designed for portable instruments. The magnets are made of 35 % cobalt steel and of such dimensions that the highest efficiency is obtained with the lowest possible weight of material. Because of their high coercitive force, 250 ørsted, and the shape of magnet adopted the magnets are resistant to demagnetizing to the highest degree, both on short-circuiting of the magneto and with shocks and other mechanical strain. The rotor is fully enclosed thus ensuring the highest reliability in operation possible. The winding is completely insulated both from stator and from rotor. There is consequently no risk of electric shocks from the metal parts of the instrument. The load curve, Fig. 4, shows the given tension and the power as functions of the external load resistance at 20 c/s. The maximum power, 3.6 W, is higher than that attained with portable instruments of earlier design.

The *AC bell* is of polarized type with magnet of 35 % cobalt steel and two coils each with 500 ohm resistance, these being wound on bakelite. The gongs are oval, stamped out of brass sheet. The sensitivity of the bell may be adjusted by varying the armature gap width. Normally the bell is adjusted to ring for a tension of 10 V.

The *induction coil* is made with closed lamellated core of siliceous alloy steel-plate, the mount and flanges being of bakelite.

The *condenser* has the duty of preventing the ringing current from passing through the speaking device. Its capacity is 1 μF and it is made for a test tension of 500 V DC.

The *battery* has an EMF of 3 V and is made up of two standard rod cells each of 1.5 V, placed in a common case measuring 36×68×85 mm. The contact devices in the instrument are springcontacts. The battery is held in place by a lid. The battery may be changed without the inset being taken from the case. Ordinary round batteries may also be used in the instrument, a special battery inset for the round batteries then being used.

In addition to the above-mentioned parts there are included with certain types of instrument other parts as well, such as buzzer, dial, extra receiver etc.

The *buzzer* is used for voice-frequency telegraphy over distances greater than those that can conveniently be covered by speech. By proper selection of the contact material in the self-break contact and the introduction of a spark quenching and noise reducing condenser of special type, sparking has been to a large degree reduced. The buzzer is fitted in an accessible position on a draw-out slide. The buzzer key is shaped with special regard to convenience in use. In instruments fitted with buzzer there is in the lid above the key a hole covered with a rubber-cloth membrane, allowing the key to be operated while the lid is on.

The *dial*, which in instruments of this kind is a necessary accessory for connection to automatic telephone networks, is watertight and provided with rubber insulated connecting cable. When in use it is placed on the side of the instrument by means of a special spring device, so designed that the instrument lid may be put on even when the dial is to be used. For carrying, the dial is placed in the free space at one end of the instrument.

The *extra receiver* is of new design and of special light-weight type. It is fitted with rubber pad which considerably improves the fit to the ear. The extra receiver is connected to the instrument by a rubber-insulated cable.

Fig. 4 X 3863

Load curve for magneto

V tension as function of ohmic load
W power as function of ohmic load

Fig. 5 X 3864

Connecting diagram for portable telephone instruments

Types and Range of Application

In order to meet the varying demands made regarding the equipment of the instrument and at the same time ensure the simplicity in operation it has seemed advisable to introduce certain regular types intended for different purposes.

Portable Telephone Instrument DPA 1001

This instrument is intended for employment in LB networks as portable telephone instrument and as simple field instrument for military use. The instrument is equipped with hand magneto and polarized bell, see the diagram, Fig. 5. The handset is attached to the instrument by a vulcanized rubber cord. The instrument is not normally provided with extra receiver but facilities for its connection are there. Weight of the instrument is 4.1 kg.

Universal Telephone Instrument DPA 1152

In many cases a demand exists for a portable telephone instrument arranged for connection both to LB system and to manual and automatic CB system. The utility of such an instrument is appreciably increased if, in addition to its actual purpose, it may also be used for line testing. The universal instrument DPA 1152, Fig. 6, is equipped with magneto for calling in LB systems and dial for calling in automatic systems. The bell is connected in series by a condenser the purpose of which is to block the DC current when the instrument is connected to CB system, see the diagram, Fig. 7. The instrument is moreover fitted with a test key which has return spring bottom position but may be locked by a turn in that position.

When the instrument is connected to *LB system*, the exchange or another instrument is called in the ordinary way by the magneto. If an extra strong signal is required, the test key is pressed whereupon the bell and the condenser are short-circuited. The whole power of the magneto is then transmitted on the line.

When connected to *CB and automatic systems*, the exchange is called when the key on the handset is pressed. In automatic systems the required number is then composed on the dial. If the test button is pressed and turned anticlockwise to the blocked position, the key may be released during conversation without clearing signal being given at the exchange. The key requires in that way only to be pressed while calling. At the close of the conversation the key is restored by pressing on it and at the same time turning it clockwise.

For fault locating in networks on the CB system it is often an advantage to be able to converse with a subscriber's instrument even though its connection to the exchange is broken. Normally this is not possible since there is no feed current for the subscriber's instrument microphone. To enable conversation to take place even in such cases the universal instrument is so made that feed current from the local battery may be sent out to the subscriber's instrument.

Fig. 6 X 5459
Universal telephone instrument DPA 1152

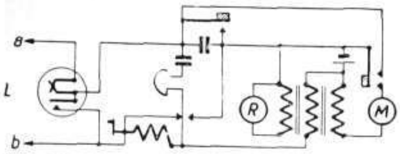


Fig. 7 X 3865
Diagram for universal instrument

This is done by pressing in the key after the instrument has been called by the magneto. If the test button is pressed during the conversation feed current is sent out independent of the key.

The instrument may also be employed for fault location on subscriber's lines. For this purpose the instrument's bell is connected in series with the magneto. When the magneto crank is turned the bell rings if the external line loop is closed. If there is a break in the line then the bell does not ring. By pressing in the test button during signalling the bell and condenser are shorted, whereupon the magneto is connected direct on to the line. If strong resistance is then felt when cranking then there is a short-circuit on the line. Even earth fault may in many cases be detected by this simple method. The instrument is then connected with the one terminal to earth and the other to one line branch. If the bell rings then there is leakage on the line. If the magneto with short-circuited bell gives strong resistance to cranking then the line is earthed at some point. The instrument DPA 1152 with dial weighs 4.5 kg. It can also be supplied without dial, DPA 1102, in which case it weighs 4.2 kg.

Field Telephone Instrument DPA 13

In consultation with experts of the Swedish Corps of Engineers a special field model, Fig. 8, has been worked out, the military and field service points of view having been the deciding factors in respect of equipment and construction. Thus the instrument has been equipped with buzzer for voice-frequency telegraphy, attaining a considerably greater range than with telephony alone. A switch for connection to both LB- and CB-networks has been fitted in view of the closing of line loop on calling that is required in CB systems. An extra receiver of lightweight type has been included in the equipment and its cord and that of the handset have been provided with plugs for connection to a jack on the instrument terminal block. A break-contact for the battery is fitted in this jack by means of which discharge of the battery through the buzzer during transport is prevented. The receiver earpieces are provided with rubber pads improving the fit to the ear and excluding external noise. Among other accessories may be mentioned a screwdriver for adjusting the buzzer, an alphabetical table for code telegraphy and a flat writing space for making notes. The instrument may be used either for telephony or telegraphy even with the lid on. In that case the cable is taken out through an aperture formed by the fitting at the one end of the lid. The buzzer key can be got at through

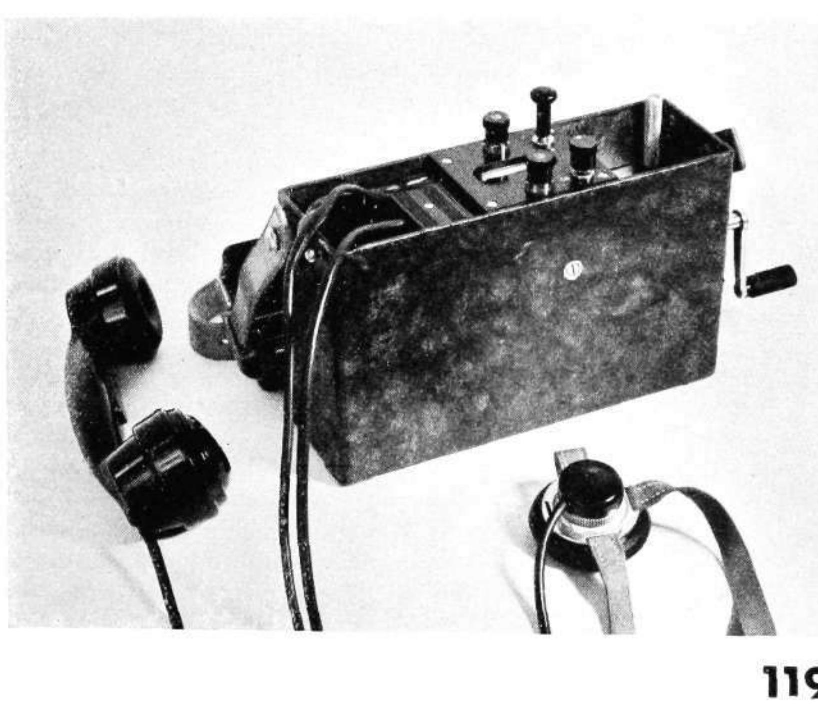


Fig. 8 X 5487
Field telephone instrument DPA 13
with extra receiver

the membrane on the lid. For carrying, the plug for the handset must be taken out, when the extra receiver and the cords may be packed in the space at one end. The instrument weighs 4.5 kg fully equipped, and 4.2 kg without extra receiver.

Properties

The transmission properties of these new instruments are remarkably good. Tests made have demonstrated that the instrument, in relation to the international standard SFERT, has a reference equivalent of + 0.1 neper for both sending and receiving. If in conformity with the CCIF's recommendations for commercial telephony one reckons with a reference equivalent for the whole circuit of + 4.6 neper in relation to SFERT, there are obtained the following lengths of line using metallic circuit in paper-insulated telephone cable:

gauge of wire	DC loop resistance	length of line
mm	ohm/km	km
0.6	120	39
0.8	68	57
0.9	54	63
1.0	44	69

For aerial lines with good insulation considerably longer distances may be covered. Thus a range of 300 km may be reckoned on for a 3 mm iron line and 400 km for a 2 mm bronze line. These figures apply to permanently laid lines of commercial type and with good insulation. In the case of field cable lines one must count on lower insulation on account of the manner of laying; moreover these lines are considerably more exposed to disturbances. When laying the cable over the ground a mean range of 30 km may be attained with metallic circuits with field cable MG 206 and 50 km for a single circuit with field cable MG 205; the last figure applies on condition that good earth connection is used. If earth currents and induction from neighbouring power lines arise then the figure must in some cases be appreciably reduced.

With voice frequency telegraphy considerably greater line lengths can be covered. Line attenuations of 6—8 neper may be permitted without trouble, which implies that the lengths of line given above may be increased by 50—100 %.

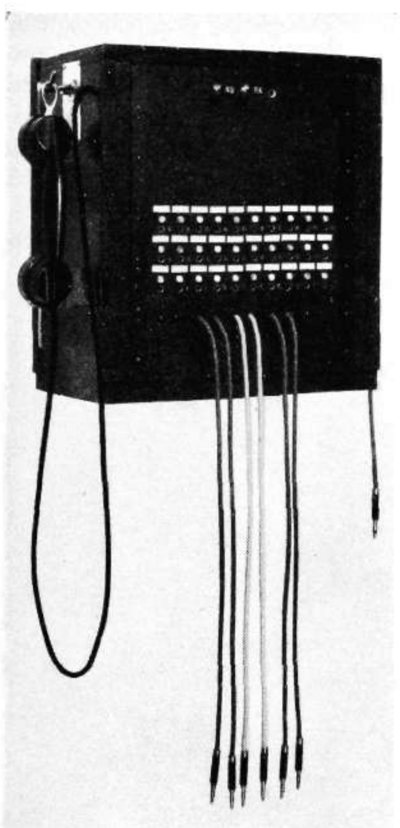
Hotel Switchboard

K. G. HANSSON, TELEFONAKTIEBOLAGET L. M. ERICSSON, STOCKHOLM

At hotels there is generally a bell calling installation by which guests may call the staff. These installations are now more and more replaced by a simple telephone installation. Instead of one or more signal buttons there is placed in a the room a telephone instrument that is connected to a switchboard set up in some convient place, e. g., in the porter's lodge.
For this purpose Ericsson has designed a galvanic telephone switchboard intended for use along with the Ericsson home telephone.

A telephone installation has the superiority over the bell system at present employed at most hotels that the guest is able to express his wants directly to the hotel attendants, so that none of these require to go to the guest's room to take his order. The guest gets an answer immediately with the telephone and any irritation that might arise due to even the shortest delay is eliminated. The guest is better served, time is saved and the work of the staff facilitated. Even in blocks of flats a telephone installation which puts the tenants in communication with the janitor is of great practical advantage and is certainly destined to become an appreciated feature in the housing amenities of our times.

In its simplest execution the Ericsson hotel switchboard AEH 10, Fig. 1, provides facility for communication between a connected telephone and the attendant at the switchboard. As, however, all circuits connected to the switchboard terminate in jacks in the field, there is possibility of arranging conversation facilities also between two subscribers, if the switchboard is provided with cord pair equipment. The connection of the circuits to jacks also gives the advantage that there is no possibility for a subscriber to overhear a conversation between another subscriber and the switchboard.



X 3866

Fig. 1
Hotel switchboard AEH 10

The switchboard AEH 10 is a wall switchboard with frame of walnut-stained dull polished oak. The dimensions of the switchboard are: height 405 mm, width 390 mm and depth 237 mm. Fully mounted it has a net weight of 22 kg. A maximum of 80 lines may be connected. If it is desired to have internal intercommunication it may be provided with up to 60 lines and 5 cord pairs. The calling devices used are lamps connected direct to the circuits. In the event of the switchboard being equipped with cord pairs these lamps serve also as clearing signals.

The connecting devices for the operation of the switchboard itself, consisting of a jack, a simple two-wire cord with plug, two press switches, a bell, together with relays, resistances, condensers and terminal blocks, are all located on a panel in the upper part of the field. There is facility for the connection of an extra bell over a terminal at the back of the switchboard. The handset is of bakelite and hangs on a switch hook.

The parts appertaining to 10 circuits, consisting of a 10-line jack strip, a 10-line lamp strip and a terminal block are combined into an independent line set. The jack and lamp-strips are placed in the field along with a strip with card frames for 10 circuits. The terminal blocks are located at the back of the switchboard. These blocks are exceedingly accessible, since the front of the switchboard is joined to the back with hinges and may be swung out. Incoming lines are connected to the terminal blocks by screw terminals. The switchboard may be mounted with any number of line sets up to the final capacity.

Fig. 2
Telephone DEP 1002

X 3868

The equipment for a cord pair consists of two three-conductor cords with plugs, together with two cord terminal blocks and a relay. These parts are mounted on a separate panel which has space for all five cord pairs. Thus if it is desired to provide the switchboard with facility for intercommunication, such a panel mounted with the required number of cord pairs is placed in the lower part of the switchboard field and the cord pair relays are connected to the two poles of the battery over a connecting block on the panel.

The switchboard is called by lifting the handset, whereupon the call lamp lights up and a signal is obtained in the bell. By means of a button the bell may be cut off when the switchboard is attended. The call is answered by inserting the answering plug in the jack for the calling circuit, whereupon the lamp goes out.

To ring a subscriber from the switchboard the above-mentioned plug is inserted in the circuit jack of the subscriber to be called and a button pressed in, whereupon the buzzer in the called subscriber's instrument sounds.

If the switchboard is fitted with cord pairs and a subscriber who has called the switchboard wishes to be connected to another subscriber, the connection is established by means of a cord pair after the desired subscriber has been rung. During this ringing the calling subscriber's line is marked in the switchboard by its call lamp remaining lit until the plug is inserted in the jack. If desired, a cord pair may also be employed when answering an incoming call or ringing up a subscriber.

When at the close of the conversation the speakers replace their handsets the call lamps of the two circuits light up, thus acting as clearing lamps, and a signal is obtained in the bell. When the cord pair is disconnected the lamps go out and the bell is disconnected.

For current feed and signalling the switchboard requires a current supply of 12 V tension. As the current consumption is exceedingly low, only 0.016 A for conversation between a subscriber and the switchboard or between two subscribers, dry cells may quite well be used for fully mounted switchboards. Since all the instruments are mounted in the same building only slight resistance need be reckoned on the lines; the battery tension may therefore drop to 9 V without any inconvenience arising. Still to ensure a certain amount of safety one should seek to maintain the normal tension.

New Ericsson Wireless Receivers

B. ARVIDSON & C. FREDIN, SVENSKA RADIOAKTIEBOLAGET, STOCKHOLM

Svenska Radioaktiebolaget presents for the season 1938—1939 a range of receivers, each of which has been selected to meet the requirements of some section of the circle of customers. For the listener who wishes to have a wireless receiver which is at the very top for quality and convenience, there is Ericsson 386, a superheterodyne with automatic push button as well as manual tuning. For those who are not disposed to go to the expense of these perfections, there are Ericsson 384 and Ericsson 383, two superheterodynes of more standardized design. For those who chiefly listen in to the local station, there is a single-circuit receiver, Ericsson 382. In addition there is a console model wireless receiver with electric built-in gramophone, Ericsson 388.

For battery operation there is the superheterodyne Ericsson 383, in two forms one with ordinary batteries and the other for connection to a motorcar battery; a portable set, Ericsson 381, is also made.

In the great pioneer country of broadcasting, the United States, as is well known, by far the greatest number of broadcast stations is built for comparatively small power; moreover, contrary to European practice, several of them are often located in the same town or centre of population. The broadcast listeners therefore have access to several local stations with a number of different programmes, while the possibility of listening in to broadcast stations at any great distance is relatively small, due to the average small power. This circumstance that several local stations in each region predominate has in the United States for a long time led to single circuit receivers, such as are widespread in Europe for local reception, having on account of their low selectivity been obliged to give way to superheterodynes.

In recent years a new principle, having its basis in the same conditions, has also begun to be observed, *viz.* the station selector and the automatic tuning. It is natural that when a small number of stations always give good reception the receivers can be provided with accessory devices which rapidly and simply adjust the tuning devices for the one of these stations it is desired to listen to at the moment.

In Europe, however, there are hardly any districts with a number of local stations having different programmes, but on the other hand the high power the European stations are built to make possible in many places a sureness of reception approaching that given by a local station. While thus the conditions here are not so marked as in the USA, yet they are analogous and so favourable that automatic tuning is of practical utility and advisable even here.

Several different systems for automatic tuning have been put forward, and these may be divided into two groups. The one group is characterized by fixed oscillating circuits, tuned to the selected stations' signal frequency and oscillator frequency being connected in by a contact device when one of these stations is to be listened to. Receivers provided with automatic tuning on this system are without the ordinary tuning condensers and do not allow of reception of other stations than those originally chosen as favourite stations and for the frequencies of which the oscillating circuits of the apparatus are set.

The other group is characterized by the receiver, similar to an ordinary receiver for manual tuning, having continually controllable tuning devices, *e. g.*, an ordinary rotation condenser. By special control devices it is possible then

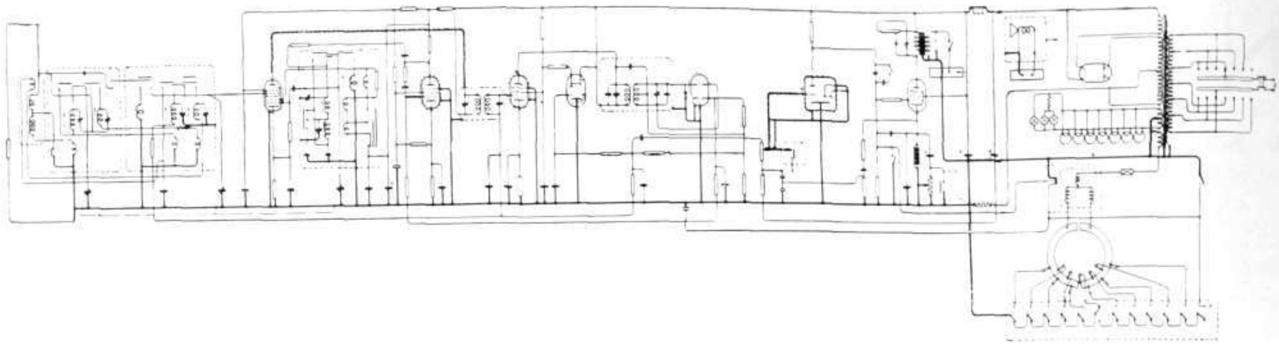


Fig. 1 X 7158

Connecting diagram for superheterodyne Ericsson 386 V

for AC, 8 valves inclusive rectifier valve, 6 tuned circuits and oscillator circuit, wave length range 16.5—51.5, 195—580 and 695—1 970 m; intermediate frequency 144 000 c/s, output 4 W

to get this tuning device to stop at certain positions set beforehand as desired and corresponding to the stations it is preferred to listen to; receivers of this type are as a rule also intended for purely manual tuning. This latter type may be considered as that best suited to European conditions and it has also proved that practically all European manufacturers are of this opinion.

The tuning device may be actuated direct by mechanical means from the control device or it may, through electrical switching or through the emission of impulses, control a motor which drives the tuning device. Receivers provided with motor-driven tuning will naturally be more easy to operate than receivers with mechanical tuning. Another advantage is that it is comparatively easy to operate them from a distance; for this purpose the apparatus requires only to be provided with an extra control device, *e. g.*, a keyboard placed at the desired spot.

These advantages have led to Ericsson's largest table model being equipped with motor-driven automatic tuning. The control device is made as a keyboard located at the front of the receiver.

Mains Receivers

The common groundwork for the year's superheterodyne receivers is formed of a successful combination of coils, valves and loudspeaker, see diagram, Fig. 1. The intermediate frequency band has been raised to 140 000 c/s—148 000 c/s to avoid the howling which arises when a long wave station interferes with double intermediate frequency. No broadcast station corresponds to the figure now chosen, $2 \times 144\,000$ c/s. The input circuits are improved and raise the signal tension 5 to 10 times; they give a valuable amplification free from noise. The image frequency suppression varies between 65 and 100 db, guaranteeing freedom from interference noises.

The valves, which follow European standards, have the following functions: a MEK 2 is used for frequency changing, a MEF 5 for intermediate frequency amplification and a MEBC 3 for rectification and low frequency amplification. Final valves and rectifier valves are different for the AC and AC/DC types.

The loud-speaker is of new design. Thanks to a new system for edge suspension it has been possible, by an increase in diameter of only 11 mm, to augment the effective cone area by not less than 50 %; this amounts now to 200 cm^2, though the diameter of the loud-speaker is only 18 cm. Bass resonance has been brought as low as 65 c/s, so that the loud-speaker may also be used in very large apparatus and is therefore to be found in all the seven models of this year. For purposes of comparison it may be mentioned that in the preceding year's range of models there were four different loud-speakers in six types of apparatus.

The cabinets of the receivers are executed in mahogany or birch with sloping fronts. In the standard equipment are included continuous volume control, connection for gramophone pick-up and external loud-speaker with switch for the built-in loud-speaker.

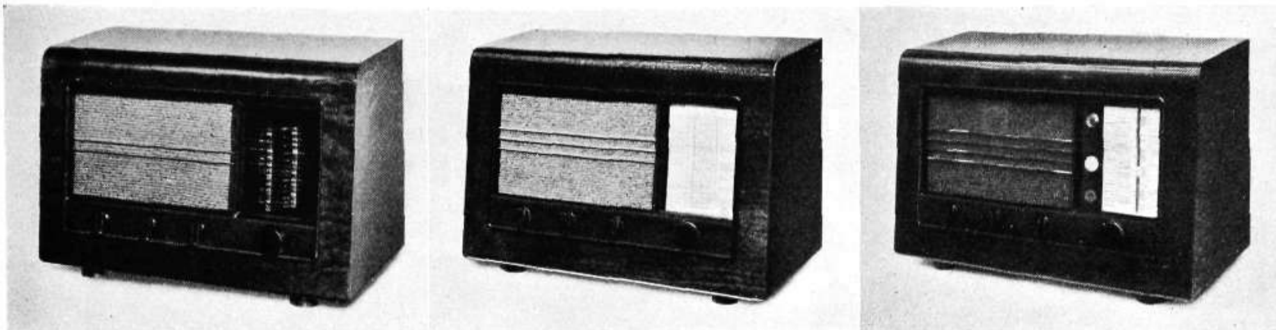


Fig. 2 X 7156
Ericsson 382, Ericsson 383 and Ericsson 384

The sensitivity of the apparatus is $3\ \mu V$ at 50 mW and the selectivity 50—55 db at 8 000 c/s. The output power is 3—4 W and the power consumption 50—60 W. The receivers have been passed by the Swedish Electric Material Control Institute and are made in both alternating current und universal models.

Ericsson 383, Fig. 2, is superheterodyne in the lowest price range, provided with standard equipment. The index is parallax-free illuminated slot type, with lens for sharp short wave indication.

Ericsson 384, Fig. 2, has for facilitating of adjustment been equipped with gear knob fine adjustment, band-width switch, optical micro-scale and tuning indicator also illuminated slot index showing the wave length range. Volume control with tone compensation and variable selectivity contribute to increased tone register. The tone control is furnished with »speech» and »music» positions.

Ericsson 388 is a console type radio-gramophone, Fig. 3, and is available in two types, with and without record changer. The wireless part is the same as in Ericsson 384 but the apparatus is provided with two loud-speakers one in the wireless part and the other fitted under the gramophone, to give the sound greater space effect. The tone control has positions for speech and music. In the speech position only the upper loud speaker is used, the tone register of which is specially suited to speech. As a result of the favourable direction effect produced by the loud-speaker's placement high up in the cabinet the clarity of the speech is increased. In the music position the two loud-speakers work in series and are so connected that the lower loud-speaker chiefly reproduces the bass register.

Ericsson 386, Fig. 4, is a superheterodyne with automatic tuning and distance control. By a simple procedure the owner of the receiver may choose eleven preferred stations of which the one wanted is brought in automatically by pressing on the button of the station concerned. Above the buttons is a holder for interchangeable cards with the station names. The twelfth button switches the apparatus for manual tuning. The apparatus may be connected to a distance control set with six buttons.

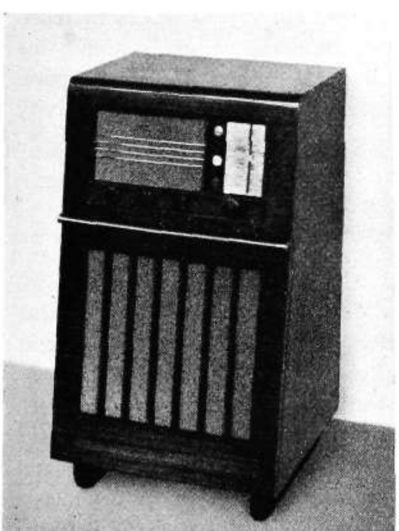


Fig. 3 X 3878
Ericsson 388

The risk of error with the automatic tuning and its adjusting is eliminated by the addition of automatic frequency control. The apparatus is further provided with optical micro scale visual tuning indicator, tone compensated volume control and tone control with speech and music positions. A small AC motor, connected to the station knob of the apparatus by a gear may by electrical switching be driven in either direction. The contacts of the motor for right-hand and left-hand running are connected each to one of two semi-circular contact discs placed on the tuning condenser shaft and insulated from each other by two insulating pieces, see Fig. 5. Eleven contact devices arranged in two semi-circular tracks make electrical contact with these discs. The contacts can be set in various positions along the track. They are numbered and connected by cables to the switches of the respective buttons. The motor is so connected that it drives the insulating plate between the contact discs

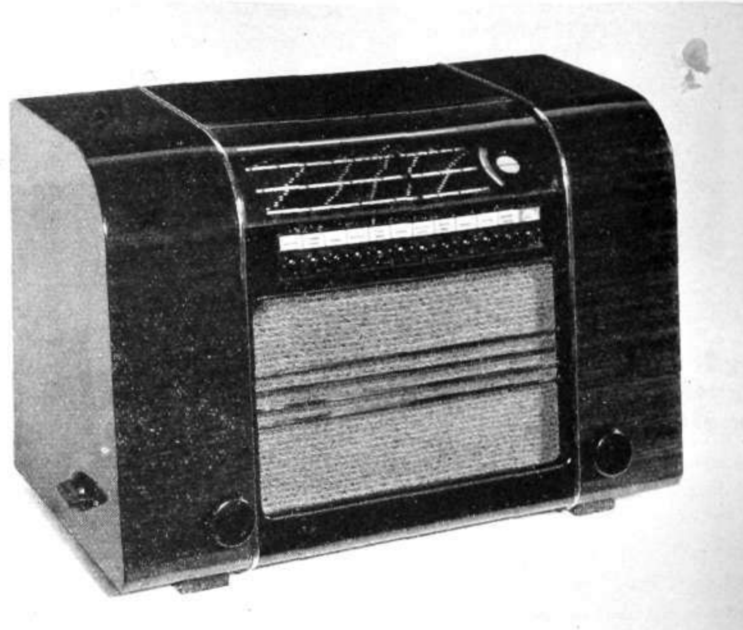


Fig. 4 X 5485
Ericsson 386

towards the contact device which is switched in. At the moment the insulating plate reaches the contact the current is broken and the motor stops. By the setting of the contacts it is thus possible to stop the motor at the required positions.

On the motor there is a relay which is actuated when the motor is running. A contact then closes the final valve's grid thus effecting silent tuning. The automatic frequency control is produced in the last circuit of the intermediate frequency stage by a device which gives positive or negative tension if the apparatus is obliquely tuned. A correction valve connected to the oscillator circuit is fed with this tension and corrects the oscillator frequency. The control device is only connected in when the button system is employed and is short-circuited by the relay immediately the motor is running.

Ericson 382, Fig. 2, is a single circuit detector receiver with the same external appearance as Ericsson 383. Despite the predominance of the superheterodyne this type of receiver still holds its position very well in districts with much disturbance or where it is only a question of receiving strong stations; the advantages of the single circuit receiver lie first and foremost in its low price, but also in its good sound quality and freedom from noise. The sensitivity with Ericsson 382 is 1 mV at 50 mW and the output power 3 to 4 W.

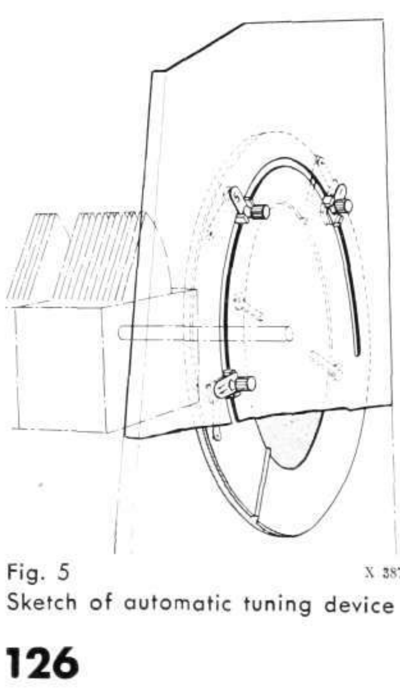


Fig. 5 X 3877
Sketch of automatic tuning device

Battery Receivers

At the time when mains connected receivers were introduced the market was flooded with exchange apparatus of the battery type which were sold out at very low prices and consequently became rather widespread. Nowadays, however, the same demands are made on the battery receivers, which are used for summer outings, in cars or on boats, as on the mains connected apparatus used in town. The older battery sets could in no way fulfil these demands and the great progress made by wireless technics in recent years have made it possible to construct today battery receivers with splendid sensitivity, selectivity and sound quality. Moreover there is required of a battery receiver great sound volume and minimum current consumption, which are obtained by means of current saving valves and sensitive loudspeakers.

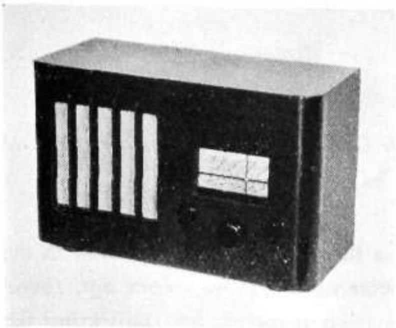


Fig. 6 X 3879
Ericsson 380

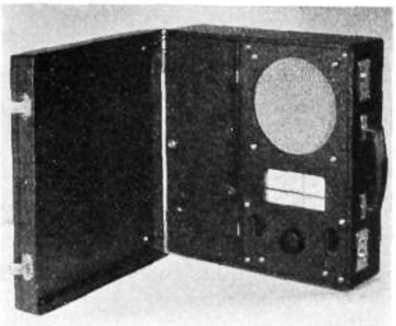


Fig. 7 X 3876
Ericsson 381

Ericsson 380, Fig. 6, is a single circuit three-valve receiver which meets all justified demands on a wireless receiver as low-priced as it is possible to make such an apparatus without sacrificing quality. It has a strong beautiful sound and it allows under favourable conditions the reception of powerful distant transmitters; its scale is furnished with the names of many stations. The batteries are built in and the current consumption is particularly low.

Ericsson 381, Fig. 7, is specially designed as a portable receiver. It looks like an ordinary travelling case and contains a two circuit receiver with high frequency stage, see Fig. 8. A frame aerial is built in to the lid of the case and this may be turned to the most favourable position. The sensitivity with the frame aerial is sufficient for the reception of European stations. The range may, however, be augmented by the connection of outside aerial and earth to the contacts provided.

The accumulator supplied with the apparatus is sufficient for 80 hours' operation and so constructed that no acid can run out during transport. There are terminals for a larger accumulator if the apparatus is to be used as a stationary one.

Ericsson 383 Bat is a superheterodyne for battery operation with the same appearance as the mains receiver Ericsson 383, see Fig. 2. It has been possible to reduce the current consumption still further by means of an economizing circuit, which reduces the anode current consumption by almost 60 % and the filament current by 30 %. The normal sensitivity is 30 μV at 50 mW and the maximum output 400 mW. These figures are altered with economy connection to 100 μV at 50 mW and 300 mW.

For connection to 6 and 12 V accumulators Ericsson 383 is made with built in vibrator converter. The sensitivity for this type is 10 μV, output 1.5 W and the power consumption 20 W.

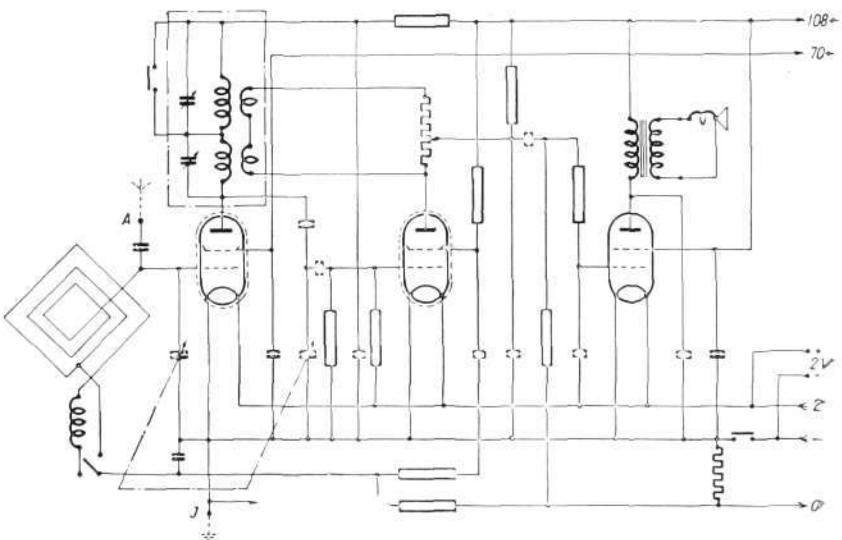


Fig. 8 X 5484
Connecting diagram for two-circuit receiver 381
for battery operation, 3 valve, wave-length range 200—550 and 700—2 000 m, output 0.25 W

Recording Discs

E. LINDSTRÖM, SVENSKA RADIOAKTIEBOLAGET, STOCKHOLM

To meet the demands of the public for up-to-dateness and variation in the wireless programmes the broadcasting companies some years ago found themselves faced with the necessity of devising a means for registering the reception of their reporting service. A natural solution of the problem was presented by registering on gramophone records. The methods employed with good results for commercial gramophone records, which are played on wax, sterotyped and then pressed out in large quantities from shellac composition, were too comprehensive however. On the other hand the discs of celluloid, gelatine etc. on the market for amateur use were far too inferior in sound quality and it was therefore necessary to bring out better recording material.

Svenska Radioaktiebolaget has succeeded in collaboration with the chemical industry in producing recording discs, furnished with a coating of cellulose lacquer, which give a very good sound quality combined with freedom from noise. The discs are made by a special method in different qualities destined for various purposes.

Sound waves as such have in all times been a difficult matter to master. Before the time of electrical recording, registration was wholly mechanical. Singing or speaking was done into a funnel which gathered up and conveyed the sound waves to the engraving box where they acted on a diaphragm connected by a lever device with the engraving needle. The range of frequency was extremely limited and success was never achieved in removing the troublesome resonances in the funnel and the engraving box. When it was found that the mechanical oscillations could be converted to electrical and these to mechanical in their turn and moreover be amplified to a convenient degree, an intermediate stage was obtained in which correction for almost all defects could be made.

The wax, which was used as the first stage for the commercial recording in the engraving of the sound waves, is altogether too delicate and unhandy and moreover can only give a couple of reproductions with an extra light sound-box. Just before 1930, therefore, blanks of metal began to be used, chiefly aluminium and zinc. The records could be played immediately after registration, with wood or fibre needles. Two methods for engraving these blanks were employed: the track could either be scored in with a sharp engraving needle or pressed into the comparatively soft plate with a blunt saphire needle. The former method, still employed in improved form by some firms on account of its cheapness, gave greater register but more needle scraping. In the latter method the needle noise was less but the high tones were completely absent. A development of the latter method consisted of discs in which the track was pressed out in advance. The material was celluloid, the sound-box guided itself in the track and impressed the sound waves in with a blunt needle. The frequency range and volume were extremely limited.

During this time various firms were working to produce a composition which would resemble wax as much as possible. The engraving needle which should be ground sharp should cut out a tough cohesive shaving and the track must display a very smooth bright surface. It should be possible for the record to be played immediately without any complicated procedure and, without too great deterioration of quality and increase in needle scratch, stand some thirty playings with steel needles.

For a time gelatine appeared to meet all requirements. With a sharply ground engraving needle, set at an angle of 75° to the disc, there was obtained a thick cohesive shaving. The frequency range was satisfactory, but in view of the comparatively coarse structure of the gelatine the needle scratch was rather serious. Moreover the gelatine was highly susceptible to moisture and heat. These discs were relatively cheap and are still used with satisfactory results by amateur beginners. The reproducing is done with curved steel needles and to minimise friction between needle and record vaseline is rubbed into the disc after recording.

In 1931, however, Svenska Radioaktiebolaget began to experiment with recording discs of acetate and cellulose lacquer. Great difficulties were, however, encountered in successfully experimenting with the recording material, as it was only gradually that the chemical industry made the discoveries which led to the possibility of producing the necessary cellulose for the record lacquer and the solvent for it. Is was not until 1935 that Svenska Radioaktiebolaget considered its records good enough to put on the market.

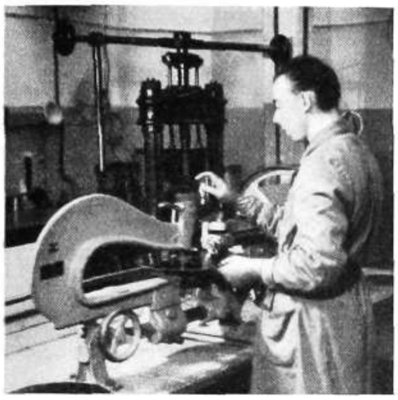


Fig. 1 X 3872
Shearing the disc material

The recording discs are made in two qualities, one more expensive with aluminium sheet base and one cheaper with cardboard base. The lacquer is the same in both cases. Aluminium sheet has been decided on, partly in view of its low specific weight making the discs light to handle and partly because of the ease in rolling aluminium sheet with the necessary evenness of surface. Any little irregularity of the plate surface shows on the lacquer surface as a small hollow or bulge. The grade of hardness is also accurately fixed. All stresses must be removed so that the discs do not bulge with the further treatment, hole-punching and cutting out. The discs must yet be stiff enough to stand light shocks. The thickness of the discs is 0.5 mm with a tolerance of ± 0.02 mm. After shearing and first rounding, Fig. 1, they are impregnated before proceeding to the lacquering. The cardboard in the cheaper blanks is glazed; after cutting out, the board material is immersed in a bath and dried to remove air formations in the pores of the paper. Otherwise the air would be brought to the surface by the lacquer and entirely spoil the disc.

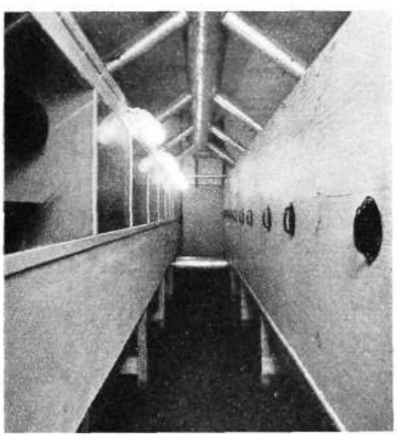


Fig. 2 X 3873
Drying chamber

Obviously good results in playing the record are intimately connected with accuracy in the lacquer manufacture. To obtain a record free from scratching it is necessary to ensure that the ingredients are of the finest quality; in particular the cellulose must display great homogeneity and the mixture must be kept stirring for a considerable time. The viscosity is checked and the lacquer is coloured black to give the finished blank a more attractive appearance. When it is dry the lacquer must not be brittle, but soft without being doughy. The harder it is the more of the high frequencies can be taken in but there is risk of needle scratch being too great. It is a question of hitting on the golden mean.

After the lacquer coating of the aluminium or cardboard there remains therefore a troublesome and prolonged drying procedure. The discs are placed in drying chambers, Fig. 2, through which air is forced by fans with moderate speed. The air naturally must be entirely free from dust particles and at the air intake dust filters are inserted consisting of several layers of cottonwool between linen cloth. The temperature and humidity are measured and corrected if deviation is too great. It is the great relative degree of moisture in the chamber in particular that render the drying difficult, but by appropriate air treatment there is obtained a drying time which is not too far removed from the normal. The time is not the same for all discs, being governed by the size of disc. When the disc is dry the edge is cleaned and a number of holes are punched in the centre to fit the various fixing devices employed at different broadcast stations. After strict inspection, Fig. 3, the disc is finished.

Fig. 3 X 3874
Inspecting finished discs

Svenska Radioaktiebolaget make six different types of recording discs, *viz:* three sizes of card discs: P 15, P 20 and P 25, and three sizes of aluminium discs: A 20, A 25 and A 30. The figures represent the diameters in cm, and the discs give different recording times according to the diameters. As everybody knows, the sound quality deteriorates the nearer the centre of the record is approached. It is the higher frequencies particularly that are affected, due to smaller radius and thus smaller periphery speed and the resultant smaller space for these waves which are the shortest. In playing off, the needle on account of its retardation has difficulty in keeping up. Engraving should therefore not be done too near the centre, preferably not nearer than 50 mm. At the outer edge 3 mm may be counted on for smaller discs and 5 mm for larger. There are thus obtained for the different types of discs the playing widths and, according to closeness of the grooves, the playing times shown on the following table:

	diameter cm	edge mm	playing with mm	playing time	
				36 grooves/cm	44 grooves/cm
P 15	15	3	22	1 m	1 m 10 s
P 20	20	3	48	2 m	2 m 30 s
A 20	20	3	48	2 m	2 m 30 s
P 25	25	5	70	3 m	3 m 40 s
A 25	25	5	70	3 m	3 m 40 s
A 30	30	5	70	4 m	5 m 10 s

Range of Application

It was only with the production of the lacquer discs that recording took on real speed. Recording studios where the general public could satisfy their human vanity by enjoying their own voices had already begun to appear before that in the large towns of Europe and America. For the broadcasting companies the introduction of first-class recording discs constituted an important advance in their reporting service. To begin with they obtained the facility of sending out, at convenient points in the normal programme times, current events which had taken place at quite other times, but in addition it was possible to gather together reports made at different places and different times. Of course there had been a deal of experimenting with various kinds of strip, of steel, of film, of paper, and first-class strip apparatus are now available for taking up long programmes. The advantages of these systems are that they can play for hours at a time without interruption and for recording of theatrical pieces, for instance, they are ideal.

In the reporting of an event, however, conditions are quite different. In that case it is frequently not desired to send out the whole report but only certain sections. For this the disc records are superior, since they may be edited together to form a programme; with the reproducing apparatus at the disposal of the broadcasting it is possible on transmission for nobody to notice the change-over from one record to another. For filing away the more sensational events the disc records are both more convenient and more durable than the steel strip. Steel strip records which it is desired to preserve are often copied out onto discs.

Expeditions to Mongolia and Farther India, *inter alia,* have been equipped with recording outfits for taking up records such as the religious songs of the natives, their speech and music. Dialect archives preserve dying speech on records. An elegant manner for a firm to carry on its sales propaganda is by means of records. Telephone recording has taken a step forward thanks to the disc records, as these are easy to file away. For conferences and congresses the disc record constitutes the most ideal secretary.

In the service of education gramophone disc recording is of great importance. In song, music and language studies it is possible to check oneself and mark progress, for stenography it is possible to get a dictation with unfailing precision. The still film, the mechanical lecturer, has its synchronized speech played on lacquer records.

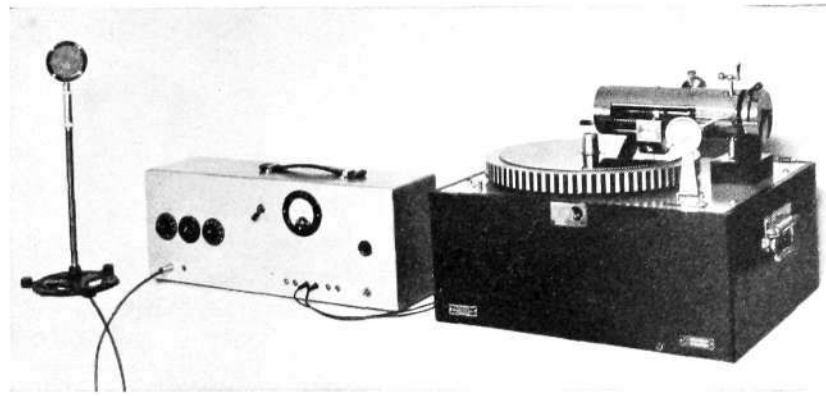


Fig. 4 X 5488
Recording apparatus
left to right, microphone, amplifier and engraving instrument

Recording

The attainment of good results obviously requires in addition to good recording discs a good recording apparatus as well; this, Fig. 4, comprises microphone, amplifier, engraving mechanism with engraving box and motor. The microphone to be used is governed by the conditions under which one is working. Broadcasting stations which have great resources at their disposal mostly employ dynamic, band or condenser microphones of high price. Studios chiefly employ the very handy crystal microphone and amateurs can achieve acceptable results with a carbon granule microphone of *Reisz* type. The amplifier's curve should be straight between 50 and 8 000 c/s with the facility of cutting out the lower frequencies. The output power to be selected depends on the quality of the engraving box.

For the engraving of the records an apparatus should be used which is so stable of construction that the intervals between the grooves are as nearly as possible equal. Those occupied with recording want as a rule to get as much as possible out of the disc, *i. e.*, have the longest possible playing time. This is done by laying the grooves as close as possible, but the requirement is dependent on the mechanical execution of the engraving mechanism. There is therefore a limit as to the nearness the grooves may lie. This is determined by the amplitude of the modulation, the elasticity of the lacquer and the sureness of playing. Assuming that the engraving needle cutting edges lie at right angles to each other, the walls will be thinner the nearer the tracks are together with the same weight on the engraving box. There may thus be risk of the lower frequencies cutting through the walls or probably that an echo arises, see Fig. 5. This echo effect will naturally be reversed, the echo coming first and the original after, due to the fact that the wall of the previously engraved groove yields to the needle's oscillations and forms a corresponding swelling. With a counterpoise to the engraving box it is possible to cut grooves more shallow and thus increase the thickness of the walls, but in reproduction the needle has difficulty in remaining in the groove and suddenly the soundbox shoots in towards the centre. Experience has proved that for music recording the maximum pitch should not exceed 36 grooves cm and for speech 44 grooves/cm. With 36 grooves/cm the track distribution, *i. e.* groove width plus groove distance, will be 0.28 mm. The weight of the engraving box is adjusted so that the groove width and the groove distance are equal, *i. e.*, 0.14 mm; the groove section will then be a right-angled isosceles triangle and the groove depth 0.07 mm. As the lacquer coating has a thickness of about 0.20 mm there exists no risk of cutting through.

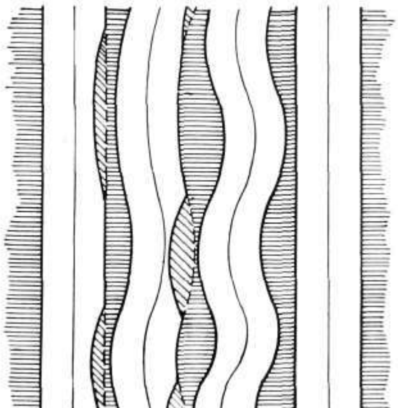


Fig. 5 X 3875
Echo effect

To determine the size of the amplitude a test is made with the strongest music that may occur and it is investigated with a pocket microscope, which should always be available when recording, to see that the greatest amplitudes have not gone over half the groove wall. The simplest instrument there is for measuring the make-up is a good eye and a 50 W lamp, preferably with reflector. The disc is illuminated obliquely from above and the varying crenelations of the image picture are studied. The width of this picture is propor-

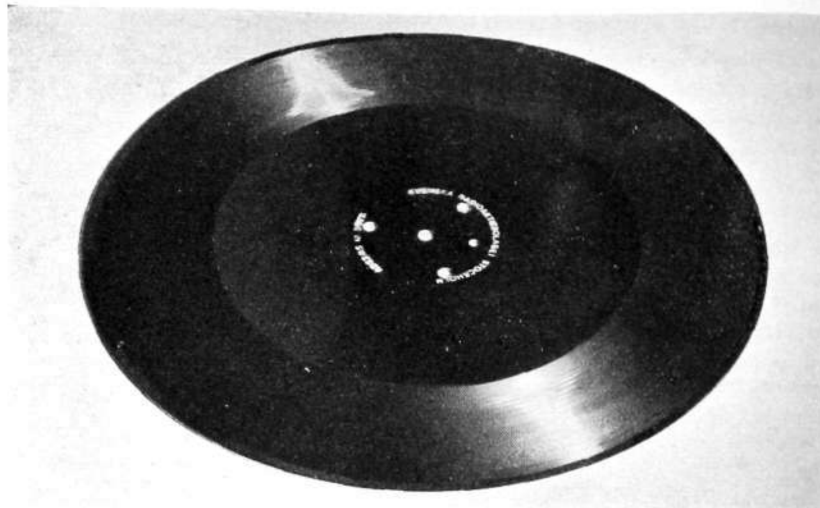


Fig. 6 X 5482
Record with Meyer picture

tional to the strength of what is recorded. The greatest width for music is 20 mm. The image phenomenon is a good aid to the study of the frequency ranges of the amplifier and the engraving box. In the microphone intake of the recording amplifier it is possible from a tone generator, which gives constant tension over the whole frequency band, to feed in the frequencies it is desired to measure. If, for example, one proceeds continuously from 50 c/s up to 10 000 c/s, there is obtained a fine picture, the Meyer picture, Fig. 6, which gives tangible evidence of the quality of the apparatus employed and is of enormous assistance in gramophone technics.

On account of the fact that the amplitude is in inverse ratio to the frequency the low frequencies would, if one modulated according to a straight curve, be so great that the groves would run into each other. Screening of the lower register is therefore a necessity. A good engraving box which is strongly attenuated would give a Meyer picture which rises slowly from 50 c/s to around 500 c/s. Between 500 and 2 000 c/s it is as near as possible straight and then rises to appr. 6 000 c/s after which it falls steeply. A strongly attenuated engraving box, however, demands access to great output from the amplifier, 15—20 W. A simpler engraving box may be operated with a 3—5 W amplifier, but its upper limit frequency will generally lie as low as 4 000 c/s. The higher the frequencies it is possible to get in, the richer in overtones will be the speech and music; the *s*-sound in speech especially comes out very soft and natural. In practice it is enough to stand at 5 000 c/s as the higher frequencies make greater demands on the reproducing devices, so that possibly one would never have the opportunity of listening to a dearly bought over-register.

A beginner with lacquer discs frequently finds these inferior to, *e. g.*, the gelatine discs formerly used. He has heard of the lacquer disc's freedom from needle scratch, but finds to his vexation that the scratch is worse instead. The natural thing is to accuse the factory of having delivered discs too dry. But generally it is not as bad as that. When engraving on gelatine discs the slope of the needle to the disc is about 75° and most of the recording apparatus for amateurs have this angle unalterable. On account of the greater toughness of the lacquer the angle must be as near as possible to 90°. If the shaving is dull and brittle the angle is wrong. With proper inclination there is brought up a tough brilliant shaving. The groove will then have its smoothest surface and the needle scratch will be at a minimum. It is important that the engraving needle is of good quality and correctly ground. Steel needles are usually employed. A saphire or diamond needle is more expensive to buy but it suffices for so many the more recordings and gives less needle scratch. Before beginning to engrave with steel needle one should always cut a groove in the centre of the disc, lay the ear against the engraving box and listen whether it cuts without scratching.

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CONTENTS

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Hats Off to Engineering

COUNT A. HAMILTON, DIRECTOR-GENERAL OF THE SWEDISH TELEGRAPH ADMINISTRATION, STOCKHOLM

At the close of the present year Count A. Hamilton relinquishes the post of Director-General of the Swedish Telegraph and Telephone Administration. In view of this event, the Ericsson Review has requested Count Hamilton to express an opinion on a question of never-failing popular interest, viz: »the telephone and the public».

Some time ago in a wireless broadcast talk I heard it suggested that the wireless broadcast had succeeded the telephone as the favourite whipping boy of the public. Maybe that is so; for one thing is certain in any case: the telephone which for generations was one of the most prolific sources for the sallies of the columnist has lost a great deal of its interest in this respect and even the more direct outpourings of the public about and over the telephone have fallen off remarkably — both the petty complaints of the fussy and the more full-blooded wrathful shouts of the irascible.

With such a situation, it might be supposed that the head of an administration which had for years been the target for shafts from all sides might have good cause for displaying a satisfied countenance, and I cannot deny that as the close of my direction of the Telegraph Administration approaches it causes me a certain gratification to record the observation expressed above. Nevertheless, the ever-watchful interest of the public in the telephone, which despite constant heckling has not been the less utilized, has provided a certain stimulance which may have had it uses, even though ambition was never lacking.

Not infrequently have the skirmishes been truly refreshing — from the first controversy on »*private or state operation*» to the last question of »*manual or automatic*». In between, the rates applied by the Administration, the metering of calls and a thousand and one other details have given rise to violent exchanges of opinion, but the struggle has invariably turned on one common aim — a better telephone service. The public has put forward its inalienable opinions, occasionally full of commonsense, at times not so well justified. The directors of the Administration have listened with sympathetic ear, quite prepared to comply if compliance might lead to greater fairness and justice, but also prepared to oppose where the attackers had lost sight of public welfare. That is how the telephone has made its way in our country, the servant of the public, today more capable and more serviceable than yesterday, yet despite the more moderate criticism still far from perfection.

And so the controversy about the telephone will continue. If it were not so it would mean that the telephone had begun to degenerate into a has-been. As a matter of fact, it is arousing more interest than ever and in the widest of circles. The explanation of the present armistice must be sought in another direction. Of course, I know of one answer: »No use saying anything to the Telegraph Administration, they have it their own way whatever you may say.» However, I like to think that the reason lies deeper, that our good intensions, our unalterable determination to do the best, not for Mr. This or Mr. That, but for a l l our clients, I mean the Swedish public as a whole, are so obvious that even among our worst critics they cannot fail to command, if not respect, at least a certain amount of confidence, and maybe perhaps understanding for o u r difficulties.

Besides, we have had a powerful ally — engineering progress. It has helped us to surmount many of the imperfections never absent from human effort and has assisted us to deprive complainants of some of their sharpest weapons. What a harassed operator can no longer stand without collapsing, the machine will do time after time with unfailing precision, and not even the most rapid-thinking brain imaginable can set hands in motion, be they ever so willing, with the speed and precision of the electrical relay's response to a current impulse — not to mention the irritating feature that has disappeared by the fact that the thousand and one wires which hung over roof tops and along pole lines, exposed to every kind of injury, may now be protected in cables.

Moreover these benefits of automatic telephone and cable engineering have also brought an indirect advantage. Entrenched behind the mysteries of technicalities, always obscure to the general public, the telephone has in a way become more unassailable. Nobody can bully a machine or a technical device with the same ease and irresponsibility he can display to a human being — not to mention the fact that the machine as a basis for witty sallies is a subject very much more difficult to handle.

Hats off to engineering.

Automatization of the Stockholm Telephone Network

H. LINDBERG, SECRETARY TO THE SWEDISH TELEGRAPH ADMINISTRATION, STOCKHOLM

In the Ericsson Review No 3, 1938, there were described the circumstances connected with the development of the Ericsson automatic telephone system up to the year 1921, when the first automatic exchange on this system was ordered for Stockholm by the Telegraph Administration. Seventeen years later, in April last, there was opened the seventh and last automatic exchange in the Stockholm network proper, to which there were at that time connected some 136 000 subscribers.

All the exchanges are executed on the Ericsson automatic telephone system with 500-line selectors, their total actual capacity being 180 000 lines. The cost of automatization — including the cost of requisite extensions to networks and exchanges — has amounted in round figures to 55 million kronor. That the money has been well expended is evident from the account below, reproduced from the souvenir publication issued by the Telegraph Administration in conjunction with the automatization of the Stockholm telephone system.

The great influx of subscribers during the world war and the congestion it caused in the telephone exchanges of the Telegraph Administration in Stockholm brought out the urgent necessity for plans of modernization of the telephone plant of the capital. At that time conversion to semi-automatic telephone operation was the chief consideration. Indeed, the remarkable phenomenon had arisen that automatic telephone practice, which from the beginning had aimed at the replacement of all manual operators' work by automatic devices, had been forced by circumstances to take half a pace to the rear — to semi-automatic exchanges. When in 1907, *Clement* in the United States began to make semi-automatic telephone exchanges, he advertized them as »modern» as opposed to the »old-fashioned exchanges operated by dials».

Even as late as 1919, there could be read in an American trade journal: »With all automatic systems the connecting devices must be supervized by human intelligence. For many years efforts have been directed to having the subscribers themselves exercize the work of supervision over the apparatus at the exchanges. The well-known automatic systems with dials came into being as a result. The automatic systems have proved the practicability of automatic connection, but despite the fact that in their highest degree of perfection they represented a distinct advance on manual systems, yet they were burdened with certain disadvantages.» Among the various objections put forward at the time, one may be recalled — that the route for the supervision of the exchange's functioning was the subscriber's line, recognized as the weakest link in the telephone system. In conclusion it was stated: In most cases the keyboard method, as employed in the semi-automatic systems, is more economical, more reliable, more accurate and more rapid, and consequently more satisfactory both for the telephone undertaking and for the subscribers.»

In Sweden, too, the same path was followed for some time. The trial exchanges set up in Stockholm were semi-automatic and the tenders for the first time invited in 1917, for large exchanges in Stockholm were likewise for semi-automatic exchanges. The question was not definitely decided at that time, one reason being that the taking over the Stockholm Private Telephone network in 1918 changed the conditions hitherto prevailing. On September 2nd, 1919, the Telegraph Administration laid before the Government its guiding lines for the modernization of the Stockholm telephone system. In this communication, which also touched on the idea of automatization, the Administration stated among other things:

»A telephone network in a large community in a state of expansion must sooner or later attain such an extent that for purely technical reasons the service of all subscribers can no longer be ensured by one range of operator positions but must be distributed over a number of such positions. In carrying out such a distribution there must be arranged side by side with the operators a rather complicated auxiliary system (B-positions) with special staff for the interchange of calls between the different exchanges. With expansion constantly proceeding, however, there will come the time when this system too will prove inadequate. With the increased size and number of sub-exchanges, the multitudinous transfer of calls between the different exchanges would, in fact, still more increase the work of operators.

There could only result deterioration of the service unless the staff were constantly increased in number. But such increase would mean enormous extension of costs, since both the operator positions and the B-positions above referred to, as also the necessary staff for both, would require to be increased, necessitating the acquisition of new premises. Operating costs, therefore, would rise rapidly without any compensating gain and large funds would be practically cast away. To continue on such a path could not be characterized as anything but the rank opposite to business-like operation.

The Stockholm telephone network has for some years been very near to this critical point. It stands out therefore as the duty of the Telegraph Administration to make arrangements in good time, not only to organize the telephone traffic in such a way that it will in the future really satisfy the demands every subscriber is justified in imposing for the appreciably increased charges he is now called on to pay, that is to be able to come into sure and rapid communication with other subscribers to the network, but also in this connection to undertake the fusion of the State network with the private network purchased in 1918, which the public are awaiting with a certain expectation. The Telegraph Administration cannot avoid the reflexion that, the State having succeeded in attaining the position that the State now practically speaking carries on telephone and telegraph work as a monopoly, the State should in this branch of administration also see to it that those relying on it are served in such a way that the question does not arise whether they might not be better served were they handed over for exploitation to private enterprise.

The only expedient available which, while ensuring the economic point of view, will attain the ends stated by the Administration is to combine the subscribers of the scattered exchanges, created one after the other, to a single complete systematically arranged telephone network within which they would be grouped, according to local and technical traffic conditions, to certain large interconnected exchanges. By this means there would be ensured also another advantage of enormous economic importance. In the first stage of the network the circuits of a number of subscribers situated at a considerable distance from the single exchange of that time must be drawn to it, and this arrangement uneconomical in itself would with the systematic re-organization of the network be altered, leading to very appreciable savings to the Administration in the form of reduced lengths of lines.

Such a systematically organized network cannot, as indicated above, be arranged for manual operation with the number of subscribers at present represented by Stockholm, without financial waste. It must therefore be constructed for automatic operation. It is only with such operation that service can proceed equally unhampered between a number of different exchanges as with a single exchange. With the perfection that automatic telephone equipment has now attained, such equipment is not only cheaper to install but also to a large extent saving of expense in operation.»

The general plan thus laid down for the modernization of the Stockholm network was based on a planning of the network for 200 000 subscribers' lines, estimated as covering requirements for 20 years to come. Eight automatic exchanges located in various parts of the city were planned. In regard to this plan, the Administration stated that it had been drawn up as far as possible on the basis of utilizing all possibilities for making use in the installation of existing buildings, cable lines and other equipment, however tempting it might be, by clearing away all the plants that during the last four decades had been added to bit by bit, to now at one sweep lay the foundations of an entirely new edifice — a temptation which receives added strength by the thought that such a procedure might even be the most far-sighted economically.

In his statement for the cabinet council records, the responsible Minister emphasized the need for new telephone exchanges and the desirability that the work of modernization should from the beginning proceed on a definite plan. In carrying out such a plan, the Minister said, the Telegraph Administration had the intention of making an important change in a technical respect, *viz:* to change over from the manual to the automatic system. After having expounded the difficulties arising with manual operation in a network as large as that of Stockholm and having given a fairly detailed indication regarding automatic and semi-automatic traffic and their advantages, the Minister summed up as follows: »Seeing that the advantages, which operation in a large telephone network on automatic systems therefore provides, are so much greater both for the public employing the traffic and for the State administration than could be attained with telephone operation with the present devices, it would appear to be recommendable that the telephone network in Stockholm be re-organized on such a system in conformity with the proposition of the Telegraph Administration.»

In 1920 the Riksdag authorized the Telegraph Adminstration to purchase the premises required for the putting in hand of the plan of automatization. And so finally firm ground had been reached.

The First Automatic Exchange

In November 1920 the Telegraph Administration invited tenders from various firms for two automatic exchanges, one for 10 000 subscribers and one for 5 000 subscribers. The tenders received were later examined by a special commission, which proposed that an order should be given to Telefonaktiebolaget L.M. Ericsson for a trial exchange of 5 000 subscribers. The commission declared that according to their calculations the Ericsson automatic telephone system was the cheapest but that it was so new that it had not yet been tested in practice. The system was, however, based on previously known and tested principles, so that any difficulties should be capable of being surmounted, a view which was shared also by the engineers of the Telegraph Administration, who had undertaken detailed investigation of a test plant set up on Telefonaktiebolaget L.M. Ericsson's premises.

The Telegraph Administration followed the recommendations of the Commission. All the tenders received were rejected as being »not to the State's advantage», and in addition the Administration, having reference to the prevailing shortness of money, decided »that the automatic exchanges in question should not be executed immediately to the extent intended». Shortly afterwards — April 23rd, 1921 — there was ordered from Telefonaktiebolaget L.M. Ericsson an automatic exchange for 5 000 subscribers. The exchange was given the name of »Norra Vasa», which it still bears. By the terms of the contract the supplier undertook that the telephone system to be employed would be so arranged that it fully answered to modern demands and that the scheme of connections should be so made out that it could deal with all combinations that might arise in large telephone traffic and especially with interchange of traffic between automatic and manual exchanges. The special parts of the installation were to be fixed not later than one month after signature of the contract by means of sealed patterns. If the system did not work satisfactorily the contract could be rescinded within the period of guarantee, two years, in which case the supplier had to refund any cash received and pay over to the Telegraph Administration the extra cost for a new exchange of the same capacity. Finally, the Telegraph Administration was accorded the right to take up the manufacture of the system in case the prices should eventually prove too high or the work proceed too slowly. The time of delivery was fixed at 21 months. On August 1st, 1923 there were connected 100 service telephones to the exchange and on January 13th, 1924 it was opened for public traffic with 289 subscribers. A week later a further 576 subscribers were connected. By February 3rd, 2 200 subscribers in all were connected.

Special arrangements had to be made for traffic between the new automatic exchange and the manual exchanges of the Stockholm network. Traffic coming in to the automatic exchange was routed over order wires and junctions in the same manner as traffic between the different manual exchanges. In these latter exchanges therefore calls to Norra Vasa exchange were handled in the same manner as calls to other exchanges in the city network. At the automatic exchange on the other hand there were for the incoming traffic, instead of the B-positions of the manual exchanges, what are called keyboard positions, Fig. 1, while incoming junction circuits to the exchange were connected each to its own second group selector. Each keyboard position had four rows each of ten keys, marked like a telephone dial *0, 1, 2* and so on up to *9*. It thus functioned like a dial but more easily and rapidly. The keyboard position comprised also a starting key, three register lamps — one for each register connected to the position — and lamp for each of the 36 junctions connected to the position.

The method of procedure for an incoming call was briefly as follows: when a calling subscriber connected to a manual exchange asked for a number in Norra Vasa, the operator sought connection over the order wire selector of the manual exchange with a disengaged keyboard position at Norra Vasa. Immediately such was found it was marked busy by means of a relay. One of the keyboard position's free registers — each position had three registers at disposal — simultaneously was connected to the position and the register cord finder was set hunting for a free junction to the exchange from which the call was orginated. A special marking lamp then indicated to the keyboard operator the number of the selected junction, this number being communicated to the operator at the manual exchange over the order wire. The connection was completed by the keyboard operator pressing the keys corresponding to the called subscriber's number and then the starting key, while the operator at the manual exchange plugged her ringing cord into the jack of the junction indicated. At the automatic exchange the junction was then further connected over the second group selector and a final selector to the number wanted in the same manner as with automatic connection. At the manual exchange the calling number was connected over the operator's cord pair in the usual manner. Occasionally there existed at Norra Vasa side by side with the keyboard operation also manual ordering of incoming calls — an arrangement employed to avoid extending the keyboard operation.

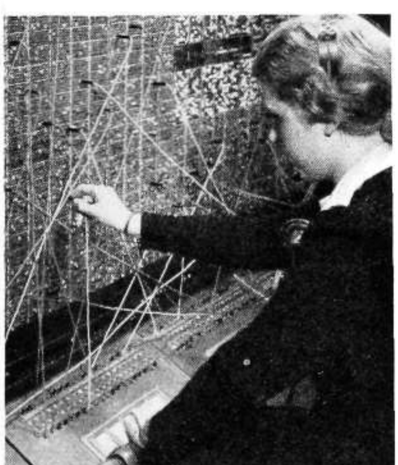
Fig. 1 X 3900
Keyboard position
for handling calls from manual to automatic subscribers

Traffic from Norra Vasa to subscribers at manual exchanges was after a short provisional period carried out over call display boards, see Fig. 2. This directing of traffic appeared automatic to a subscriber with automatic telephone, since the subscriber never came into conversation with an operator. When the subscriber dialled the six-digit number for the call, it was fed to a register in the ordinary way, after which the first group selector went out to the 10 000-line group indicated by the number. The junction from this group terminated with cord and plug in the junction position of the manual exchange concerned. In this position there were also displayed boards where the number dialled by the automatic subscriber was displayed and could be noted by the operator. She then connected the junction cord on which the calling subscriber waited, and which was marked by a lighted lamp, to the called number, ringing signal then being automatically sent out if the number were disengaged. If the called subscriber were busy there was tension in the jack sleeve to which connection was made, which tension indirectly acted on a series switch belonging to each junction, which was thereby put in operating position and sent out busy tone to the calling subscriber.

A call display board comprised five groups of lamps with ten lamps to a group. Each lamp corresponded to a fixed figure from *0* to *9* and the figure stood out immediately the corresponding lamp was lit. On the board were only marked as many figures of the subscriber number as were required by the size of the exchange, the other figures being taken up in directing the call to the exchange in question. Thus for call to subscriber *13 57 36* the first digit *1* was used for directing the call to the proper exchange, the second digit *3* being lit in the first lamp group, *5* in the second lamp group and so on. Lighting of the different lamps was effected by means of sequence switches at the manual exchange, revertive impulses being sent to the register comprised in the connecting chain at the automatic exchange. The sequence switches thus performed the same function as regards the register, as the second group selector and final selector perform with a connection inside an automatic exchange.

Norra Vasa worked splendidly on the whole. Obviously a number of alterations and adjustments had to be made, but these were remarkably few with regard to the fact that the exchange was a trial plant and the first of its kind. The oldest part of the exchange has now been working for 14 years. It shows such slight wear that it can with certainty be maintained in operation for a considerable time yet.

The beginning had been successful, but everybody was not pleased. Above all, it was the dial which caused irritation — the apertures were too small, it could not be operated in the dark and it was in any case a trouble. The last criticism came chiefly from subscribers with a large amount of traffic. There were even some who terminated their subscription because of it and in other cases such strong protest was made that the complainants were allowed to return to manually operated instruments. Even in 1925 the question of automatic or semi-automatic traffic was still being discussed. A proposal was made that subscribers with large traffic should have semi-automatic service and thus be relieved of the dial »so that they might while the connection was being established have one hand free to handle documents, notes and the like and also, if the operator answered »busy», be able to ask for another number without delay».



X 3888

Fig. 2
Display board
for handling calls from automatic to manual subscribers

Even the changed numbers due to automatization gave rise to some dissatisfaction and discussion. In this respect there were from the beginning two different proposals, one for figures alone (six-digit numbers) and one with an exchange abbreviation and figures (an exchange letter and five digits). Advocates of the former alternative maintained that the dials would be »cleaner» since there would be nothing but figures on them and not, as in the second alternative, both figures and letters, while in addition the system ensured greater simplicity and clearness when dialling. In support of the second alternative it was declared among other things that the old numbers with name of exchange were so fixed in the public mind that it would be easier for the subscribers to recall numbers with exchange letters directly indicating certain parts of the city than the new numbers all of figures, which moreover would make the old subscriber numbers change in character. A vote on the subject was taken in 1928 among the subscribers to »Norra Vasa» exchange. Of the 6 500 subscribers asked, 2 711 replied and of these 2 004 declared for the number with exchange prefix. The Telegraph Administration considered, however, that it need not accept as a definite expression of opinion this voting result »since the 58 % who did not reply might quite well be supposed to be content with the present arrangement», *i. e.*, a purely six-digit subscriber number.

Completion of Automatization

The following automatic exchanges have been connected: »Kungsholmen» for 15 000 numbers in June 1928, »Centralen» for 20 000 numbers in March 1929, »Söder» for 30 000 numbers in May 1931, »Södra Vasa» for 30 000 numbers in March 1932, »Östermalm» for 25 000 numbers in April 1933 and »Norr» for 15 000 numbers in April 1938, see map, Fig. 3.

In the same building as the Norr exchange there have been also arranged a new »name-call» exchange, completed in February 1938, and the special exchange devices required for traffic to automatized suburban exchanges. The number of subscribers in Stockholm with name-call on January 15th, 1938 was 404 and these were connected to the name-call exchange with 3 300 circuits altogether operating exclusively for calls to name-call subscribers. A special PBX subscribers' exchange — for subscribers with several lines but only one calling number — was opened in August 1931 and extended in July 1937.

In conjunction with the completion of the Kungsholmen and Centralen automatic exchanges there was applied an alteration in the traffic between manual and automatic exchanges, in that the keyboard positions which for Norra Vasa were located in the exchange itself were concentrated to a single operating place common for all automatic exchanges. This change provided a number of advantages and could be carried out without any great expense, since the junction lines between the stations within the Stockholm network, because of the geographical circumstances, all passed over one of the exchanges in the centre. In the new keyboard department the positions were provided with three

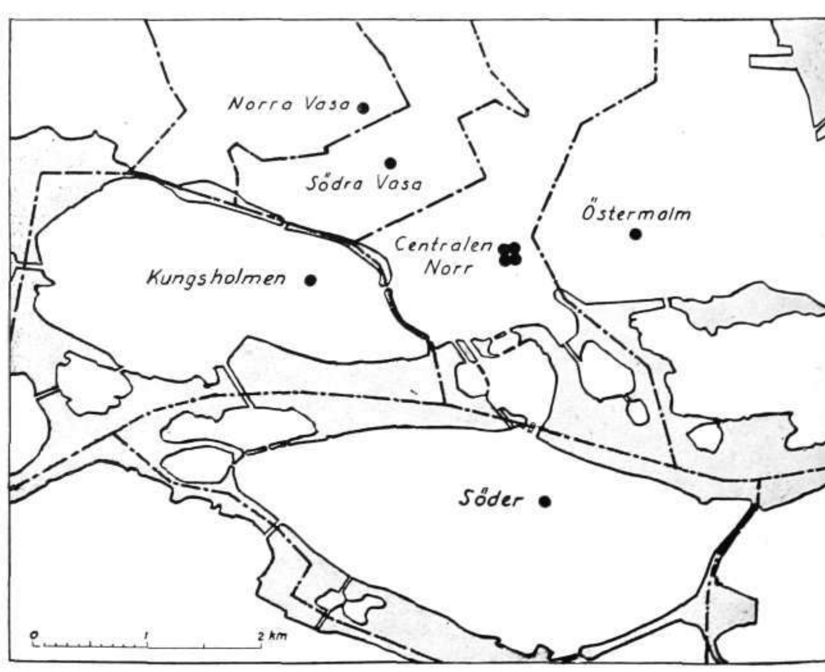


Fig. 3 N 5513
Telephone exchanges and exchange areas in Stockholm 1938

Fig. 4 X 5508
The semi-automatic name-call exchange

separate key sets. At the same time the registers could be simplified, since the keyboards themselves acted as the registering part of the register, and might therefore contain only the three revertive-impulse registers.

At the manual exchanges the change was introduced of discarding the order wires to the automatic exchanges. Instead, the junction jacks were provided with visible test and divided into groups each for 10 000 numbers. Thus there was one bundle of junctions to Norra Vasa, one to the lower 10 000 numbers of Centralen and one to the higher 10 000s of Centralen and so on. When an operator at a manual exchange had, for instance, to make connection to a subscriber in the lower 10 000s of Centralen, she pressed a key belonging to the bundle junctions for that 10 000. This caused lamps to light up for all junctions within that group. After she had connected the ringing plug of the cord pair employed to one of the free junctions she obtained connection with a disegaged operator at the keyboard position and gave her the called subscriber number. The keyboard operator then completed the connection in the manner described above for Norra Vasa. The selector was restored when the operator at the manual exchange, having obtained clearing signal from both instruments, removed the ringing cord from the junction jack.

With the automatization of Norr exchange the last manual exchange disappeared in the city area proper of Stockholm and with it the traffic over call display boards. The keyboard department remains only for serving incoming local traffic which has not yet been automatized.

When the figure *0* is taken for a name-call, the figure *8* for a suburban regional call or the figure *9* for ordering a trunk-call, it is true that operators contribute in all such cases to establishing the connection, but it is talking machines which answer the call as indication that the order can be communicated and it is — at least at the name-call exchange — other machines which carry out the main part of the work of connection. In fact, at the name-call exchange, Fig. 4, the operators' work has been simplified to comprise only reception of the order and the pressing of a key for the name-call subscriber to which the call shall be established — all other connecting work is done by automatic equipment. At all automatic exchanges, however, there are manually served positions where the subscribers' trunk calls are handled. At these positions also there are performed the reference and information services that are necessary, as when a subscriber has a changed number or has been cut off or when a connection has been made to line out of service.

Some of the automatic exchanges have since been extended and supplemented. Thus the line finder equipment at Centralen was increased during 1935 and the Kungsholmen exchange has been enlarged on three occasions, its capacity now being 30 000 numbers. Norra Vasa was brought up to 10 000 numbers during 1929 and on various occasions Söder has been extended to comprise rack bays for 40 000 and connecting devices for 38 000 numbers.

The actual capacity of the automatic exchanges was 179 500 numbers in April 1938 and the number of main circuits connected to the exchanges amounted on January 1st, 1938 to 135 263 with 168 000 instruments altogether. The cost of the exchanges amounted in round figures to 27 million kronor, of which approximately 23 million would go to work executed by Telefonaktiebolaget L.M. Ericsson and some 4 millions to work done by the Telegraph Administration.

During the period of automatization work has been executed on the network to an amount of 27.5 million kronor in round figures. Of this sum approximately 13 million kronor has gone on work directly connected with automatization. The number of telephone instruments connected, disconnected or moved during the period in question amounted to 682 000. The book value of the exchange premises housing the automatic exchanges is in the neighbourhood

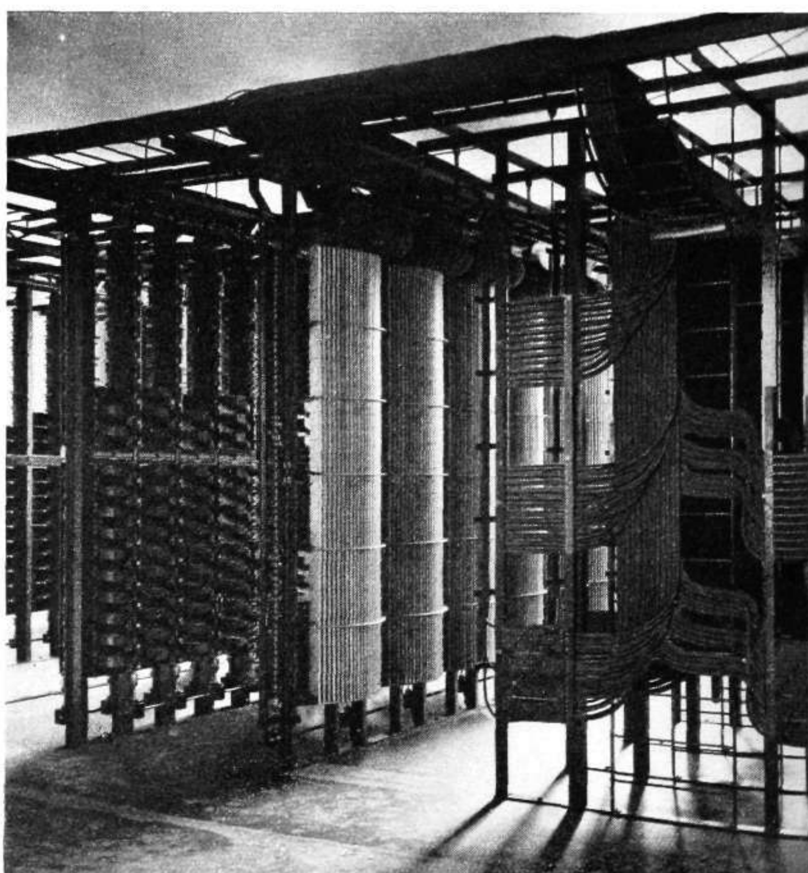


Fig. 5 X 5511
Intermediate frame and bay racks
at Kungsholmen automatic exchange

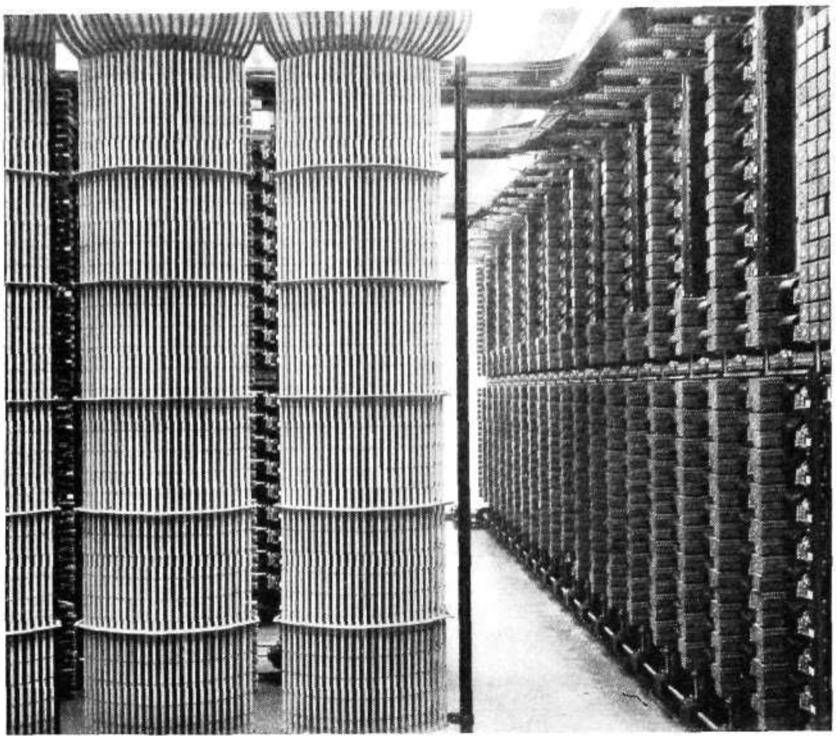


Fig. 6 X 5509
Rear view of selector frames and multiple
at Norra Vasa automatic exchange

of 8 million kronor and the floor surface utilized in Stockholm for telephone purposes is around 35 000 m². The extent of the network executed may be gathered also from the fact that Stockholm prior to automatization had two distinct telephone networks each with its own exchanges, circuit routes and installation buildings. The one was installed for central battery and the other mainly for local battery. By the automatization Stockholm obtained a uniform telephone network for automatic central battery operation, a number of exchanges reduced from 14 to 9 and definitely defined exchange areas. At the same time there was carried through a uniform numbering of all telephones in Stockholm — naturally not without hollow protests from those who had to give up »a good old number» for a new one that was, of course, less good.

From a picture of the situation at the moment when a new automatic exchange is being opened to traffic is it possible to illustrate further some details of the work of automatization. The installation work is practically completed. Each subscriber has received his new instrument with the dial sealed. The transfer is about to take place. This is done either by all subscribers at one time — say during one night — being connected over to the automatic exchange, or the transfer being carried out in stages with a small number of subscribers at a time. The latter procedure was adopted in Stockholm throughout, purely as a matter of precaution due to the fantastic interest which the Stockholm telephone public takes in any telephone changes. Even though the automatic exchange be obviously of such dimensions that all connecting devices and all traffic routes within the exchange and between it and other exchanges of the network would suffice also for peak traffic, that by no means implies that it is also equipped to meet the situation that would arise were all the subscribers to the exchange on the first morning of connection almost at the same instant to lift their handsets »to see how it works».

It would not work. After the connecting devices of the exchange had all become occupied the remainder of the calls would remain unanswered, at least as long as the subscriber concerned did not get tired and make a fresh call — still further adding to the chaos which had already arisen. In such case an installation, first class for all ordinary purposes, would have appeared inadequate, merely because it had been exposed to an isolated abnormal strain.

Naturally such a happening should be avoided as far as possible. That is why connecting over took place in small stages — generally with 1 000 subscribers at a time. The subscribers concerned, moreover, had been well prepared in advance. They received printed notices telling how to manipulate the automatic telephone and were visited by instructors who further developed and explained the same subject. If any of them — and usually there was quite a number — in spite of all went wrong in practical application then the traffic supervision service of the exchange came to the rescue. After a few days people were sufficiently experienced for the next group of subscribers to be connected. This method of procedure required special connection routes between the new and the old exchange during the period of transition. Moreover the manual exchanges of the network had to be kept accurately informed of the progress of connecting over so that they might know whether a certain subscriber on a given day was connected to the new or the old exchange. But it was considered that this extra work was more than justified by the increased efficiency which was thus ensured.

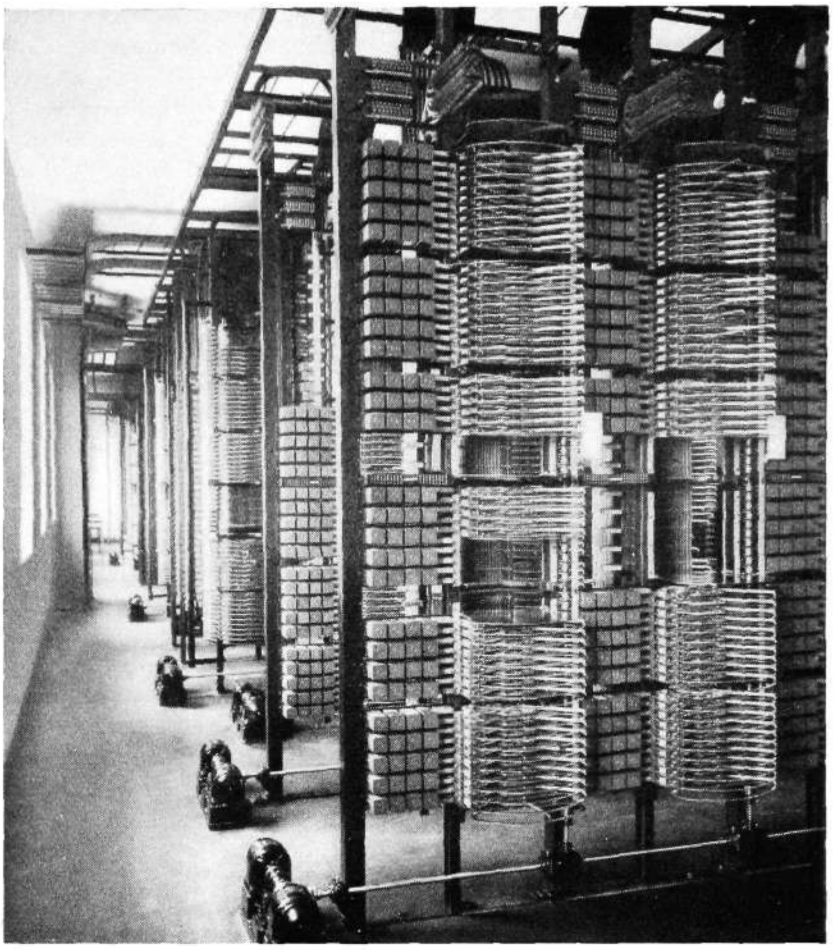
Automatization has now moved outwards from the centre of the city to the suburbs. A number of exchanges has already been converted — Lidingö Villastad was automatized in January 1933, Lidingö Brevik and Lidingö Skärsätra in January 1934, Äppelviken in February 1936, Enskede in January 1937 and Tureberg and Sundbyberg in February 1938 — while still more are in course of conversion or planned.

Statistics of the Stockholm automatic exchanges during 1937

exchange	Centralen	Södra Vasa	Norra Vasa	Söder	Kungsholmen	Östermalm
Traffic frequency						
exchange connected	spring 1929	spring 1932	spring 1924	spring 1931	spring 1928	spring 1933
average of subscribers connected during the year	16 284	21 409	6 880	28 089	20 621	20 949
outgoing calls during the year	99 527 511	44 429 244	14 716 869	56 922 106	40 733 755	51 596 413
call minutes per busy hour for outgoing calls	72 640	41 930	16 320	52 220	34 550	46 200
call minutes per busy hour for incoming calls	27 280	34 690	12 880	44 580	30 090	38 260
average of connected registers	330	234	144	296	165	268
average of connected line finders	2 000	1 350	595	1 700	1 205	1 420
Reliability						
technical fault percentage (outgoing calls)	0.22	0.04	0.07	0.09	0.16	0.06
traced exchange faults	2 131	870	328	1 490	1 187	908
total traced exchange faults per subscriber	0.13	0.04	0.05	0.05	0.06	0.04
total traced exchange faults per 10 000 calls	0.21	0.20	0.22	0.26	0.29	0.18
total of faults entered in exchange books	22 648	9 186	5 021	12 561	11 338	9 193
Maintenance costs						
maintenance hours	38 190	29 180	18 950	32 040	31 540	29 980
wages for maintenance staff	66 000	50 860	34 650	55 190	53 060	51 890
costs of material and repairs etc. in the automatic system	3 650	550	560	780	630	750
total maintenance costs	69 650	51 410	35 210	55 970	53 690	52 640
maintenance staff	18	13	8	14	13	13

Fig. 7
Selector frames
at Söder automatic exchange

X 5510



Traffic Intensity and Faults

When talking of the capacity of automatic exchanges, reference is usually to the number of central circuits or, popularly expressed, of subscribers that may be connected to the exchange. The building up of the exchange, however, is also governed by the traffic intensity. It is obvious that a small number of subscribers telephoning intensively can give rise to more telephone calls than a large number of subscribers each of whose traffic is relatively insignificant. This circumstance may easily be exemplified by a couple of the Stockholm exchanges. At Centralen where the mean connected subscribers during 1937 amounted to 16 284 there were handled in that year over 99.5 million outgoing calls, while the corresponding number of calls at the Söder exchange, with a mean of 28 089 subscribers, was only 56.9 million, as may be seen from the table. In other words each subscriber to Centralen telephoned on the average more than three times as often as each subscriber to Söder. Centralen, therefore, must be adapted for a traffic intensity, reckoned per subscriber, three times that of Söder — if both are to operate approximately the same.

This adaptation of the exchange capacity of performance is carried out for each exchange and is maintained by almost daily traffic counting. The result is not only that exchanges with approximately the same numbers of subscribers may be different in certain respects, but also that one and the same exchange must from time to time be altered in details to adapt it to changed traffic conditions. If, for instance, there is need for increased number of facilities for simultaneous call, then the number of registers is increased. By the provision of more line finders it is possible for an increased number of simultaneous outgoing calls to be dealt with etc. Adaptability to the prevailing traffic is, indeed, one of the great advantages of the Ericsson system.

The demands imposed on the efficiency of an automatic exchange, or, one may say, the power output of the exchange, is expressed in call minutes per unit of time. By call minutes is understood the number of calls multiplied by the average conversation period. One call minute, therefore, is equal to one call which proceeds for one minute or two calls each lasting half a minute and so on. By measuring the traffic during the hours of the day when it is at its greatest there is obtained the number of call minutes per busy hour and by adapting the various details of the exchange to this peak traffic the automatic exchange is given an efficiency which is adequate for the heaviest load that may normally be expected. Later arises the question, that the load for various reasons is subjected to continuous change, *e. g.*, by reduction or increase in the number of subscribers. This is ascertained by more or less automatic supervisory devices and usually gives rise, as stated, to special measures to adapt the exchange to prevailing conditions.

The situation is in principle the same as with a manual exchange. There an operator can carry out a certain number of connections per hour. With increase in traffic the number of operators requires to be augmented. In an automatic exchange it is possible with a certain number of connecting devices to have a certain number of call minutes. If the number of call minutes is increased then the number of connecting devices must be augmented. It is, however, not only on the question of principle that relation with the manual exchange may be traced. Not even the most perfect automatic exchange is so terribly automatic that it can entirely dispense with human aid — at the Stockholm city exchanges represented by fitters, trunk operators, supervisors etc. But it is painfully free from fault, according to the supervising operators: per 100 outgoing calls it makes, expressed statistically, less than 0.1 errors. This in no way means that the remaining 99.9 calls result in conversation —

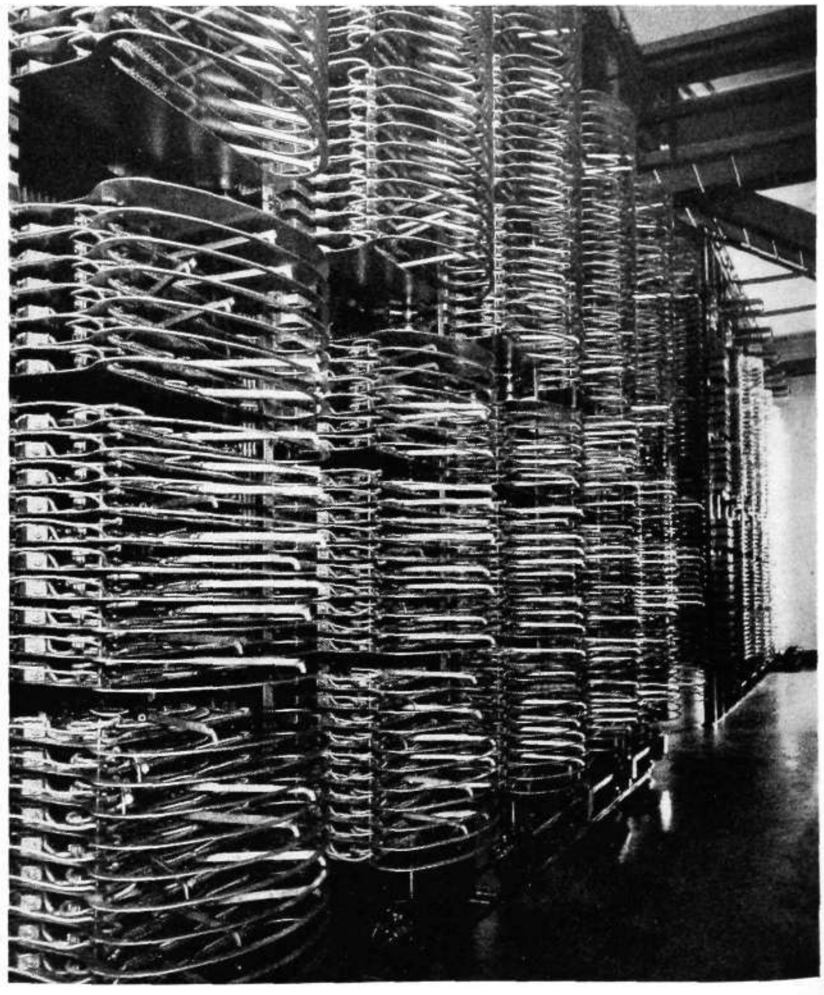


Fig. 8
Section of selector racks
at Söder automatic exchange

X 5506

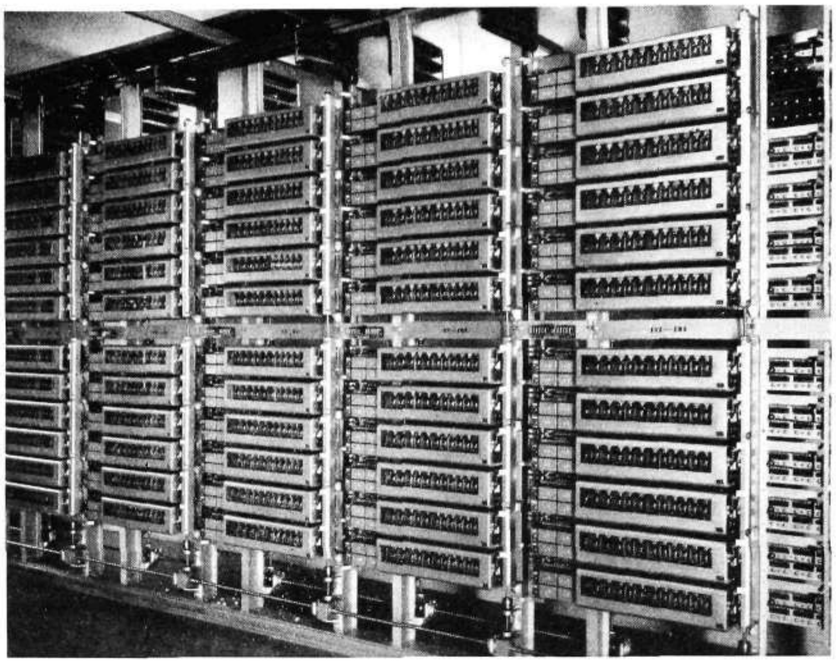


Fig. 9
Register frames
at Norr automatic exchange

X 5514

far from it. That happens according to statistics only in 79.2 % of cases. The unsuccessful calls are due to »no answer» in 8.6 cases, »busy» in 10 cases, »changed or vacant number» in 0.5 cases, »subscriber's error» in 1.5 cases, »operator's error» in 0.1 cases and finally »technical fault» in 0.1 cases.

If now that tenth of one per cent is due to technical fault in the exchange itself — the cause may lie elsewhere, *e. g.*, in instrument or line — then it is not long lived. The maintenance staff of the exchange is constantly on the alert for faults and by systematic routine tests, cleaning and adjustment rounds and with the aid of supervisory positions and alarm devices faults are revealed and removed with exceeding rapidity. In the Stockholm automatic exchanges there were carried out during 1937 approximately 70 000 recorded fault tracings, of which about one in ten led to localization of an exchange fault. Between one quarter and one half of these fault tracings were caused by the subscriber's handset being carelessly replaced or not replaced at all at the end of calls. The maintenance staff employed at the exchanges numbered 79 persons, and the exchange faults localized at the various automatic exchanges were distributed as follows: Centralen 2 131, Södra Vasa 870, Norra Vasa 328, Söder 1 490, Kungsholmen 1 187 and Östermalm 908. This gives between 0.4 and 0.13 faults per year and subscriber, and between 0.18 and 0.29 faults per year and 10 000 calls. The most favourable figures apply to Östermalm exchange. There a subscriber with 1 200 outgoing calls per year must, on the basis of statists, keep on for something between 25 and 40 years for an exchange fault to be localized among his calls. That would give him plenty of time to reflect on the good operating reliability of the Stockholm automatic exchanges.

He might come to the conclusion that no fault *can* arise. Then a visit to an exchange might be recommended. If then he directs his steps to Söder automatic exchange he enters the exchange along with 89 underground cables comprising in round figures 102 000 wires. The length of wire in the exchange cables amounts to approximately 15 240 km equivalent to about 10 times the distance between Stockholm and London. The number of soldering points is about 6 500 000 and the number of contacts in distribution, relays, selectors and the like about 1 260 000. If one includes the contact points also in the selector multiples and the trunk multiples, then a further 14 500 000 may be added. Having totalled and pondered on all that, he may well raise his hat to a technique which to all appearances completely and without fault wields sway over so much.

Financial Results

To estimate the influence which automatization in Stockholm has had on the capacity of the local telephone operation to yield interest, conditions immediately after the purchase of the Stockholm Private Telephone network can hardly be taken as a basis. The enormous fluctuations in the value of money and the changes in rates resulting during and immediately after the world war in fact make a comparison between conditions then and now worth little. As from July 1st, 1924, however, the rates of subscription were reduced in the main to their present level. Then too, as stated, the complete fusion of the traffic between the State and the private network was carried out and it has therefore seemed convenient to take as point of departure for a financial comparison the year immediately following, *i. e.*, 1925. It is true that at that time there was one automatic exchange — Norra Vasa — in operation, but the results from the operations in their entirety can only have been influenced by it to a very small degree.

During 1925 the gross surplus from telephone operation in Stockholm, *i. e.*, the surplus available before making allocation to depreciation fund and before deducting of interest on capital, amounted to about 3.1 million kronor — an amount that was not sufficient for interest and amortization. As comparison, the surplus for 1937, reckoned in the same manner, amounted to approximately 10.9 million kronor, thus representing an increase of about 7.8 million kronor. This considerable improvement in the financial result has chiefly been produced by the savings resulting from automatization. Still further improvement in this respect will be obtained, now that the Norr exchange and the name-call exchange have been converted, the one to automatic and the other to

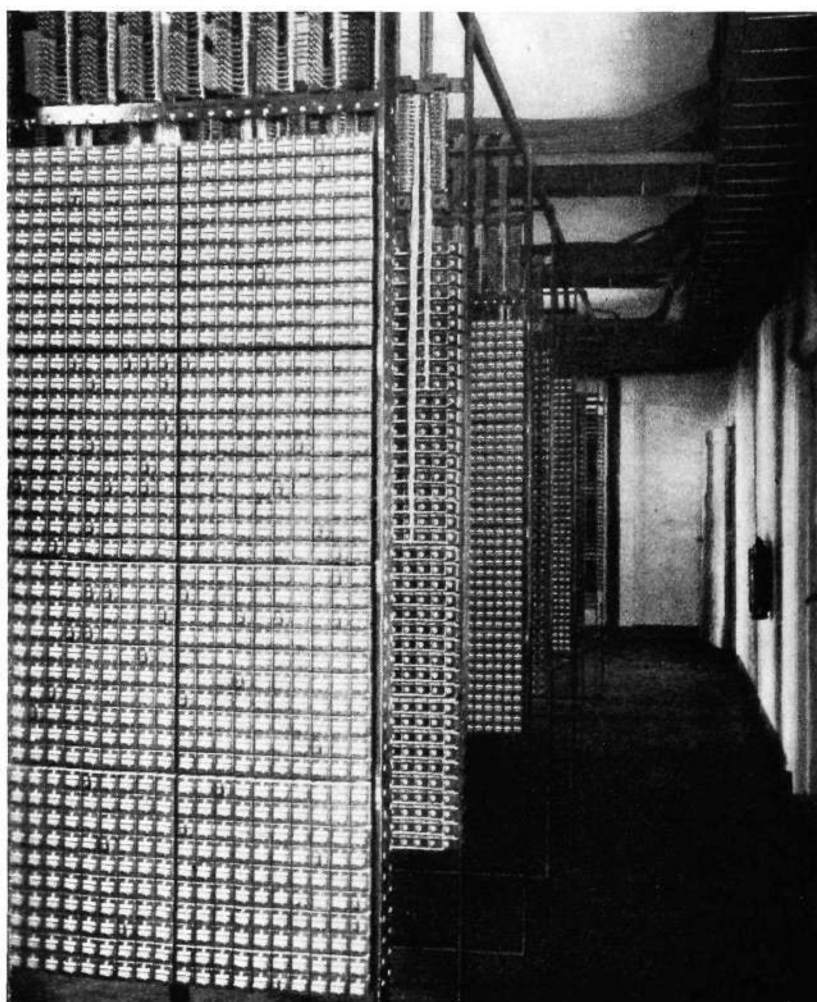


Fig. 10
Call metering frames
at Söder automatic exchange

X 5512

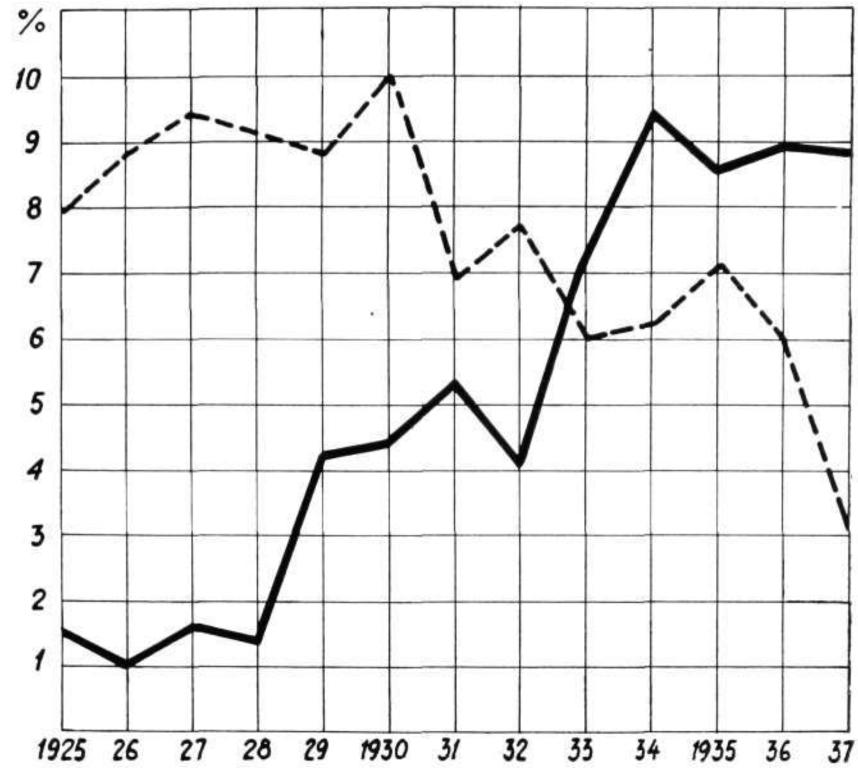


Fig. 11 X 5515
Financial surplus of telephone operation in percentage of network value
——— Stockholm network
– – – rest of the country

semi-automatic operation. The size of this further saving may be estimated at about 0.8 million kronor per year. In addition, it may be declared that with the present charges a paying telephone operation with manual service is in general unthinkable in a network of the size now attained by the Swedish capital's telephone plant.

The development year by year of the percentage of yield on the local telephone operation in the Stockholm area and in the rest of the country may be seen by the diagram, Fig. 11, which very clearly reflects the improvement that has occurred. The reduced yield in recent years for the rest of the country is connected chiefly with the work that is being carried on for the improvement of rural telephone conditions.

The total costs for the automatization in Stockholm and the work of extension that has accompanied it, due to increase in subscribers, amounted at the close of 1937 to 55 million kronor in round figures. Of this amount only a small part, representing extensions to exchanges and network, has been taken on the books as capital increase, the remaining part being accounted for as operating costs or paid out of depreciation fund. In view of the considerable increase in instruments that has taken place the book value of the telephone plant per instrument had — despite automatization — been reduced from 557 kronor in 1925 to 474 kronor in 1937. Compared with conditions in other countries the latter figure may certainly be regarded as particularly low. The cost of automatization of the central Stockholm network, therefore, taking into account not least the improved financial result of the telephone operation that has unquestionably been achieved, must be said to be money well employed to an unusually high degree.

Changes in the World Telephone Situation 1930—1938

A. LIGNELL, FORMER DIRECTOR OF TELEPHONES, STOCKHOLM

The number of telephones in the world had on January 1st, 1930 attained its maximum to that date of 34 526 000 instruments or 1.8 telephones per 100 inhabitants. The economic depression that prevailed during the period 1930—1933 caused a setback in the number of telephones, see Ericsson Review No 4, 1935. This setback most severely affected the world's foremost telephone country, the United States, but in Europe too the depression made itself felt, though to a slighter degree, and mainly in the manner that the growth hitherto apparent in the number of telephones was smaller in some countries while in others it ceased entirely and in a few cases it was converted into a decline. It was not until the beginning of 1936 that the world telephone position rose somewhat over the level of 1930 or to 35 028 000 instruments, though this was equivalent only to 1.63 telephones per inhabitant compared with 1.8 on January 1st, 1930. On January 1st, 1937 the number of telephones throughout the world was 37 098 000 or 1.71 per 100 inhabitants. Thus the telephone density prevailing in 1930 had not yet been regained.

It may be of interest to see how telephone density has changed in the chief telephone countries of the world, see diagram, Fig. 1. The United States, where the number of telephones reached a maximum on January 1st, 1930 of 20 086 000 telephones, or 16.4 instruments per 100 inhabitants, lost in the years 1931—1933 over 3 million instruments and the number of telephones fell in relation to the population from 16.4 to 13.3 on January 1st, 1934. The subsequent better times brought about an increase in the number of telephones, these in at the close of 1937 amounting to 19 450 000 or 15.1 per 100 inhabitants, which figures are still below the maximum figures for 1930. Canada too felt the depression sharply and the number of instruments sank from 1 399 986 or 14.2 per 100 inhabitants in 1930 to 1 266 228 representing 11.48 per 100 inhabitants on 1st January 1937.

In Europe, Denmark lost at the beginning of 1937 the leading position it held as the country with the largest number of telephones in proportion to population. Sweden, which on 1st January 1930 had 8.3 telephones per 100 inhabitants against Denmark's 9.6, had when 1937 opened 10.97 against Denmark's 10.89 and by 1st January 1938 the telephone density in Sweden had risen to 11.8. The heaviest increase occured for the years 1936 and 1937 during which years the total increase amounted to almost 100 000 instruments. This strong increment has continued during 1938, in the first quarter of which year a net increase of 15 200 instruments was apparent. The reasons for this favourable development are to be found partially in the prosperous times, but mainly in the lower telephone rates and the efforts of the administration to make the telephone available for every home and on the same terms no matter where the subscriber may reside. It is well, perhaps, to add that this expansion has not endangered the good financial results of operation, which in the years 1935—1937, after considerable allocations to depreciation fund, yielded 9.54, 9.28 and 8.45 % respectively on the average amount of capital engaged during the year. The reduction in 1937 was due to the effect of rises in salaries of officials and workers together with heavy rises in the prices of material.

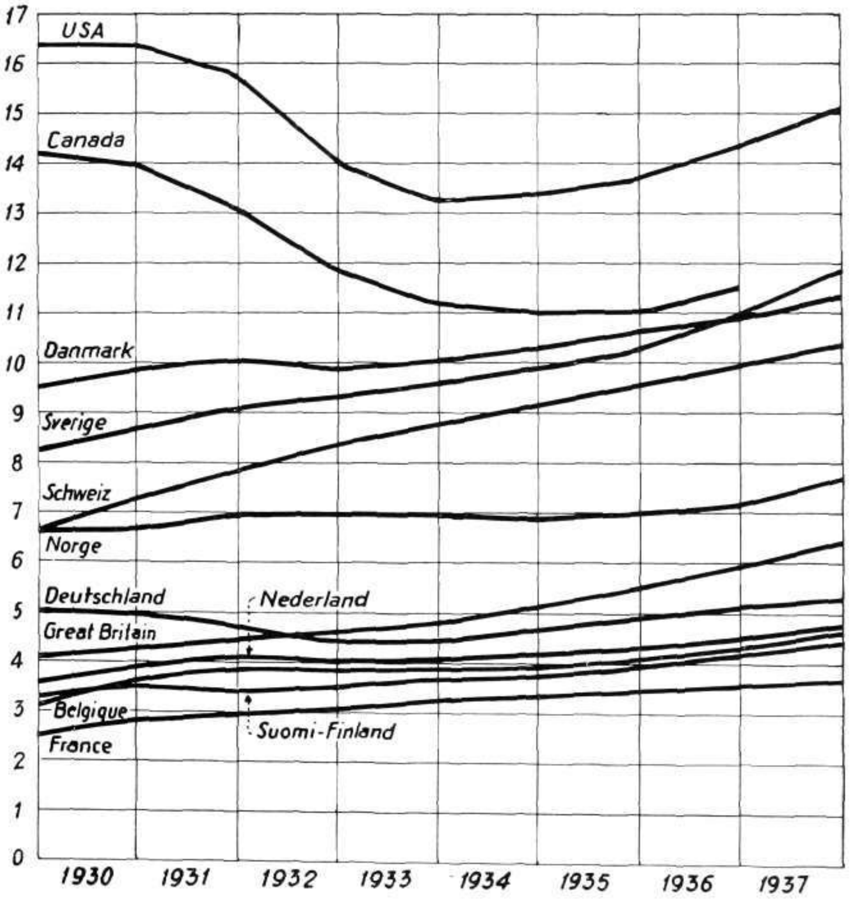
During the period under review Switzerland has displayed the most regular and, on a percentage basis, the greatest increase, and the telephone density of that country has risen from 6.7 instruments per 100 inhabitants on January 1st, 1930 to 9.86 on January 1st, 1937. Of the other countries, Great Britain has shown incomparably the heaviest increment from 4.1 to 5.93 telephones per 100 inhabitants. Germany, which in the years 1931—1933 showed falling telephone density, had by January 1st, 1937 returned to the same density as 1930, and the remainder of the countries included in the diagram show for 1937 an increase in telephone density of approximately 1 % compared with 1930.

The number of telephones in Europe's chief telephone countries was on January 1st, 1937:

		increase since January 1st, 1930	
		absolute	percentage
Germany (31/3)	3 341 074	248 769	7.8
Great Britain	2 791 597	904 871	48.0
France	1 481 788	425 754	40.3
Sweden	687 566	178 505	35.1
Switzerland	412 324	143 610	53.4
Denmark (31/3)	408 875	67 076	19.6
Netherlands	382 173	97 740	34.4
Belgium (28/2)	361 685	102 012	39.3

In Italy and Russia the number of telephones has risen considerably since 1930, to 560 660 and 950 000 respectively, but the telephone density in these two countries is still comparatively small, being 1.31 and 0.55 instruments per 100 inhabitants respectively.

Among the world's large cities Washington and San Francisco take first and second places for telephone density with 37.43 and 37.0 instruments respectively per 100 inhabitants, Stockholm coming next with 34.78. Then come eight American cities and only after them count Zurich, Copenhagen and Oslo with 22.73, 22.42 and 22.39 instruments per 100 inhabitants respectively. London, Paris, and Berlin had on January 1st, 1937 respectively 15.82, 15.13 and 12.67 telephones per 100 inhabitants.



X 5476

Fig. 1
Telephone density in different countries
during the years 1930—1937

Sieverts Kabelverk over Fifty Years

K. HILDEBRAND, PRESIDENT OF THE NATIONAL DEBT OFFICE, STOCKHOLM

The period of fifty years that has elapsed since Max Sievert in May 1888 established the foundation of Sieverts Kabelverk covers more progress in the various fields of technology than any corresponding period in the history of mankind. Especially does this apply to electrotechnics. Thus the history of Sieverts Kabelverk is contemporaneous in essential parts with the history of the development of electrotechnics, a circumstance which without a doubt exercized a favourable influence on the building up of the enterprise. On the other hand, it should be remembered that the undertaking has in the measure of its own contributions furthered developments in the domain of activity with which it is associated.

It is a reminder of this and to commemorate the half century that the Board of Sieverts Kabelverk has decided to issue a jubilee publication, comprising a historical account of the undertaking's activities during the years that have gone and a collection of technical articles written by leading experts.

Below will be found a review of the historical portion of the publication.

The First Years (1888—1894)

The creators of Sieverts Kabelverk, the brothers Max and Ernst Sievert, came from the town of Zittau in Saxony, where their father was Stadtrath and pastrycook. Max Sievert was born 1849 and devoted himself to agency business in the machinery line. He made several journeys to Scandinavian countries, Finland and Russia and recognized the great opportunities offered by Sweden for an able and energetic machinery man with good connections in machinery producing Germany. In 1881 he founded Max Sieverts Maskinaffär at Stockholm and this undertaking rapidly furnished him with a considerable income, which enabled him to give his active nature still further outlet. Thus it was that in 1888 he established the Alpha factory at Sundbyberg, mainly for the manufacture of horse-shoe nails; since then it has taken up machinery-making and the fabrication of anti-friction metal, condensers and moulded bakelite articles for wireless apparatus and telephones etc. A little later in the same year he started a small factory for electric wires and cables, this also in Sundbyberg. Some years earlier, in 1884, he had acquired Swedish nationality.

His brother, Ernst Sievert, was born 1863 and first came to Sweden as a youth of twenty. After some years back in Germany he returned to Sweden in 1887 to remain for good. Following a short period of employment at a foundry, he was taken in by his brother Max as technical manager for the factories. From what can be judged this was an exceedingly good selection and the brothers collaborated splendidly together, with Max standing out until his death in 1913 as the born leader. A third brother, Georg, born 1861, was later associated with the management of the cable works, but not so prominently as his two brothers.

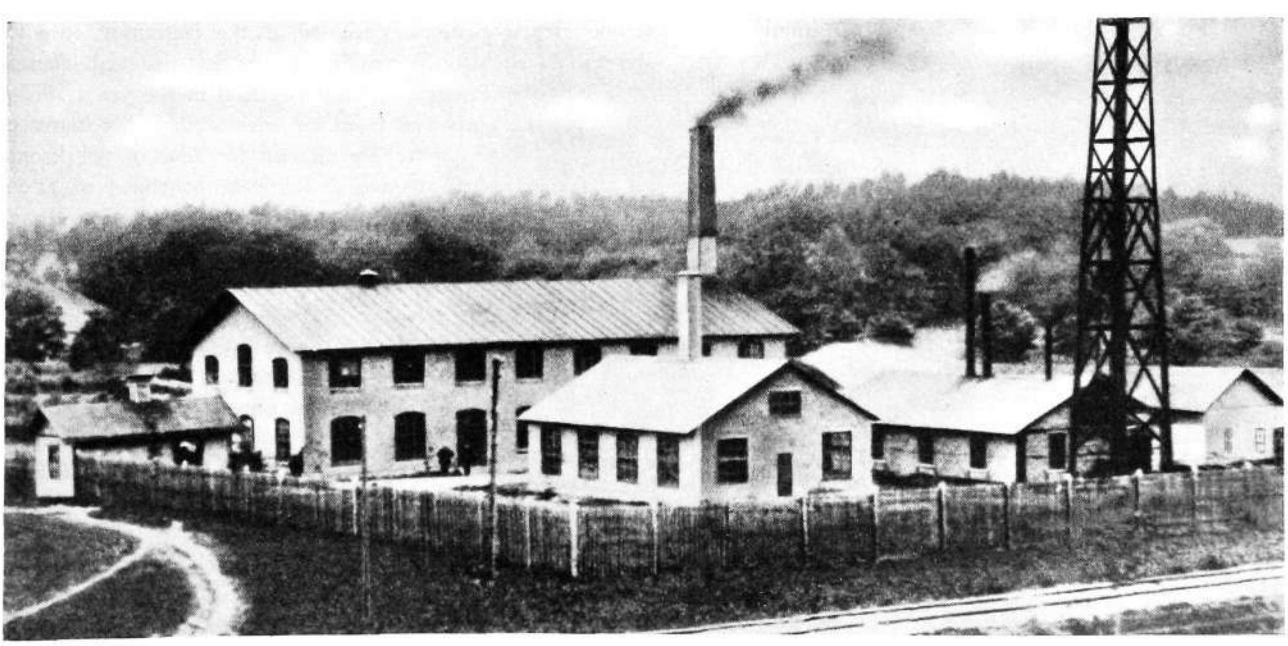
It was telephone manufacture in particular that was the first to make demands for the manufacture of covered wires. The leading man in this connection was Lars Magnus Ericsson. Most of the wire employed for winding the induction coils in telephone instruments was taken from abroad, the greater part through Max Sieverts Maskinaffär. Ericsson enquired of Sievert, however, whether he would not be willing to take up the manufacture of this wire in Sweden. Thus the company which now owns the cable works was through its founder the initiator of the undertaking and that company's large orders constituted during the early period an invaluable support.

After the necessary preliminaries, the work of establishing the wire factory was begun on May 17th, 1888 in a single rented room at Sundbyberg. Manufacture was directed at the beginning to silk-covered copper wire, but almost immediately cotton-covered copper wire and telephone cords were added. At an early stage too other specialities were taken up, such as iron and German silver wire as also bronze wire. Ernst Sievert was given the position of factory manager. The staff was the smallest imaginable: at the beginning of December 1888 it consisted of two male and twelve female workers, the number having risen by December 1894 to sixteen workmen and fifty-two women. In the first years the clerical work was handled at the offices of Max Sieverts Maskinaffär in Stockholm for a price which also covered postage and a number of other expenses, yet all the same at the beginning stood at 50 kronor per month.

The manufacture was more and more specialized with a view to satisfying the requirements of various customers. In the oldest price-list preserved — dated October 1892 — there is to be found an ample assortment with description in word and picture of what the factory had to offer. A few introductory pages are taken up with tables of area, weight and resistance for copper wire, also of area in cables, and comparisons of English measures and millimetres. The first prices listed applied to bare, chemically pure electrolytic copper wire with 98—100 % conductivity and tinned copper wire, also bare flexible copper cables with the same conductivity. The pricelist then gives silk-covered copper wire and German silver wire, cotton-covered copper wire and dynamo wire, telephone and bell wire also wire covered with guttapercha and pure rubber. The greatest variety is to be found in the section for wire and cable for electric light. There is included too jute-covered wire and cable as also special wires for dry, damp, damp and warm and wet and warm premises. Further there were cords for electric lighting, telephone cords with terminals of Ernst Sievert's patent, microphone cords, switchboard cord with double and single conductors, single conductor cords and silk cords as well as cables or lines for lightning arresters. It was stated in the price list that further variations of the different types could be supplied.

Fig. 1
Sievert's wire factory 1890

X 7155



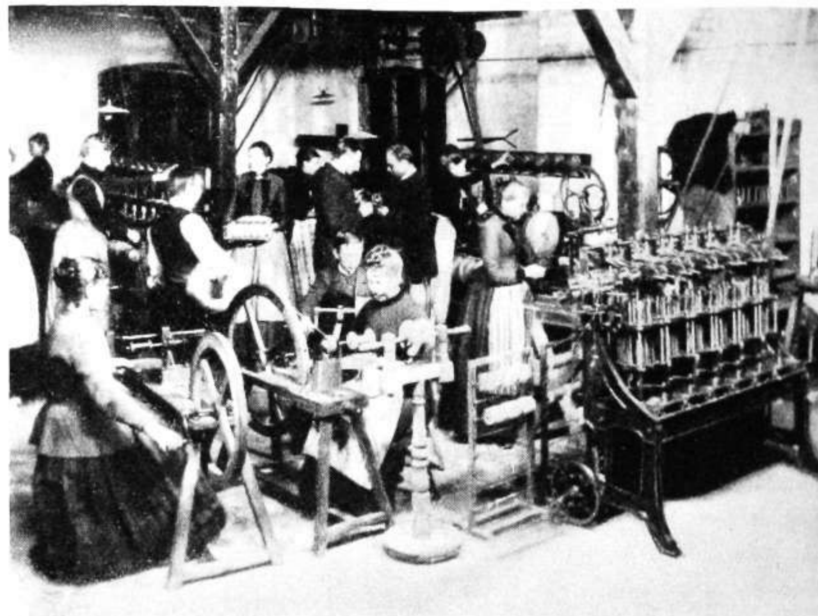


Fig. 2
Cotton covering 1888

X 5489

The best clients were the Ericsson telephone works and the Swedish Telegraph Administration. Deliveries from the wire factory to the Ericsson works were mostly silk-covered copper wire and coils, but also microphone cord, six-wire silk cord, single switchboard cord and bare copper wire. It was of inestimable advantage to the wire factory to have such a good and stable client, whose payments for the years 1888—1894 amounted to a total of 348 615 kronor, varying from year to year between 15 872 kronor in 1888 and 76 664 kronor in 1894.

The Telegraph Administration at the beginning made quite small purchases but these increased and surpassed those of Ericsson during the last two years of the period. This coincides with developments during that time. The Administration proceeded cautiously at the beginning in the matter of telephony, solely from the standpoint that it wished to counteract the reduction in telegraph traffic due to the rise of telephone communication, by telephonically connecting industrial and other places with telegraph stations between which the traffic could be forwarded over the telegraph. As, however, the decrease in telegrams became more and more disquieting, the Telegraph Administration was obliged to take up seriously the competition with the private telephone companies and associations. Moreover in the years 1891—1894 the Telegraph Administration extended its workshops, designed at the beginning only for repair work, in order to take up also the manufacture of new material. Therein lies the explanation of why the Telegraph Administration in the years 1888—1890 made comparatively small purchases from the wire factory, but increased them later at a rapid pace. After a purchase amount for 1890 of 962 kronor the succeeding year represented an amount in the neighbourhood of 11 000 kronor with a continuous annual rise up to 113 516 kronor in 1894. In all the Administration paid out for goods purchased during the years 1888—1894 a sum of 255 327 kronor.

The State Railways began purchasing from the wire factory earlier than the Telegraph Administration but their purchases remained at small amounts during the period — for the seven years all told only 8 000 kronor, mostly for silk-covered copper wire. The Stockholm Private Telephone Company bought to an amount of 64 000 kronor during these years. A large number of Swedish firms took small quantities of goods.

Manufacture was extended year after year and the setback, so common with new manufactures, would appear not to have occurred. Financing was taken care of during the years 1888—1890 by temporary loans, accorded by Max

Sievert or by his machinery business. No bank credit was resorted to beyond the discounting of customers' bills. Even in 1888 a small net profit was earned and the following years produced good results.

The Joint-Stock Company up to the Outbreak of the World War (1895—1914)

From the opening of 1895 the enterprise took the form of a joint-stock company under the name of Max Sieverts Fabriks Aktiebolag. The Sievert brothers held a clear majority of shares. The first subscribed capital amounted to 200 000 kronor, which prior to the world war had been increased successively to 1 200 000 kronor partly by new subscription and cash payments to the old shareholders and partly through the issue to them of bonus shares. Max Sievert was managing director up to his death in 1913, after which his brother Ernst took over the position.

The rapidly growing production — it amounted in 1895 to 95 000 kg, in 1905 to 375 000 and in 1913 to 1 623 000 kg — rendered necessary practically incessant extension of the factory area and the factory buildings. Immediately premises had been newly installed for some of the new departments, there sprang up almost at once the need for increased space, which had the disadvantage that the plant could not be increased on any general plan, but it was necessary to erect new buildings where space was available without consideration of the best collaboration between the departments. In June 1904, the offices were moved from Stockholm to Sundbyberg.

It was not until 1910 that Sieverts Kabelverk took up the making of lead-sheathed cable both for power technics and telephony. Max Sievert's interest in taking up lead cable manufacture may be understood whent it is realized that the Telegraph Administration in 1909 purchased abroad lead-sheathed cable to an amount of 450 107 kronor. The first contract was signed with the Telegraph Administration in October 1910 and the first delivery was completed in June 1911.

Round about 1910 the silk covering at the cable works attained its comparatively greatest extent, but since then this manufacture has, especially since the introduction of enamelled wire, been on the back grade. At that time the productions included telephone cord on a large scale, this being mainly sold to England. In the main it may be said that the cable works from 1910 kept pace with developments. During this period it achieved a number of note-

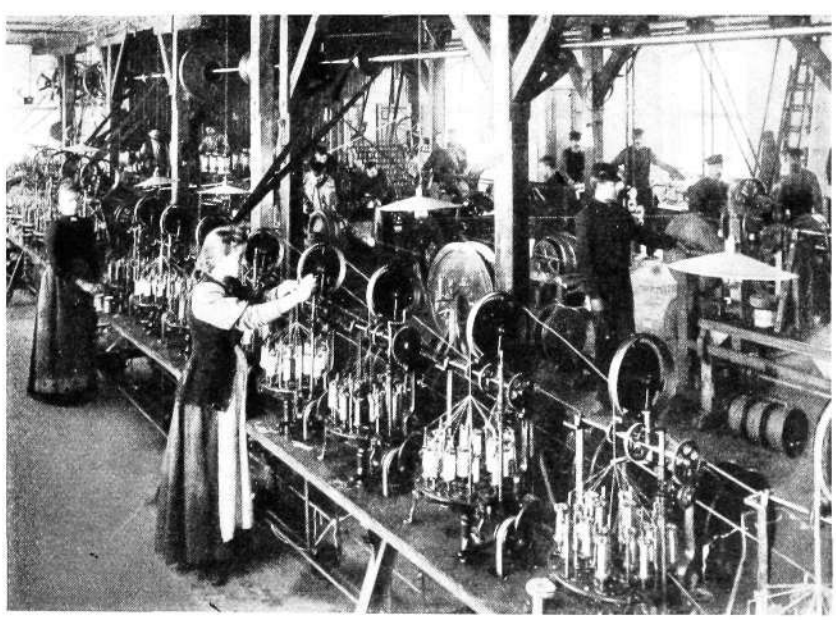
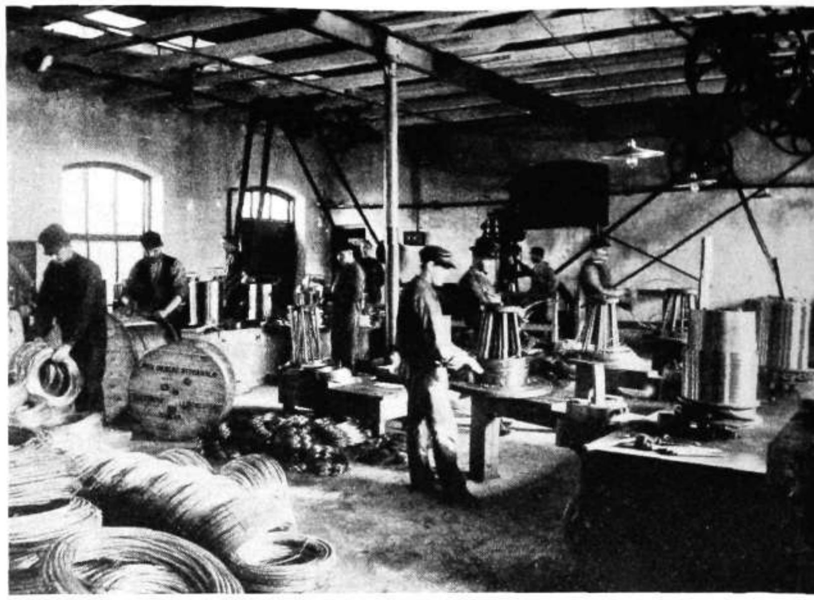


Fig. 3
Braiding department 1893

X 5499



X 5490

Fig. 4
Wire drawing 1893

worthy performances. Though both methods and instruments were wanting for the estimation of a number of properties for high tension insulation, yet from an early stage cable installations were executed for impressive operating tensions. Thus in 1912 Sieverts Kabelverk supplied the first high tension cable, a marine cable for 10 000 V, and a couple of years later, in 1914, the first 30 000 V cables were made. These cables have now been in operation for almost 25 years, which is good evidence of the reliability of manufacture. At this time and somewhat later there were also laid a number of high tension marine cables in Sweden and Norway.

The progress of sales was stimulated by fresh price lists with particulars of the current types of wire and cable and their prices. The most detailed was the seventh, printed in 1904; in the introduction it was observed that previous price lists had sections for dry, for damp and for wet localities, but that these headings were now discarded, since the demands on the insulation of the wire were also governed by other circumstances than form the basis of the classification stated. Account must also be taken of the tension, of the current, the different manners of mounting etc. For installations serving dissimilar purposes the demands on the line material must be essentially different even if similarity existed respecting the humidity of the air. The nature of the insulation was therefore taken as the basis for classification. In the next price-list it was stated that all line material was insulated in conformity with standards adopted in Germany as prescribed by Verband Deutscher Elektrotechniker.

The first years of the limited company belonged to the depression of the eighteen nineties, but afterwards the company had the advantage of rising prosperity, which was interrupted however, by the comparatively brief periods of crisis 1900—1902 and 1907—1908. The cable works was not severely affected by the crises, probably because the company was not dependent on bank credits.

The value of turnover increased rapidly. In 1895 it amounted to 352 500 kronor, in 1905 to 1 315 500 and in 1913 to 3 639 900 kronor. The best private client was still Ericsson and among the State administrations the Telegraph Administration was the most prominent. The activities of the cable works were also based on the rapidly growing electrical industry. Asea was the largest customer in this domain. Among the clients abroad may be mentioned A/S Elektrisk Bureau, Christiania; National Telephone Co., London; London Electric Wire Co., and the General Electric Co., Manchester, as also Marconi Wireless Telegraph Co., London.

In a specialized sales statistic from 1911 the changes in manufacture may be followed: in 1911 there were sold 230 100 kg lead and iron armoured cable against 460 300 kg cords and wire and in 1913 the former descriptions represented 1 062 400 kg while there were only 610 700 kg of the latter. Cords and wire have gone down in a couple of years from two—thirds of the production to a little over one third.

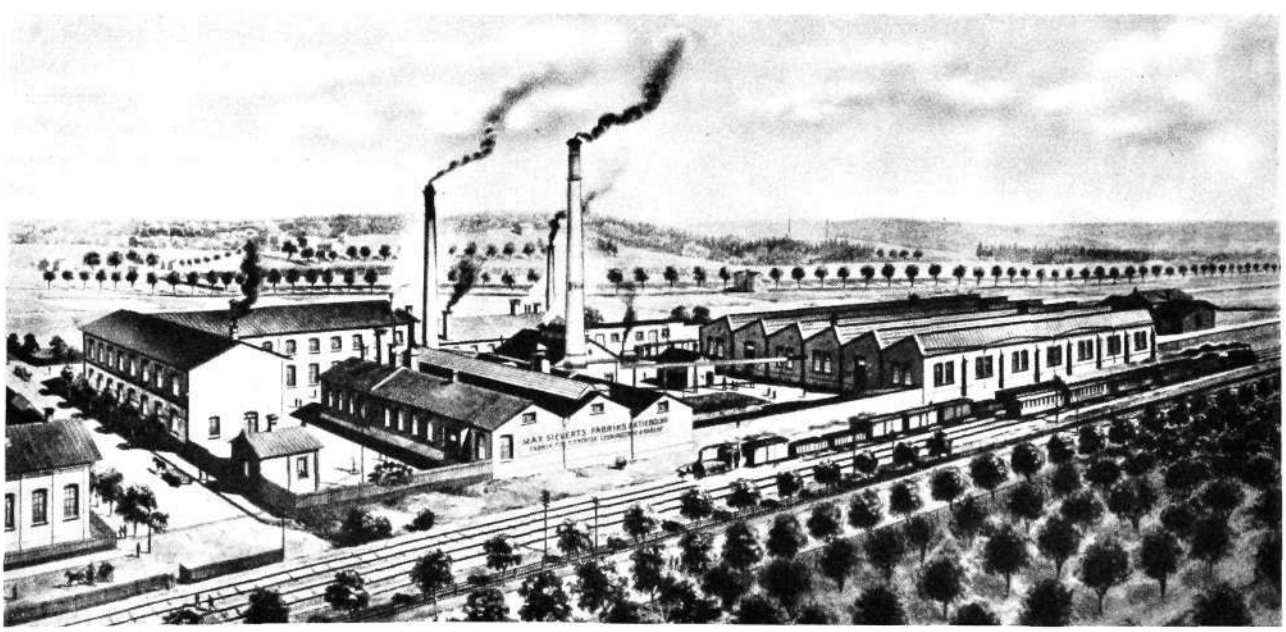
In perusing the balance sheets of Max Sieverts Fabriks Aktiebolag attention is particularly taken with the absence of bank debts. There are no bank credits and no debenture loans. Max Sievert continued with his cautious policy of the time prior to the existense of the joint stock company. He himself furnished any additional money that might be required and those related to him did the same. Often they allowed their dividends and remuneration to remain in the business and thus facilitated the financing. The company had almost exclusively safe clients who paid cash or gave bills which could be discounted at the bank. Bill credit was thus resorted to but that was the sole way in which the collaboration of the bank was requested. Financing was facilitated by a cautious policy in regard to distribution of profits. The greater part of the annual profits was placed to a disposition fund which along with other funds was utilized in the business.

The World War and the Post-War Period (1915—1927)

The world war and particularly its two closing years caused considerable difficulties for big industry, based as it was on unhampered import of raw materials and export of manufactured goods. Control by the State came in as early as the late summer of 1914 and imposed itself deeper and deeper. Repeated stock-taking of goods involved a large amount of work and the commissions commenced their activities. Sieverts Kabelverk had a mission of importance to the community to fulfil, in a time when oil and coal failed, in furnishing the country with wires and cables for the distribution of electric light and electric energy. Clients were eager to obtain goods and the factory worked at full pressure as far as raw materials of various kinds could be procured. For the works manager and engineer it was a matter of adapting themselves constantly to circumstances, by seeking out new raw materials when the customary ones were not available and to devote their efforts as much as possible to treating low-grade material in such a way that some kind of good result could be achieved.

Fig. 5
Sieverts Kabelverk 1899

X 7159



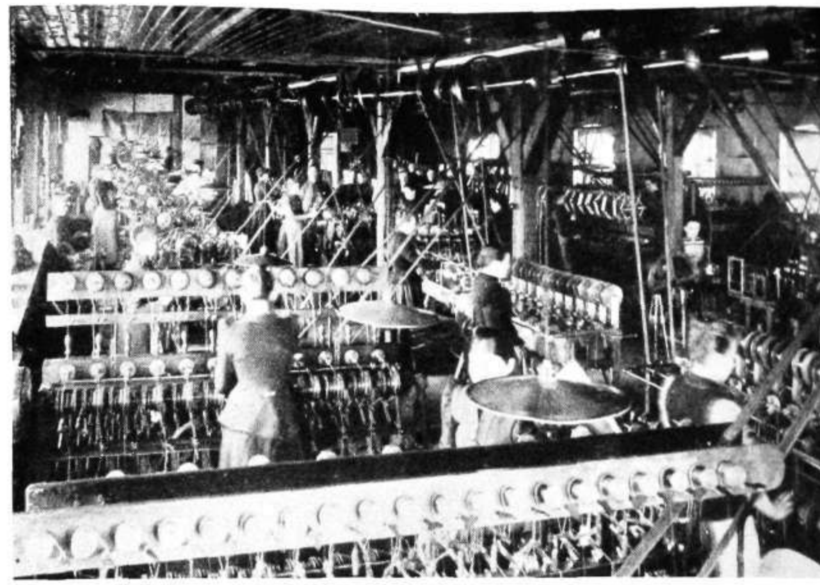


Fig. 6
Silk covering 1895

X 5491

With the exception of England, which for two years continued to buy goods from the cable works, it will be found that exports really only went to the Scandinavian countries and countries to the east: to Russia during the four years 1914—1917 and to Denmark, Norway and Finland during all the five years up to and including 1918, though strongly reduced quantities went to Finland in the last two of these years. A certain export could be maintained with Holland and China for three years. When the Swedish market, however, could absorb the whole production of the cable works the reduction or cessation of exports did not signify so much. It was more difficult with raw materials which during the later years of the war had to be procured in the country itself or imported with the aid of the State authorities on the basis of commercial agreements concluded with the Entente powers. From the financial point of view the cable works had nothing to complain of, but on the contrary enjoyed a brief period of rapidly rising income. From directors' annual reports it was apparent that the company despite all difficulties was sailing before a favourable wind.

The manufactures were chiefly based on copper wire which in 1917 began to be scarce until it practically disappeared in 1918. Copper in other forms was resorted to from 1917, largely because compensation was accorded by clients. Recourse had to be made to zinc in its place for the manufacture, though at first only in small quantities, but to a larger extent in 1917 and in 1918 in appreciably large quantities. The consumption of iron and steel was also increased during the war period. One good thing was that the access to lead was good and tin only began to fail during 1918. Judging solely by the weight figures for rubber the supply seems comparatively good, but these included large quantities of regenerated rubber. In 1918 only an insignificant amount of cotton yarn was available and shift had to be made as far as possible with cotton and jute fabrics, other yarns and raw cotton. The total figures for yarn etc. for the different years demonstrate clearly how bad was the position in 1918. It became increasingly necessary to resort to paper of many different kinds.

The Rationing Period

According as the shortage of goods in the country grew worse, it became necessary for State bodies to intervene in order to distribute more evenly the quantities of raw materials in which scarcity prevailed, above all for the benefit of those industries which might be regarded as specially important under the existing circumstances. It was a hard blow for an undertaking which had the caution to lay in a stock to see a large or small part of it taken over to be handed to another enterprise which had not been so farsighted, but in principle the procedure was unavoidable. There was a certain danger in the fact that measures must be improvized both as regards organization and regulation. A burdensome rule of forms to be filled up was the consequence but it must be admitted that the many stock-takings and questionnaires were in the main a necessity in order to give the commissioners and other provisional State bodies, and through them the Government, an idea of the real position.

As concerns the cable works, trouble began during 1917. The Government considered it necessary to regulate the supply of base metals, *i. e.*, copper, lead, tin and aluminium. The direction of the measures was entrusted to the provisionally formed State Industry Commission. A number of ordinances were issued, such as requisition of copper, lead and tin scrap as also various forms of aluminium etc. in the beginning of March 1917. In the middle of May came a new requisitioning, this time on unworked metals such as copper, tin and lead. The requisition was subject to exemption for certain industries, among them the cable works. Dealings were also regulated and the Industry Commission came to agreements with the Swedish copper smelters among others respecting the smelting of copper scrap. The quantities obtained for distribution were not particularly large but the most immediate needs could be filled.

The scarcity of paraffin oil increased the demand for conductor wires. The Industry Commission managed, more particularly by means of iron conductors and strict rationing, to satisfy in the main the demand of the various electricity distribution societies for electric light and power in rural districts, where the paraffin shortage was most severely felt. Towns and industries too were assisted to a large extent. In November 1917 there was issued a prohibition of the employment of copper for certain kinds of conductors. The Industry Commission began to advise the employment of zinc wire, pointing out that zinc was available in the country in exeedingly large quantites and that such wire had been manufactured and used on a large scale in Germany for many years, while the home copper works had taken up the manufacture of it with good results.

The requisitions above referred to and the regulating based on them were not sufficient in the long run. In order to ensure a more effective control all existing stocks of copper in the country were requisitioned, including scrap and waste, whether they were at industrial works or in private ownership, whenever they amounted to at least 10 kg. On April 9th came a still more drastic decree on the regulation of trade in and employment of copper, tin,

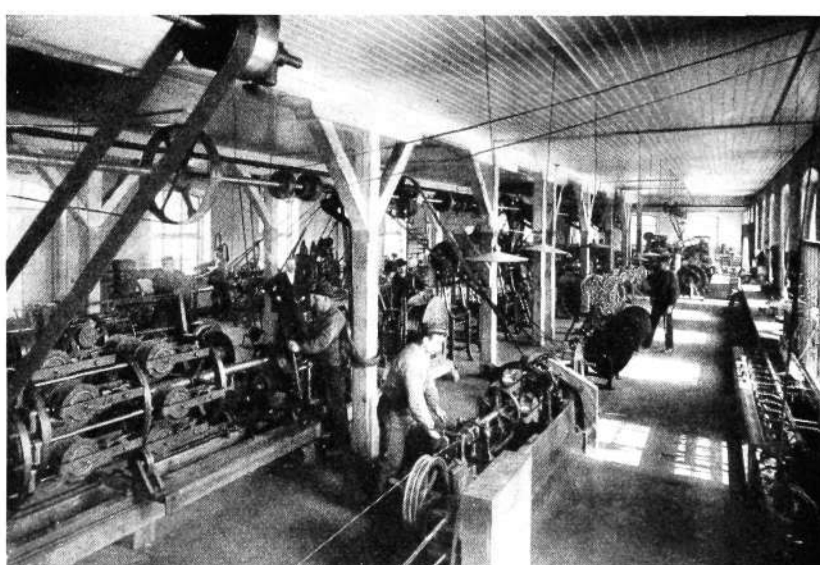


Fig. 7
Cable hall 1895

X 5492

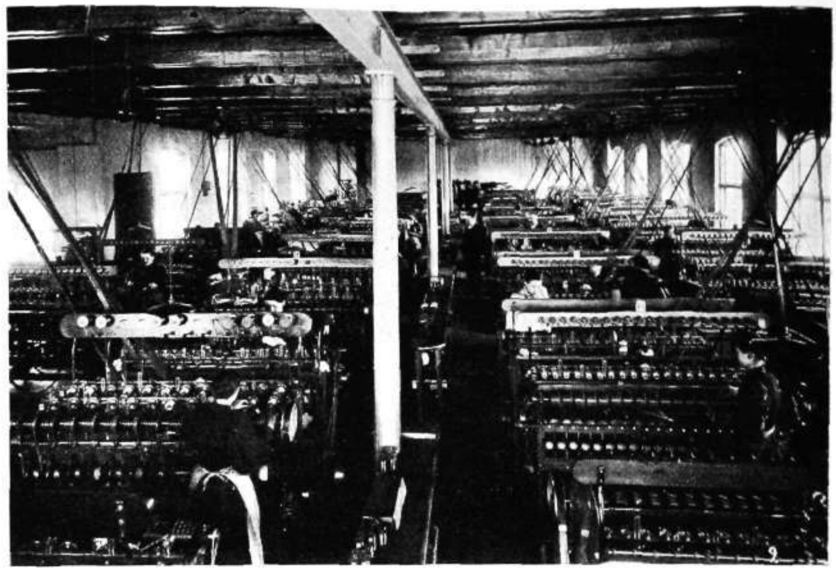


Fig. 8
Silk covering 1895

X 5493

aluminium, zinc and lead, in which were even included alloys in which there was in total more than 5 % of one or two of the three first-named metals. The ordinance applied both to unworked and semi-finished and scrap, with the exception of zinc and lead for which it was only a question of unworked goods. Only with the permission of the Industry Commission could these wares be sold or used for manufacture. The execution of large electrical installations which were dependent on distribution of copper was submitted in each case to very close examination. After the drawing of zinc wire serviceable for electricity transmission purposes had been tried out, the production of insulated zinc conductors showed a heavy increase.

The manufacture was facilitated by the fact that the cable works must require with every order received for electric cable or wires containing copper that the buyer should supply copper to the amount estimated to be contained in the wiring ordered. Gradually the deliveries of compensation copper became very plentiful and might number a hundred a day from the most varied sources, both private persons and large and small firms in trade and industry.

These deliveries consisted almost exclusively of scrap in various forms or of objects made of copper, such as cooking vessels, flasks etc. which the cable buyer concerned considered he could dispense with in order to provide himself with the possibility of having electric light. The various deliveries had first to be sorted and valued according to a list provided by the Industry Commission and this sorting was a job much appreciated by the workers. It was always with a certain curiosity that the different parcels were opened and examined. Naturally it was amusing for those who came across something unusual or otherwise interesting, for example an ancient vessel, interesting coins and the like. According to records the cable works during the whole compensation period received more than a ton of compensation copper in the form of foreign coins. Naturally quantities of bronze coins were also mixed with them, but these had to been taken out. After sorting, the different qualities were packed in cases and were sent in truck loads to some metal foundry. There the copper was melted down and run into wirebars, which were rolled out into wire, usually 6 mm. In this form the copper was re-delivered to the cable works.

There was great relief when in the middle of June 1918 is was publicly announced that after detailed negotiations the allied powers had engaged themselves to let through satisfactory quantities according to existing conditions of a large number of necessity goods, among which were noted raw rubber, cotton, cotton goods, copper, tin etc. The consideration for this trade agreement was that Swedish shipping tonnage should for the time being be given up.

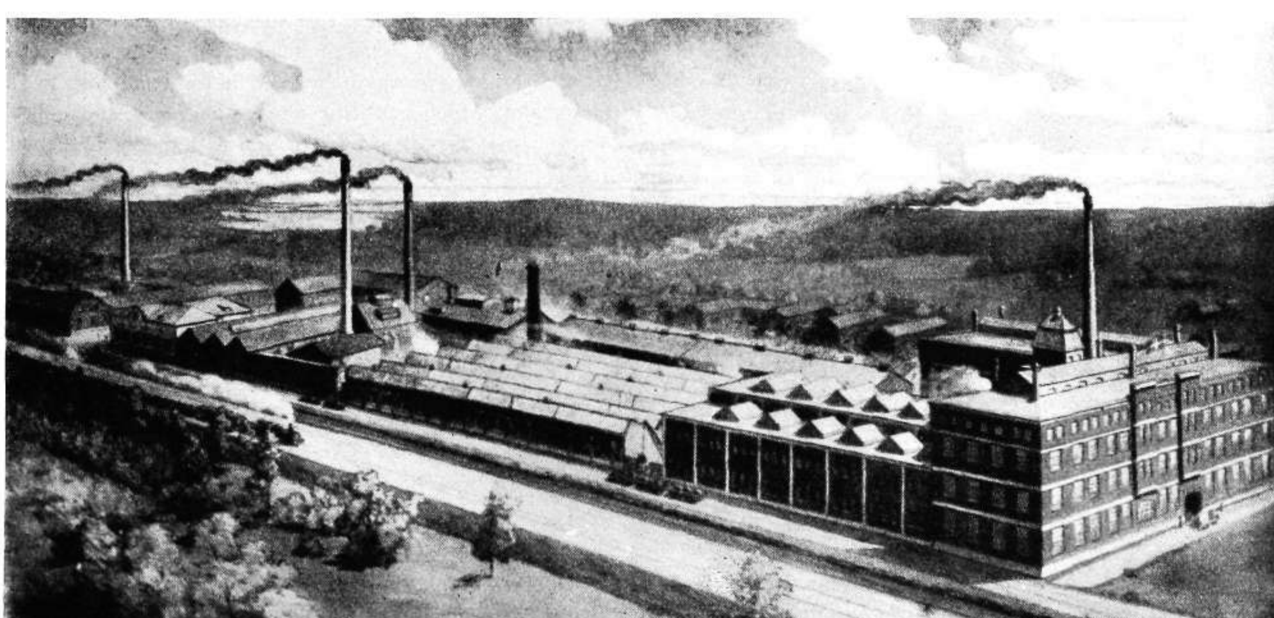
It was indeed high time that an improvement occurred. The raw material scarcity had driven prices up in fantastic manner, so that tin in the middle of 1918 was being paid for at 50 kronor per kg or a little more. In a short time, however, the price fell below 10 kronor as a result of State intervention. The supply of copper became during the latter part of 1918 rather more abundant, enabling more rational employment. The Industry Commission fixed certain guiding principles for the judging of existing applications. In July 1918 Sieverts Kabelverk obtained the right to manufacture, without hindrance from prevailing regulations, insulated conductors of copper in current manufacture, though deliveries could only be made against special permit.

In a communication of 12th December 1918 the Industry Commission confirmed a provisional arrangement concluded the previous day concerning abandonment of the employment of zinc for electric conductors. The manufacture of zinc wire at the metal works was to be stopped at once. Balances of orders for zinc wire for electric purposes, which had not yet been executed by the metal works, were to be replaced by orders for 80 % by weight of copper at certain prices. On January 24th, 1919 the manufacturers made this regulation milder by declaring themselves willing to renounce all replacement deliveries of copper conductors without compensation. All parties were desirous of discarding zinc conductors as soon as possible, though not long before it had been proclaimed that all were comparatively pleased with them! In January 1919 the strict ordinance of 9th April 1918 was revoked and that brought to an end the rationing of base metals.

In December 1916 the scarcity of rubber was so serious that private stocks of raw rubber and regenerated rubber were requisitioned. This enabled these goods to be reserved for such manufactures as possessed special importance from the standpoint of the country's military and economic measures. To provide the rubber industry with the possibility of maintaining operations to the extent that was considered particularly desirable there were furnished during the first half of 1917 the largest possible quantities of raw rubber and regenerated rubber for the production of certain important technical rubber wares. As, however, the ever increasing difficulty of import conditions lessened the probability of supplies, it became necessary in the early summer to practise more drastic economy. For some time ahead the most necessary requirements could be filled, mainly because raw rubber in a number of cases could be replaced by regenerated goods for which as yet no shortage had arisen. The Government was obliged, however, to impose prohibition on the transport

Fig. 9
Sieverts Kabelverk 1912

X 7160



CONDITIONS.

1. The said goods and any goods manufactured therefrom (including by-products and waste) shall not be exported to the Central Powers or their allies or to territory in their occupation, and may be exported: (a) to Denmark only on production to the Swedish Handelskommission of a certificate showing that the Merchants Guild or Chamber of Manufacturers of Copenhagen have given a guarantee satisfactory to the representative of the Associated Governments in Denmark in respect of the goods proposed to be exported; (b) to Holland only if the goods proposed to be exported are consigned to the Netherlands Oversea Truts with their consent; (c) to Norway only if consigned to or guaranteed by an Association with whom the Associated Governments have an Agreement, and in other cases under the usual guarantee in force in Norway attested by the Norwegian Minister of Finance; (d) and to Russia and Finland, and Roumania only with the consent of the representative of the Associated Governments in Stockholm.

2. The said goods and any goods manufactured therefrom (including by-products and waste) shall only be sold to reliable persons, and in exchange for a written undertaking, similar to this undertaking, and after the seller has satisfied himself that such goods and any goods manufactured therefrom (including by-products and waste) will not be exported in any form, save as herein provided. Such undertaking need not *be required from a purchaser purchasing in the ordinary course of retail trade where the invoice value of the* goods sold at any one time shall not exceed 100 kronor, provided that this exception shall not extend to cover a *succession of such sales to the same person, firm or company at frequent intervals.*

3. »Associated Governments» means the British, French, Italian and United States Governments.

Fig. 10 X 5516
Form of State Trade Commission
for import application

without special permit of rubber waste and worn rubber ware. At the same time there was in England at the end of the first half of 1917 requisitioned Swedish rubber goods not settled for to a total amount of 1.1 million kronor and these quantities remained right up to the end of the war.

Supplies of rubber first started to come in during November and December 1918 after the big trade agreement had begun to come into force. Up to then the factories had been recommended to make their productions in substitute qualities. In view of this the demand for rubber vaste and worn rubber ware was particularly great. Prices soared, but were reduced by suitable measures by 40 to 50 %. Even in September 1918 — that is after the existence of the great trade agreement — waste and worn goods were being requisitioned. In December, however, it became possible to take up again in the country the manufacture of all special articles.

It was an exceedingly complicated procedure that the cable works had to go through in order to obtain raw rubber. First it must make application to the Industry Commission, which after approval forwarded it for legalizing to the Comité Interallié at Stockholm, which gave the applications special numbers. The documents then went to the Swedish Trade Commission which through its organ in London handed it over to the allied blockade committee. There it was submitted to strict examination, both to ensure that larger quantities of goods were not requisitioned than allowed by the trade agreement and to ascertain that the application was not made by a firm which on the grounds of previous transactions was suspect to the British Government. The examination completed the documents were passed to the War Trade Department in London or the War Trade Board in Washington, either of which could grant or reject licence. If the application successfully passed the whole of this fire, it was for the firm itself to get into contact with sellers of the goods in England or USA and arrange for shipping space. Similar forms were prescribed for a number of other goods.

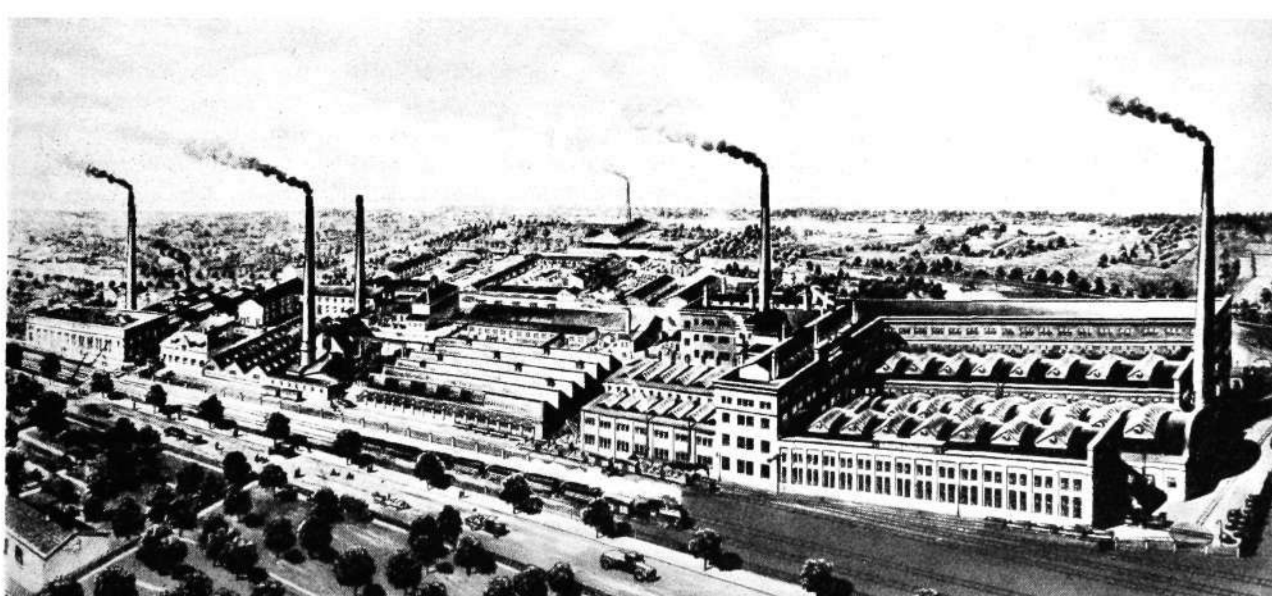
In November 1918, like a bolt from the blue, came a notification that an application by Sieverts Kabelverk had been rejected without explanation. The Trade Commission stated that it was awaiting further information regarding the cause and took it for granted that the London office was keeping the question of licence open and not neglecting any opportunity to seek to get the licence made out; it was a matter therefore of waiting events. In the same month came a rejection respecting a quantity of resin and in the beginning of December still another concerning paraffin wax. The reason for the rejections would appear to have been some statement that Sieverts Kabelverk was founded by Germans and that it was owned by German shareholders. This last, of course, was not correct, but it was only after considerable trouble that the company succeeded in getting through the parcels of goods in question.

In December 1918 the new Finnish State presented an official offer of 130 tons old galoshes, 8 tons motorcar outer covers, 2 tons inner tubes and 100 tons technical rubber goods, altogether 250 tons. If the quantity could be imported into Sweden the Industry Commission would distribute it among all the rubber factories and cable works which had formerly been supplied with raw rubber. As the parcel could not be separated and a part of the waste was of inferior value, no factory could obtain the better qualities alone but all qualities must be distributed in equal proportions among the factories. As the matter was urgent, Sieverts Kabelverk replied immediately that it would agree to take over a portion of the goods offered but only on condition that most of the other rubber factories did the same. This provides an outstanding example of the extremes to which the shortage of goods compelled the factories, and the remarkable thing is that this episode occurred nearly half a year after the conclusion of the great trade agreement. By Government decisions in April and July 1919 all rationing of rubber was revoked.

In 1915 an agreement was come to with the British authorities by which they undertook to let through a certain quantity of cotton per month. The agreement expired in January 1917 and we had to be content with a provisional arrangement until August of the same year when a new agreement was concluded for a certain monthly import on condition that Sweden imposed export prohibition on practically all cotton goods and undertook to require certain guarantee engagements for licences to Denmark and Norway. The import proceeded in the meantime without the Trade Commission requiring to intervene, but in September 1917 notice of termination was given from the British side and no new agreement came to pass. In November there was issued an ordinance of requisition of cotton existing in the country with the exception of a couple of specialities. In January 1918 a fresh requisition was made of all stocks of cotton yarn of various kinds, with a pair of insignificant exceptions, and in February was issued prohition of transport without special per-

Fig. 11
Sieverts Kabelverk 1918

X 7161



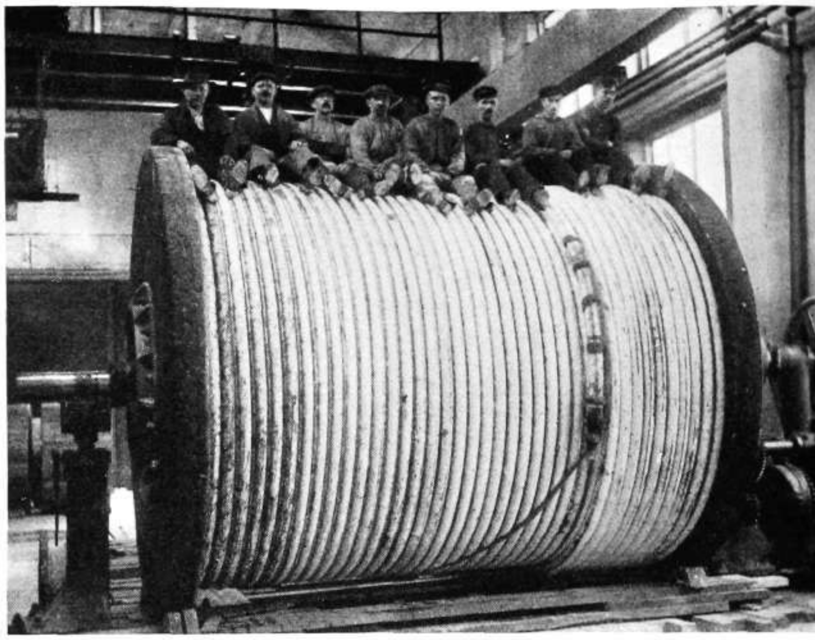


Fig. 12 X 5494
Marine cable, manufactured 1921
2,500 m long, weight 20 t

mit for waste and rag articles of cotton. It became almost impracticable for the cable works to procure any cotton yarn until the great trade agreement opened up new prospects. At the close of January 1919 cotton rationing was revoked. The supply of cotton to the Swedish cotton industry increased rapidly during the year and with it the the possibility of the cable works purchasing the requisite quantities of cotton yarn.

Eradication of Wartime Material

The liquidation of the rationing system proved to carry with it deplorable consequences in many respects, which would seem quite natural since the factories had been obliged to purchase substitute raw materials for their productions and these no longer allowed of marketable commodities. Thus Sieverts Kabelverk suffered considerable losses on the zinc wire that had been bought and which could no longer be utilized. Another unfortunate consequence was that all the new installations, which had been carried out at a rapid rate during the electrification fever 1918—1920, were executed in inferior material, which was apparent particularly as regards zinc conductors. Justifiable criticism could also be made against the installation methods, the installators likewise having worked without adequate knowledge and experience.

The result was that the number of outbreaks of fire rapidly increased. While payments against fire damage per year during the period 1914—1916 were below 15 million on kronor the average, they rose in 1920 to about 50 million. To what extent the electric installations contributed to this result can naturally never be determined with any great certainty. Investigation gave the result, however, that the risk of ignition in installations executed with wartime material must be considered as at least 20 to 30 times as great as in other installations.

The fire insurance institutions therefore became uneasy and in the beginning of April 1921 they took measures to attain improvement in the disquieting conditions, partly with a view to getting annulment of the prescriptions which permitted the execution of electrical installations with wartime material and partly to prevent electrical installations being carried out by incompetent electricians. Their action led to the desired result. On April 5th, 1921 there was issued an ordinance revoking the statutes of the rationing period on installations with wartime material and containing new prescriptions respecting damp and inflammable premises.

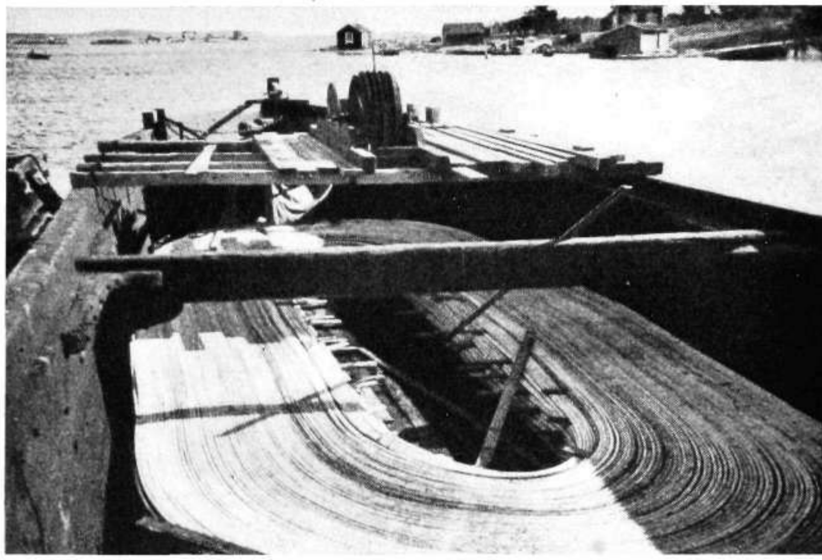


Fig. 13 X 5495
Transport of marine cable 1923
20 km long, weight 41 t

In addition the assurance companies established a wartime central which procured information about the existence of wartime material in industrial works, large goods stores and farm establishments. By the introduction of suitable stipulations in the corresponding insurance conditions there was obtained in the succeeding years practically complete elimination of wartime material in industry and agriculture. Moreover there were reconstructed as a matter of judgment one fourth of the wartime installations in towns and villages voluntarily by the owners. The regulations were supplemented by a comprehensive work of enlightenment. Experience had shown that the conduit installations formerly so common in damp premises, as for example in industrial plants and agricultural offices caused the majority of electrical fire damage and a change-over to rubber-lead system, which despite strong opposition from various quarters was slowly but surely making its way, was required of necessity. Since no new State regulations of installations according to modern conceptions might be expected for many years, Sieverts Kabelverk initiated at the beginning of 1925 a collaboration with fire insurance companies and electricity works aimed at bringing about informative and propaganda courses for electrical engineers, electricians and fitters with the object of demonstrating the danger of poor electrical material and of carelessness in the execution and maintenance of electrical installations, together with the advantages of properly employing the modern electrical installation material which was beginning to come onto the market. The cost of these courses was at first defrayed by Sieverts Kabelverk and later by Telefonaktiebolaget L.M. Ericsson and the cable works together and they have been attended by several thousand interested persons.

All the work devoted to the removal of the faulty wiring and installations of the later war period naturally favoured Sieverts Kabelverk's activities. The increased demand for what has been called peace time material and a sharpening of the demands on manufacture could only operate beneficially on the cable works which had constantly sought to maintain it on a very high level. The intimate collaboration between the cable works and the institutions and organizations which were working for safer installations and material has naturally also been to the gain of the cable works.

Research is Intensified

It is fairly obvious that a manufacture such as that of cables must be based on theoretical studies. Such have to a certain extent also been carried on right from the commencement of the manufacture of cables. There was, however, long lacking a sufficiently detailed knowledge of a number of important conditions for the design and strength of the cables. Manufacture in many cases went so much more radiply than research work that it was only from cable plants in practical operation that knowledge was gained of a number of phenomena which gave rise to new experiments and new shaping of guiding principles. It was found in this sphere as in the question of aviation that a great deal of new had been thought out and tested in various countries during the war years. Knowledge of this, as pointed out above, was only obtained after the conclusion of peace, and then it was found that approximately the same problems in different countries had led to rather similar solutions.

When the cable works in 1910 began to manufacture lead-sheathed cables and for several years afterwards, there existed really no other prescriptions for judging the quality of a high tension cable than voltage test, which in certain cases was supplemented by flash-over test. In the spring of 1921 there was started at the cable works detailed research work into the electrical properties of impregnating compositions. To arrive at a correct basis for the problems related to this, hundreds of oils were thoroughly tested and in many cases trial cables were made with different impregnating compositions. The oil research had reached such an extent in 1923 that the cable works fitted out a special laboratory. This received, however, other tasks also, chiefly the investigation of asphalts, rubber mixtures, paper etc. Moreover work was carried on in the latter part of 1923 and the beginning of 1924 with the determination of ionization in high tension cables and it was proposed to construct canals in the copper cores these being in communication with pressure tanks arranged at the ends. In this way the principle for the oil cable, of such importance later, was discovered by Sieverts Kabelverk.

In the latter part of 1924 and for some years after, research work was chiefly devoted to insulation material for condensers. As early as the beginning of the 20th century there had been discussion regarding the advisability of employing these for the protection of electrical installations against atmospheric excess tensions, mainly lightning. Knowledge of the nature of the over voltages, however, was for a long time far too small to allow of estimating the suitable size of condenser, while some time elapsed before manufacturing practice was in a position to produce condensers reliable in operation. In the manufacture of condensers, especially for high tensions, it was found that particularly strict control of the homogeneity and purity of the insulation

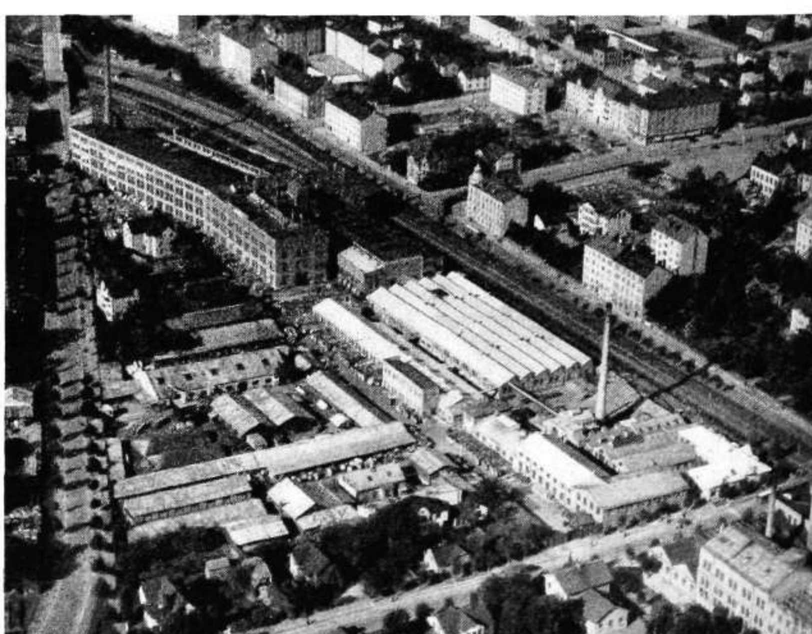


Fig. 14
Sieverts Kabelverk 1938

X 5507

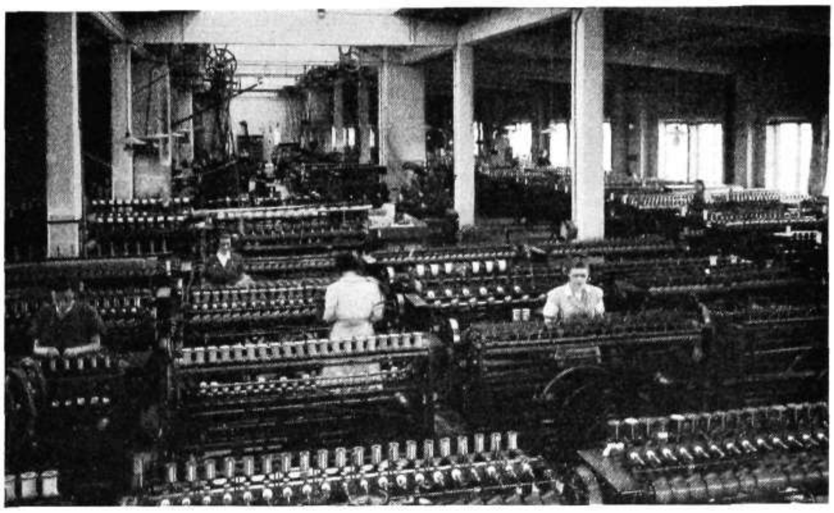


Fig. 15 X 5496
The great silk covering room

material employed was of the greatest importance. Direct collaboration between the material testing laboratory and paper and oil technics has contributed to constant progress in the improvement of the properties of insulation.

In the domain of teletechnics, loaded cable installations were dominant throughout the 1920's, while at the beginning only the two-wire system was employed. At the time it was considered inadvisable to have lengthy marine cables loaded, since in the event of repair it could not be ensured that the loaded section concerned would afterwards have the same length as prior to repair. Soon, however, there was realized the value of four-wire conductors for long loaded connections, but as cable telephony was extended to greater distances certain injurious phenomena were observed. The remedy was to raise the cut-off frequency and right up to 1934 all long distance cables in Sweden were planned on this system. The misgivings felt regarding loaded marine cables were dissipated with the transition to four-wire cables for these as well.

In the technics of installation there was gradually evolved a conductor, the rubber-lead conductor, which constituted an innovation in principle and later became the model for corresponding conductors in other countries. It was, however, important not only to find a good conductor but also to bring out a new system of fittings. After comprehensive work in designing things were ready to make a start with manufacture at the beginning of 1922. The fittings consisted of junction box, switch and lamp-holder with protecting glass. Perhaps the most important part was the packing where the cable entered the box. As soon as the set was completed a trial installation was made, this being left undisturbed while the insulation was measured at regular intervals. In 1930 one of the fittings was taken down and replaced by one of new design. After seven years of operation the old parts were externally in a deplorable condition but internally there was no trace of rust or other deterioration.

In this way Sieverts Kabelverk had evolved an installation system which offered great practical advantages. The wiring stood out against mechanical and chemical action. Internally it was so solid that air circulation and resulting condensation was eliminated. Humidity could not penetrate the wiring and the system could be employed in all descriptions of localities, no matter whether they were dry, damp or inflammable. The laying of the wiring was facilitated and as the cost of the wiring and of labour was not made too high the new system has been able to compete successfully with older ones, in view of its technical merits. It was not long before a number of improvements were made in the system and in this connection it received its present name, the Gebe system. This improved system was ready in 1931.

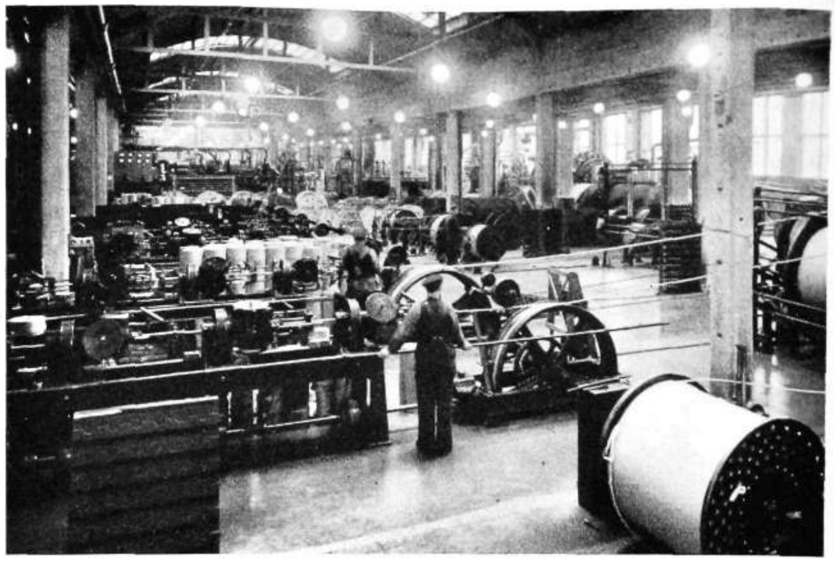


Fig. 16
The cable hall

X 5497

Varying Prosperity

The war years were of great significance for Sieverts Kabelverk. Production grew in a manner exceedingly satisfactory to the management of the undertaking, which is evident from the fact that in 1914 goods delivered amounted to 2 096 000 kg, but in the years 1920 and 1928 attained 4 050 800 and 6 130 000 kg respectively. In the last-named year power cables represented 2 894 000 and telephone cables 1 873 000 kg, while sundry goods including installation material and fittings showed the figure of 1 366 500 kg. The two last groups of goods had approximately doubled from 1920, while power cables increased at a slower rate, though still constituting the largest group. Export was as formerly relatively weak, which finds its natural explanation in the war restrictions and the subsequent aggravated competition for markets. There was also the circumstance that home buyers could take practically the whole production. In 1920 and 1921 large deliveries were made to Norway which drove the export figures for those years up to 1.5 and 1.0 million kronor respectively. Besides the Scandinavian countries, various quantities were taken by Great Britain, Belgium, Esthonia, Latvia and Poland. China, Australia and South Africa too were clients.

Among the Swedish clients the State undertakings went more and more to the front. As earlier, the Telegraph Administration came first, buying during the years 1910—1919, the war years included, to an amount of 18.2 million kronor. Purchases by the Telegraph Administration increased strongly in succeeding years and amounted to 27.3 millon kronor during the years 1920—1928. The State Railways and the Board of Waterfalls, controlling the State electric power plants, also increased the purchases appreciably but were still a long way behind the Telegraph Administration. Still reckoning from 1910, Asea comes first among private clients with purchases for about 21 million kronor. Telefonaktiebolaget L. M. Ericsson stood at about 9 million kronor for purchases.

Fig. 17
Cabling machine
for phase-mantled high tension cables

X 3886

The fluctuations between boom and depression evidently affected the operations of the cable works more than would appear from the foregoing. It is surprising, however, how the cable works was able to come well through even the worst depressions of the last quarter century. In this there collaborated the strong financial position of the company independent of credit giving banks or bondholders with the unbroken development of electrotechnics, which demanded ever more electric conductor material.

Following the crisis of 1907—1908 there came an improvement in business, the full development of which was rather checked, however, by great labour disputes in Sweden during 1909. After that prosperity set in seriously; cer-

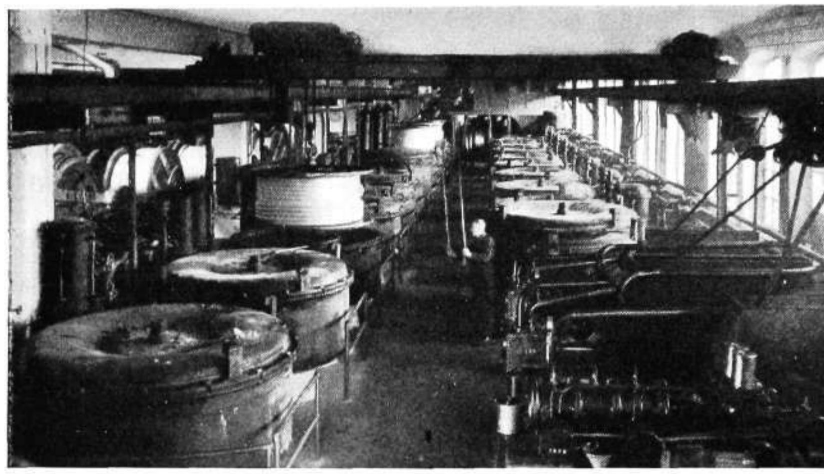


Fig. 18 X 5498
Impregnating department for cables

tainly it was disturbed at intervals by disquieting international political conditions, but in the main it persisted up to the beginning of 1914. During these years industrial production increased considerably. It was also of importance to the cable works that during the years 1908—1914 the water power utilized or under development displayed strong increase. The developments of the times were thus fabourable to the cable works. Certainly just prior to the outbreak of war there occurred a deterioration of the world economic situation, but the effects of this were removed as concerns electric line material by the remarkable conditions of the war years which have been already described.

A natural result of the long and destructive war years was a profound economic crisis which affected victors, vanquished and neutrals. It was a question of converting war industry back to peace manufacture. Stocks collected had to be realized, a catastrophical fall in prices occurred, world trade was reduced on account of economic defensive measures which proved ruinous for all parties. War indemnity claims made the position still worse and inflation was turned into deflation. Industry had enormous difficulties to deal with and was still further burdened by the introduction of the eight-hour day in 1920, a radical revolution which immediately settled a large number of labour disputes.

During 1922 a dawning improvement of the situation became apparent and during the years 1923—1925 industry in the main went through a gradual process of convalescence. In March 1924 Sweden returned to the gold standard, a year before Great Britain and long before most of the other countries, which gave evidence of fresh stabilization, but laid extra burdens on export industry. Improvement continued, however, up to the close of this period. It was quite natural that the cable works should be affected by the crisis and the years 1920 and 1921 produced vary large losses, 4.1 and 1.3 million kronor respectively, which obliged the company to stop operations during the first two months of the year, and then there were the effects of the eight-hour day law which showed themselves in increased costs of production, as also the burdensome taxation, and finally various writings off of worthless credits. A final factor was the acute German competition; by means of the low rate of the mark and the consequent very low wages compared with the Swedish, the German factories had been selling in 1920 at prices which lay 30—60 % below the actual Swedish cost of production. The difficulty of the cable works in competition was aggravated by the fact that there still remained large stocks of raw materials bought earlier at high prices, which must be used up.

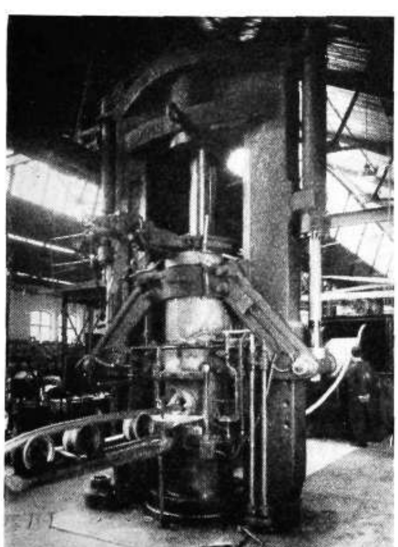


Fig. 19 X 3887
Lead press
for lead-sheating cables

However, cable manufacture displayed a gratifying upward trend, but the net profits recorded remained at rather low figures — in 1926 only a bare 30 000 kronor. Despite the great losses at the opening of this period, or maybe rather on account of them, the technical staff strained all efforts to maintain

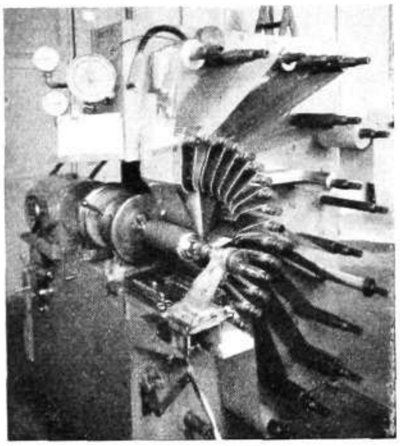


Fig. 20 X 3885
Winding machine
for condensers

the manufacture on a high level, fully comparable with what other factories could show. Scientific investigations were the order of the day, to the great advantage of manufacturing, and in this way the 1920's represented a noteworthy phase of Sievert Kabelverk's history.

Sieverts Kabelverk Changes Ownership

After Max Sievert's death in 1913 the board of directors was enlarged and several members of the family came in as members or auditors. Ernst Sievert, however, retained the decisive influence in the family company, the share capital of which had been increased to 2.4 millon kronor. When in 1928 Telefonaktiebolaget L. M. Ericsson offered to buy the whole of the shares for 7.3 million kronor, Ernst Sievert considered it was advisable to sell.

With that the Sievert family disappeared entirely from the management of the cable works. It was Max and Ernst, who with the assistance of their brother Georg, had created the undertaking and conducted it forward to its high position in the cable industry. They had succeeded beyond all expectations, and not only for their own benefit, for they had provided work and livelihood to an ever-increasing number of employees. It furnishes a splendid example of what able and prudent men can achieve when they devote all their willpower to planning and carrying out something new and great. With foresight and courage they met the difficulties encountered and it in no way diminishes the honour due to them to remark that their industrial work was borne up by the developments of the times as on a great and mighty stream. They started out with a very modest capital and built up their undertaking without resorting to the aid of banks or financiers — a truly outstanding phenomenon in the history of big industry.

The Decade 1928—1938

On July 1st, 1928 Telefonaktiebolaget L. M. Ericsson took over the direction of Sieverts Kabelverk. A long time had elapsed between Lars Magnus Ericsson's exhortation to Max Sievert to take up the manufacture of electric conductor wire and the final incorporation of the prosperous cable works in the Ericsson group, but the bonds had never been broken, the two undertakings having had uninterrupted collaboration as supplier and customer. The head of Ericsson's own cable works at Älvsjö, G. Olsson, became managing director and leading men of the telephone company joined the cable works board.

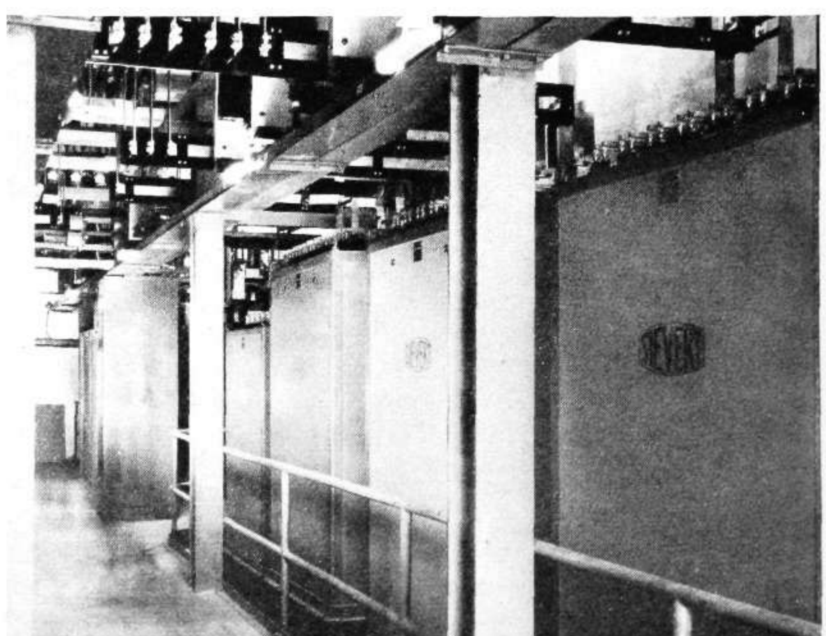


Fig. 21 X 5500
Phase compensating condenser
2 000 V, 1 000 c/s

If the time before and after the beginning of July 1928 is studied it will be observed that there was a profound difference of ideas in the two boards, which may be characterized by the fact that the old regime in certain respects had gathered something of the bonds of tradition and of patriarchal feeling, while the new order was more imbued with the strictness of modern business. Thus the sales organization received more attention than previously, as was quite natural in view of Ericsson's widespread activities throughout the world. In a brief time export was doubled, which certainly did not amount to much, but indicates the increased efficiency of sales work and the advantage to the cable works of utilizing the sales organization of the Ericsson group in various countries.

Production was very strongly increased. Goods delivered stood in 1929 at 8 222 000 kg, which in itself was a relatively good total quantity, but grew later to 18 000 000 kg in 1937, representing more than the double. In the last-named year power cables contributed to the total figure with 5 878 500 kg, while telephone cables and sundry goods represented 8 580 400 and 3 496 000 kg. The middle group had now gone past the leading group. The Telegraph Administration during this period bought to an amount of not less than 52 million kronor and the State Railways 9.7 million kronor. The Board of Waterfalls too was a good client. Large deliveries went besides to electrical firms and works.

During the 1930's Sieverts Kabelverk has occupied itself mainly with cable manufacture. This coincides with the growing demand for cables for telephony and the increased distribution of light and power. The oil laboratory established in 1923 laid the foundations of comprehensive research into insulation material, which during the next ten years was further expanded.

It has been stated earlier that manufacturing practice for condensers was developed and improved by Sieverts Kabelverk. The chief contributing factor was the experience in the domain of power condenser construction gained through the more and more general employment of condensers for phase compensation in power networks. In 1932 the question of condensers for overvoltage protection was once again seriously brought up in conjunction with the order by the Board of Waterfalls to Sieverts Kabelverk for two 55 000 V batteries. This first trial on a large scale proved successful and condensers now constitute a recognized overtension protection.

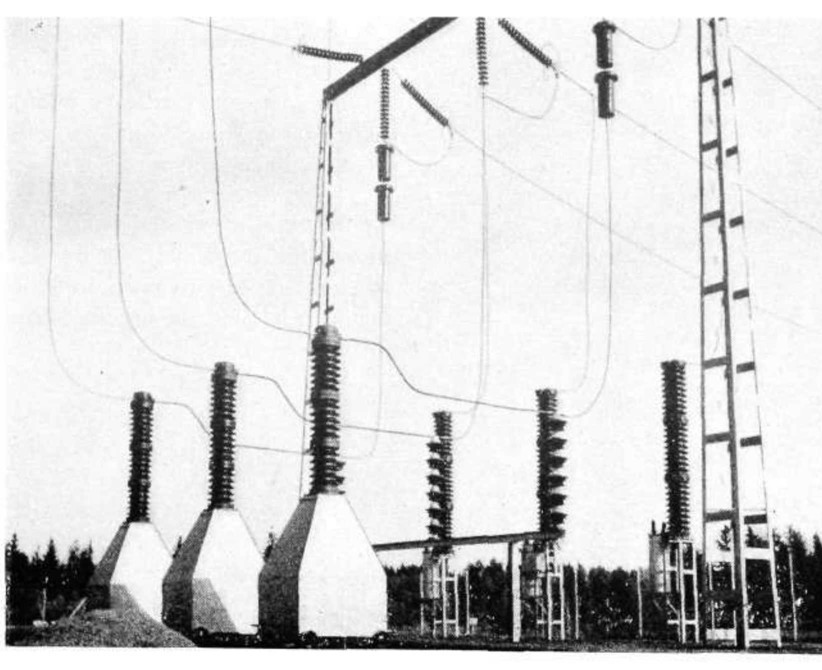


Fig. 22 X 5501
Condenser-transformers for 220 $\sqrt{3}$ kV

Fig. 23 X 5505
Transport of cable drum 1921 and 1938 — also progress

During the 1920's considerable work was devoted by Sieverts Kabelverk to the production of installation material to be employed in damp and inflammable localities in agriculture and industry. A new phase of development began round about 1930 and resulted in the working out of new types and the application of various simplifications, so that one could now speak of the Gebe system as a universal system for all kinds of premises instead of as from the beginning being regarded exclusively as for damp and inflammable localities.

The latter part of the 1920's was marked by a rapid economic expansion which in Sweden lasted longer than in most other countries. The Stock Exchange catastrophe in New York in 1929 brought in a general world crisis, which did not affect Sweden seriously, however, until 1931. Exports were reduced and because of the general money crisis the burden of the financing of the vast Kreuger undertakings fell more and more on Sweden. As moreover the import surplus required to be paid for, a difficult situation arose. At the close of September — one week after Great Britain — Sweden abandoned the gold standard and established its economy on the basis of paper currency in close alliance with the English pound. Recent years' experience has demonstrated how wise this policy was, but the immediate effects were naturally disquieting. Thus the cable works immediately cancelled all current quotations and endeavoured to adjust its scale of prices to the new circumstances. The position became worse during the latter part of 1932 but by 1933 a decisive improvement was already making itself apparent, and this proceeded steadily right to the close of 1937. It was not until 1938 that signs of a swing over in the situation have been detected, though no real turn has occurred as yet.

Sieverts Kabelverk has come through the crisis of the 1930's in a singularly fortunate way: it is only for the year 1932 that any fall in turnover and net profits is apparent — no annual loss has required to be reported and, with the exception given, a good even rise has been observed. From 1928 to 1937 turnover has approximately trebled and the net profits increased five times. Funds taken from profits have been employed to increase the share capital to four million kronor.

At the close of its first half century Sieverts Kabelverk therefore stands out financially strong and with its manufactures on a high level of quality. There is therefore every reason to believe that it will continue in the future to maintain its place among the cable industries of the world.

Ericsson Technics

Ericsson Technics No 3, 1938

L. F. Gaudernack: A Phase-Opposition System of Amplitude Modulation

The increasing economic importance of power efficiency for high-power broadcast stations is illustrated showing that some 50 per cent saving is possible. Different known modulation schemes are compared as regards necessary input power, including the recent Chireix and Doherty systems. The influence of rates for electric power is stressed. A so-called »phase-opposition» system is discussed starting with simple circuit theory, first for series and then for parallel-tuned circuits. Principally the system is based on the co-operation of two generators, *i. e.*, one »carrier» generator constantly excited, and one side-band generator whose excitation is changed 180 degrees in phase according to the phase of modulation. The mean input power is calculated for this system, giving about the same input as good systems for about 30 per cent modulation, but 10 to 25 per cent more power at 100 per cent modulation. Finally a consideration of tube characteristics is given and possible means for obtaining linearity are shown.

Ericsson Technics No 4, 1938

Conny Palm: Analysis of the Erlang Traffic Formulæ for Busy-Signal Arrangements

The *Erlang* lost calls formula for busy-signal arrangements, which is used nowadays by many telephone administrations as a basis for the calculation of groups of selectors and circuits, is generally considered as being valid for very general conditions. As yet, however, there does not seem to exist any proof of the validity of the formula, except in cases where limiting assumptions have been made as to the distribution function of the durations of the calls. In the present article a deduction of the formula is given which shows its validity independent of the distribution function valid for the durations of the calls. The method used for this purpose entails, it is true, quite a number of laborius computations but requires only quite elementary mathematical means which are well known to the engineer. The result shows the general validity not only of the *Erlang* lost calls formula but also of all other expressions allied with this formula, valid for states and occupations which may be interesting when measurements are to be carried out. In order to permit of judging the practical value of these formulæ, an analysis has been made of the assumptions required and of some conditions from which deviations may arise in practical application. Further, in the last chapter there is carried out an investigation of the individual durations of the congestion states for different types of distribution functions for the holding times. The result obtained should present some interest when suitable dimensioning rules are to be prepared.

Ericsson Technics No 5, 1938

Vilhelm Peterson: Determination of Attenuation Minima in Electric Wave Filters

The present paper explains a method for finding minimum attenuations in filters composed of several cascade-connected filter sections having attenuation peaks located at different places of a frequency scale. The method is graphical and based on the derivative for the attenuation curve having zero value at a minimum point. The position of the minima for a few common filter combinations having at most two variable *m* values has been determined by means of derivative curves. The image attenuations of these minimum points have been calculated and reproduced in diagrams in such a manner that the minimum attenuations may be read directly.

The influence of reflexion attenuations has been investigated with a view to finding the minima of the effective attenuation of a filter when it is matched to ohmic resistances, and it is shown that the reflexion attenuation can easily be taken into account.

Finally the application of the method to band-pass filters is discussed, in the case where single-peak band-pass filter sections are used in addition to ordinary *m*-derived constant-*k* sections.

Ericsson Technics No 6, 1938

T. Laurent: Le commutateur de fréquences multiples — une nouvelle méthode pour le raccordement de filtres séparateurs dans un appareillage terminal à fréquence porteuse

In this treatise a new method is expounded for the connection separating filters in a carrier frequency terminal equipment, using a multiple frequency switch. The method effectively prevents mutual characteristic disturbance between the filters and gives to the whole frequency complex by purely reactive means an input impedance essentially real and independent of frequency.

The method will find application especially in those cases where a good adjustment is required at the filter input side, *e. g.*, on account of far-end cross-talk or where the filter complex is to be balanced in a fork connection, *e. g.*, in order to be utilizable in common for both speech directions; it is well justified, however, for other cases also.

The multiple frequency switch is a complicated device which hardly permits of mathematical treatment other than with frequency transformations which therefore predominate in the mathematical theories advanced. From the theoretical standpoint the treatise presents many interesting novelties, particularly as regard the summation of frequency functions. *Inter alia* the tangent function stands out as an important special case of a sum of *n*-functions, and in frequency transformation with tangent function the reactance elements are transformed to homogeneous artificial lines or networks with an infinite number of reactance elements.

It is demonstrated that, at some future time when perhaps the problem of designing short homogenous lines with great propagation time has been solved, it will be possible for all filtering to be done with devices comprising such conductors instead of the extensive complex of coils and condensers.

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TABLE OF CONTENTS

The Ericsson Group

Associated Enterprises

EUROPE

Československo Prchal, Ericsson & spol.	*Praha I*, Malé náměstí 1
Danmark L. M. Ericsson A/S	*København K*, Studiestræde 24
Deutschland Ericsson Verkaufsgesellschaft m. b. H.	*Berlin W 35*, Tirpitzufer 60—62
Ericsson Österreichische Elektrizitäts A. G.	*Wien XII*, Pottendorferstrasse 25/27
Eesti Tartu Telefonivabrik A/S	*Tartu*, Puiestee 9—11
España Cía Española Ericsson, S. A.	*Getafe (Madrid)*
France Société des Téléphones Ericsson	*Paris XX*, rue Villiers-de-l'Isle Adam 111
Great Britain Ericsson Telephones Ltd	*London WC 2*, Lincoln's Inn Fields 22
The British Automatic Totalisator Ltd	*London WC 2*, Kingsway 56
Electric Totalisators Ltd	*London WC 2*, Kingsway 56
Production Control (Ericsson) Ltd	*London WC 2*, Lincoln's Inn Fields 22
Italia Società Elettro Telefonica Meridionale	*Milano*, corso del Littorio 3
»SIELTE», Società Impianti Elettrici e Telefonici Sistema Ericsson	*Roma*, via Appia Nuova 572; C. P. 24 (Appio)
»FATME», Fabbrica Apparecchi Telefonici e Materiale Elettrico Brevetti Ericsson	*Roma*, via Appia Nuova 572; C. P. 25
Società Esercizi Telefonici	*Napoli*, Palazzo Telefoni, piazza Nolana; C. P. 274
Società Urbana Immobiliare	*Napoli*, Palazzo Telefoni, piazza Nolana; C. P. 274
Jugoslavija Jugoslovenski Ericsson A. D.	*Beograd*, Knez Mihajlova 9; P. F. 726
Nederland Ericsson Telefoon-Maatschappij N. V.	*Rijen (N. Br.)*
Norge A/S Elektrisk Bureau	*Oslo*, Middelthunsgate 17; P. B. MJ 2214
Polska Ericsson Polska A. S. Elektryczna	*Warszawa*, aleja Ujazdowska 47
Polska Akcyjna Spółka Telefoniczna	*Warszawa*, Piusa XI, 19
România Ericsson S. A. Română	*București I*, Splaiul Unirii 13
Suomi O/Y L. M. Ericsson A/B	*Helsinki*, Neitsytpolku 1
Sverige Telefonaktiebolaget L. M. Ericsson	*Stockholm*, Döbelnsgatan 18
Svenska Radioaktiebolaget	*Stockholm*, Alströmergatan 12
Sieverts Kabelverk	*Sundbyberg*
Aktiebolaget Alpha	*Sundbyberg*
Svenska Elektromekaniska Industriaktiebolaget	*Hälsingborg*, Rönnovsgatan 18
L. M. Ericssons Försäljningsaktiebolag	*Stockholm*, Kungsgatan 31
L. M. Ericssons Signalaktiebolag	*Stockholm*, Sveavägen 90
Fastighetsaktiebolaget L. M. Ericsson	*Stockholm*, Kungsgatan 33

ASIA

British India Ericsson Telephones Ltd	*Calcutta*, Grosvenor House, Old Court House Street 21
Nederlandsch Indië Ericsson Telefoon-Maatschappij N. V.	*Bandoeng*, Tamblongweg 11
Türkiye İzmir ve Civarı Telefon Türk A. S.	*İzmir*, Dr Hulusu caddesi; P. K. 314

AMERICA

Argentina Cía Sudamericana de Teléfonos L. M. Ericsson S. A.	*Buenos Aires*, Moreno 986
Corp. Sudamericana de Teléfonos y Telégrafos S. A.	*Buenos Aires*, Bernardo de Irigoyen 330
Cía Argentina de Teléfonos S. A.	*Buenos Aires*, Bernardo de Irigoyen 330
Cía Entrerriana de Teléfonos S. A.	*Buenos Aires*, Bernardo de Irigoyen 330
Brasil Sociedade Ericsson do Brasil, Ltda	*Rio de Janeiro*, rua General Camara 58
México *Empresa de Teléfonos Ericsson S. A.*	*México, D. F.*, 2:a Victoria 53/61; apartado 1396
Cía Comercial Ericsson, S. A.	*México, D. F.*, Artículo 123, No 10
Cía de Teléfonos y Bienes Raíces	*México, D. F.*, 2:a calle Victoria 53/61; apartado 1396
Uruguay Cía Sudamericana de Teléfonos L. M. Ericsson S. A.	*Montevideo*, rio Branco 1381
United States of America Sven T. Aberg	*New York (NY)*, The Swedish Chamber of Commerce, 630 5th Avenue

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Grèce C. Missaelidis	*Athènes*, Lefcossias 12
Latvija W. Endel	*Riga*, Doma laukums 7; P. K. 86
Lietuva Th. Witte	*Kaunas*, Sporto gatvė 2
Portugal Sociedade Herrmann Ltda	*Lisboa*, Calçada do Lavra 6
Rodi Fratelli Calomeni	*Rodi (Egeo)*, C. P. 139

ASIA

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Manchukuo A. Mauer	*Dairen (South Manchuria)*, P. O. B. 138
Palestine Jos. Muller	*Haifa*, Kingsway 49; P. O. B. 243
Iran Irano Swedish Company A. B.	*Teheran*, Khiabane Pahlevi Koutcheh Dr Malek Zadeh
Philippines Elmac Inc., Electrical & Machinery Co.	*Manila*, Rizal Avenue 627; P. O. B. 625
Saudi Arabia Mohamed Fazil Abdulla Arab	*Jeddah*
Siam The Borneo Co., Ltd	*Bangkok*, Ban Tawai, New Road
Syrie C. A. Loïsides	*Beyrouth*, place de l'Étoile; B. P. 931

AFRICA

Égypte Swedish Industries	*le Caire*, rue El Maghraby 25 B. P. 1722
Moçambique J. Martins Marques Ltda Sucr	*Lourenço Marques*, rua da Electricidade 9; C. P. 166
Southern Rhodesia Rogers-Jenkins & Co. (Pty), Ltd	*Bulawayo*, Fort Street 124; P. O. B. 355
Union of South Africa Rogers-Jenkins & Co. (Pty), Ltd	*Johannesburg*, Marshall and Nugget Streets; P. O. B. 654

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Bolivia Cía S K F de Bolivia	*la Paz*, avenida Montes 642; cas. 678
Chile Flaten, Royem, Anker y Cía, Ltda	*Santiago*, Morandé 230; cas. 2168
Colombia Göte Fernstedt	*Medellín*, calle 49, 51-21; apartado 43
Ecuador Ivan Bohman y Cía	*Guayaquil*, Boulevard 211; cas. 1317
Peru Neisser y Cía	*Lima*, Mercaderes 432; cas. 597
Venezuela Harry Gibson	*Caracas*, Salvador de León a Coliseo 24; apartado 891

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