

*The L. M. Ericsson
Review*

VOLUME 4

1927



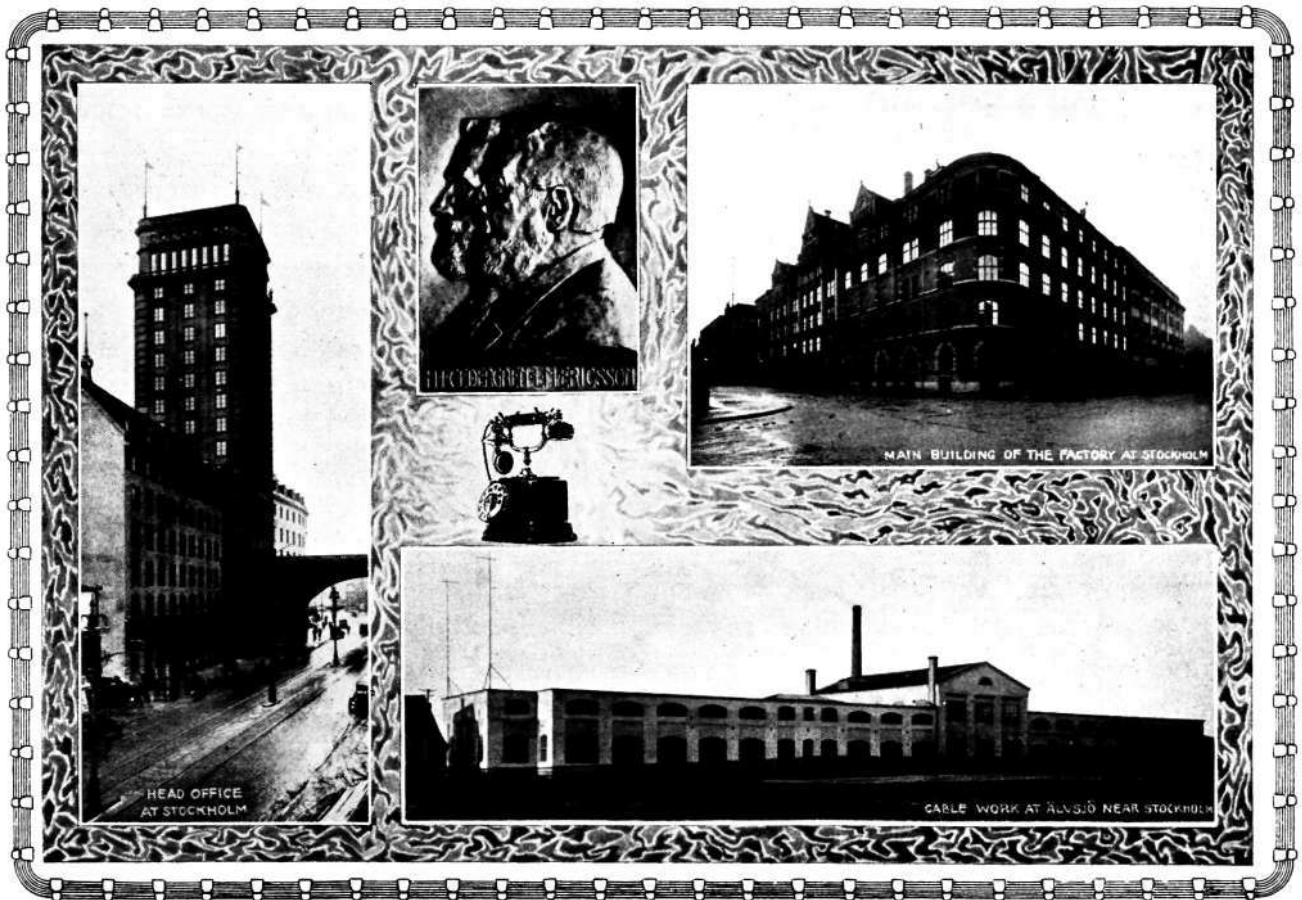
The L. M. Ericsson Review



VOL. 4

JANUARY—MARCH 1927

Nos. 1-3



IN YEAR 1927 TELEFONAKTIEBOLAGET L. M. ERICSSON IS ENTERING THE SECOND HALFCENTURY OF ITS EXISTENCE.

ENGLISH EDITION

THE L. M. ERICSSON REVIEW

ENGLISH EDITION.

JOURNAL OF
TELEFONAKTIEBOLAGET L. M. ERICSSON, STOCKHOLM.

Responsible publisher: HEMMING JOHANSSON

Editor: WOLDEMAR BRUMMER.

Issued quarterly. ~ ~ ~ ~ ~ Yearly subscription rate: 7/-

All communications and subscriptions to be forwarded to the Editor.

To our readers and collaborators:

In support of our statement in the first number of The L. M. Ericsson Review for 1924 that the purpose of this journal was to spread information concerning the activities of this company and associated enterprises as well as to form a tie between these latter and the parent company, Telefonaktiebolaget L. M. Ericsson has decided to supplement "The L. M. Ericsson Review" with a new sheet which is to appear once a month under the name of the "Ericsson News", beginning with this year.

Consequently, The L. M. Ericsson Review will in the future contain articles of a more scientific and technical character bearing on the various activities of the Ericsson organization; also, it will take up subjects of like nature for discussion. On the other hand, new items concerning orders and deliveries of more vital interest as well as statistics and other data concerning the activities and development of the company and its various branches will be published in the "Ericsson News". Furthermore, this latter publication will contain various additional information of interest for this concern. More detailed information on this subject is given in the announcement in the first number of the "Ericsson News".

We will take pleasure in sending the "Ericsson News" without extra charge to all those who now receive "The L. M. Ericsson Review".

In order the better to serve its foreign interests, the company has found it necessary to publish "The L. M. Ericsson Review" not only in Swedish, English and Spanish, as heretofore, but also in French and German, beginning with the current year.

"The L. M. Ericsson Review" takes this opportunity to extend its most hearty thanks to all those who have evinced their interest for this publication by contributing articles to the same and expresses the hopes that the bond between the company and its several branches as well as with its many friends over the whole world, which The L. M. E. Review has proved to be, may be still further strengthened, and that contributions for the advancement of this common object may be received from wider and wider circles, within as well as outside of the concern.



R 598

Mustafa Kemal Pascha.
President of Turkey.

Swedish Telephones in Angora.

A short notice in Nos 5 & 6, Vol. II of this journal imparted the information that the Turkish Post Office Administration had placed an order with L. M. Ericsson for an automatic exchange of 1000 lines for the city of Angora. The completed plant was opened for service on September 11th 1926, the number of subscribers then being about 400. Since then the number of subscribers has increased so rapidly that all of the thousand lines are now subscribed for. As a result, the Post Office Department has taken steps towards increasing the capacity of this exchange from one thousand to two thousand lines.

The above figures on the growth of the net are a fair example of the well nigh American speed with which the city of Angora is growing, this development being characteristic not only for the telephone communications but for all other government activities as well.

Like most Turkish cities, Angora has very old traditions and is said to have been founded by king

Midas in the 7th century B. C. Alexander the Great stopped here during one of his campaigns. During the year 25 B. C. Angora was conquered by the Romans, and a monument from the Roman era still remains in the ruins of the temple of Augustus and Rome, in the vestibule of which the mural inscriptions give the financial accounts of the emperor Augustus. The Arabs conquered the city in 695 A. D. and in 806 it was pillaged by Harun-al-Rashid (Aaron the just), caliph of Bagdad. From the Arabs the city passed into the hands of the crusaders, and after passing through various vicissitudes was conquered by the Turks in 1360. In 1402 Tamerlane annihilated the Turkish forces, captured the sultan Bayazid I, and placed the city under Mongolian rule only to be retaken by the Turks some years later.

It is since Mustafa Kemal Pascha selected Angora in 1920 for the seat of the new government, however, that this city has come to be of any real importance. In 1923 Mustafa Kemal Pascha was elected presi-

L. M. Ericsson

dent of the Turkish republic and to Angora was given the distinction of becoming the capital of the country. Much has been done since then to make Angora worthy of this elevated position. High up on a rocky elevation lies the oldest part of the city, surrounded by great walls built in part with material from the still older, now almost obliterated section of the city. Beneath it, on the plain, lies the new city, intersected by broad streets lined with modern buildings. Many new buildings for the various government departments may be seen, some finished, some still under construction, while several more have been planned for. The building activities are for the greater part concentrated in the outskirts of the city, in the vicinity of the railway station, where a large meadow is situated. Formerly, the marshy character of this area made it a veritable



R 599 Ruins of the Roman Baths in Old Angora.

nest of malaria but it has now been drained and is being made into a park, thus effectually ridding the city of this dreaded fever. The most desirable location within this section of the city is occupied by the new, imposing building of the Grand National Assembly, the first one visible when going towards the city from the station. Close by is the new post office building in which the automatic telephone exchange is housed.

Not only the government, but also the City of Angora is carrying on extensive building operations. Thus, the municipality — aided by the government — has erected a modern flour mill and bakery which can produce 7000 loaves of bread per day, an ice plant which fills the requirements of the entire city and — 8 kms to the West of the city — an entire industrial centre with electric power plant, brickyards, limekilns, a cement factory and a woodwork factory.

Between this industrial centre and the city lies the

private estate of the chief executive. Here, with the aid of modern agricultural machinery, Mustafa Kemal Pascha has succeeded in cultivating a considerable area of previously useless soil. The excellent example thus set by Mustafa Kemal Pascha in breaking new ground and putting it under cultivation is but one of the many proofs of his indomitable energy and capacity for work.

On a height about five kilometres East of the city lies an extensive residence district in which is located the private residence of the president as well as the various foreign embassies and legations. Private building activities have increased considerably during the last years and many new private residences may be seen on every hand. The importance of Angora as the heart of Turkey will be still further accentuated with the completion of the rail-



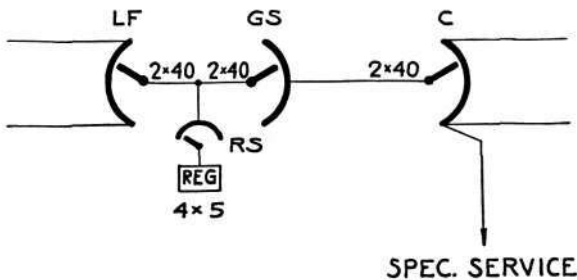
R 600 New Quarters of the National Assembly.

way leading East from Angora as well as of the projected line from Angora to the Black Sea.

When it was decided to modernize the telephone communications of Angora, the Post Office Administration was in favour of an L. B. system, and in 1924 L. M. Ericsson received an order for four L. B. switchboards with one position each and for a total capacity of 400 subscribers' lines. This equipment was delivered in Angora at the appointed time but was never put to use, because already at that time the authorities realized that, at the rate the city was developing and being modernized, it would never suffice, even if it was extended to its full capacity of 1200 lines.

It was then that the director general of the postal department, Fahry Bey, an able and farsighted man who had devoted his best energies to the development of telephone communications in Turkey, decided that Angora should have the best and most modern tele-

phone system obtainable. In May 1925 L. M. Ericsson was again invited to take up negotiations, these latter resulting in the signing of a contract calling for the delivery of a full automatic telephone exchange, including frames, racks, cables and line relays for 1000 subscribers' lines, and switching devices for 700 lines, besides 700 telephone instruments and a manual switch-board for fifty lines. The negotiations were carried on with Mr. Fahry Bey personally, all the details and technicalities of the contract being handled by Zeki Bey, technical chief of the Post Office administration. Captain Yngve Johnson, managing director of The Swedish Oriental Trading Co., — general agents in Turkey for the L. M. Ericsson Company — acted as representative for L. M. Ericsson. A few months after the signing of this contract, an order was placed for switching devices for 300 additional subscribers' lines. Thus, when the exchange was opened for traffic on September 11th, 1926 it was completely equipped for 1000 lines.

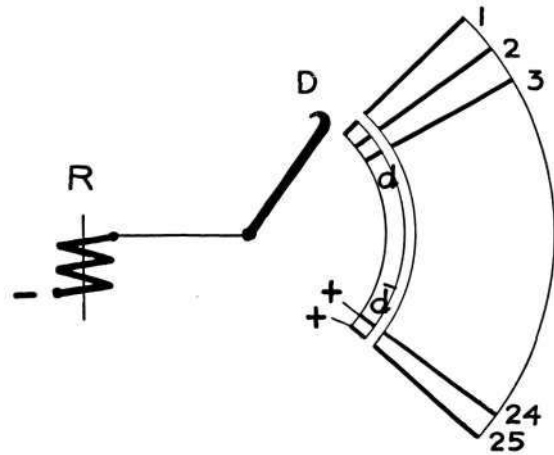


R 605 Fig. 1. Skeleton Diagram of the Automatic System in Angora.

The automatic telephone exchange in Angora is built according to the Ericsson system with 4-digit numbers. Thus, when the entire number series is taken into use a capacity of 10,000 lines is reached. A skeleton diagram of the Angora exchange for 1000 lines is shown in Fig. 1. The figures denote the number of switching devices for which the racks are built and wired. The one five hundreds group contains only regular subscribers' lines, while the other five hundreds group, besides subscribers' lines, contains also a number of special lines and junction lines to and from the two manual sub-exchanges in Tehan-Kaya and Ketzi-Euren. The connectors in the latter group are arranged for mixed traffic, i. e. traffic to ordinary subscribers as well as to connections with two or more lines to a number. The principle on which these connectors function is shown in fig. 2.

The multiple frames in the connector rack are constructed with insulated contacts *d*. Multi-line con-

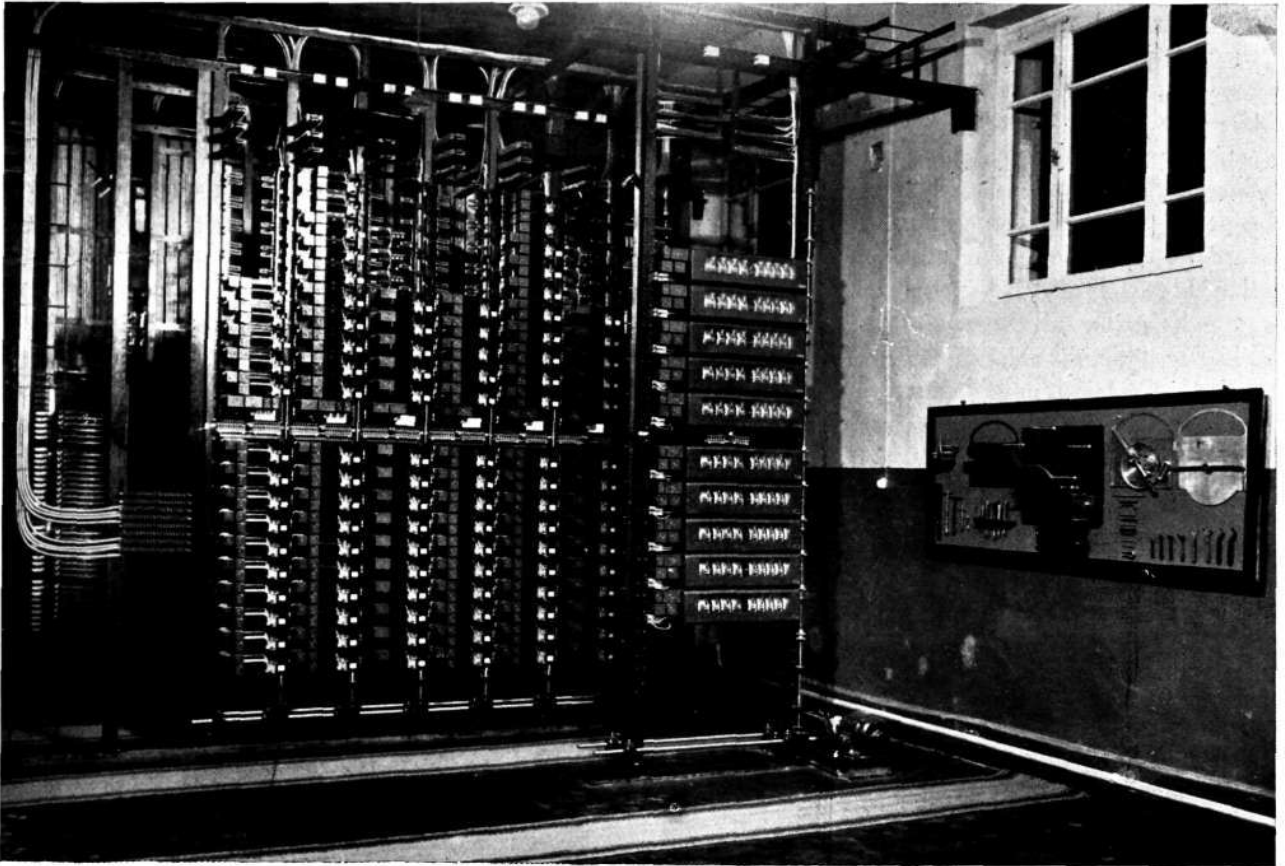
nections are carried to certain multiple frames whose contacts *d* are connected to positive, the contacts *d* of the multiple frames with only ordinary subscribers' lines being insulated from positive. The connectors proper are furnished with a contact spring *D* in like manner with the line finders. This spring *D* is connected to a relay *R* whose function it is to connect up the connector so that it shall function as an ordinary connector or as a connector for multi-line connections (P. B. X. connector), depending on which position it has been set to by the rotary movement. If it is set opposite a multiple frame containing P. B. X. lines the relay *R* is energized over the spring *D* and the contact *d*, which latter is connected to positive. If the connector is set opposite a multiple frame with ordi-



R 606 Fig. 2. Switching Relay for P. B. X. Connector.

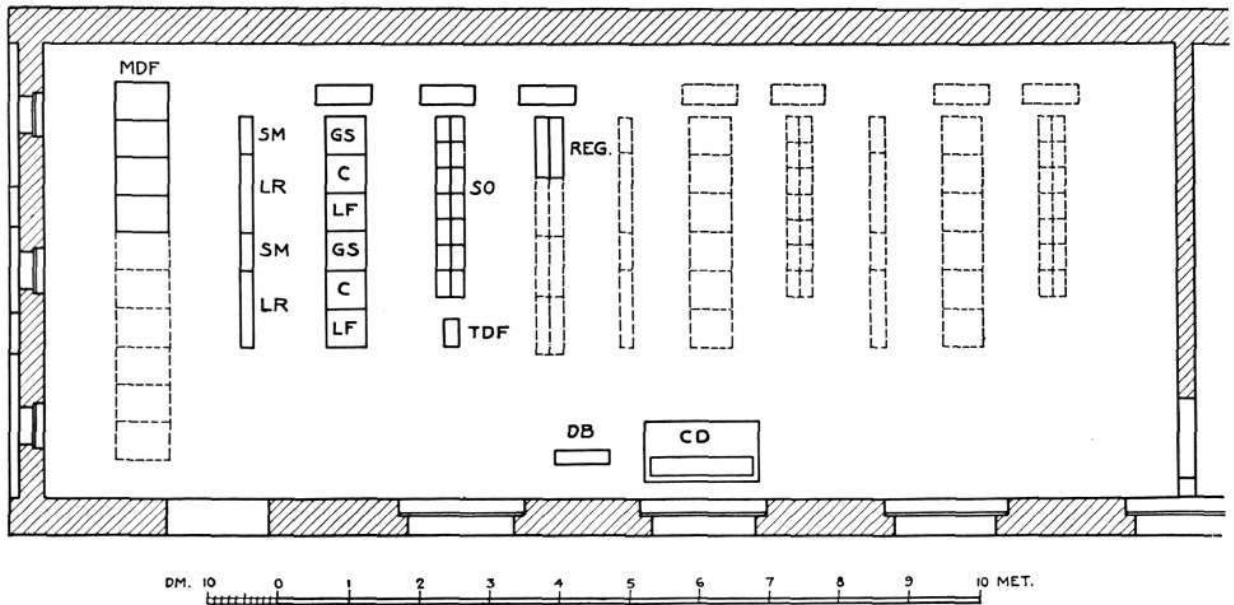
nary subscribers' lines, the relay *R* remains de-energized.

When connecting up ordinary subscribers' lines the procedure is the same as for an ordinary connector. On the other hand, if the connector is directed towards a multiple frame with multi-line connections, the relay *R* energizes and switches over the connector so that it functions as a P. B. X. connector. The connecting up of the connector to the line wanted by the calling subscriber is controlled by the register, as usual, the connector stopping at the first line of this number. If this line is disengaged, the connection is made and the ringing signal given as usual. Should the first line be busy, however, the radial movement continues and the connector seeks out and connects up a disengaged line. If all the lines belonging to this number are busy, the connector stops on the last line and the sequence switch is set to the position from which a busy signal is sent out to the calling subscriber.



R 567

Fig. 3. The New Automatic Exchange in Angora.



R 607

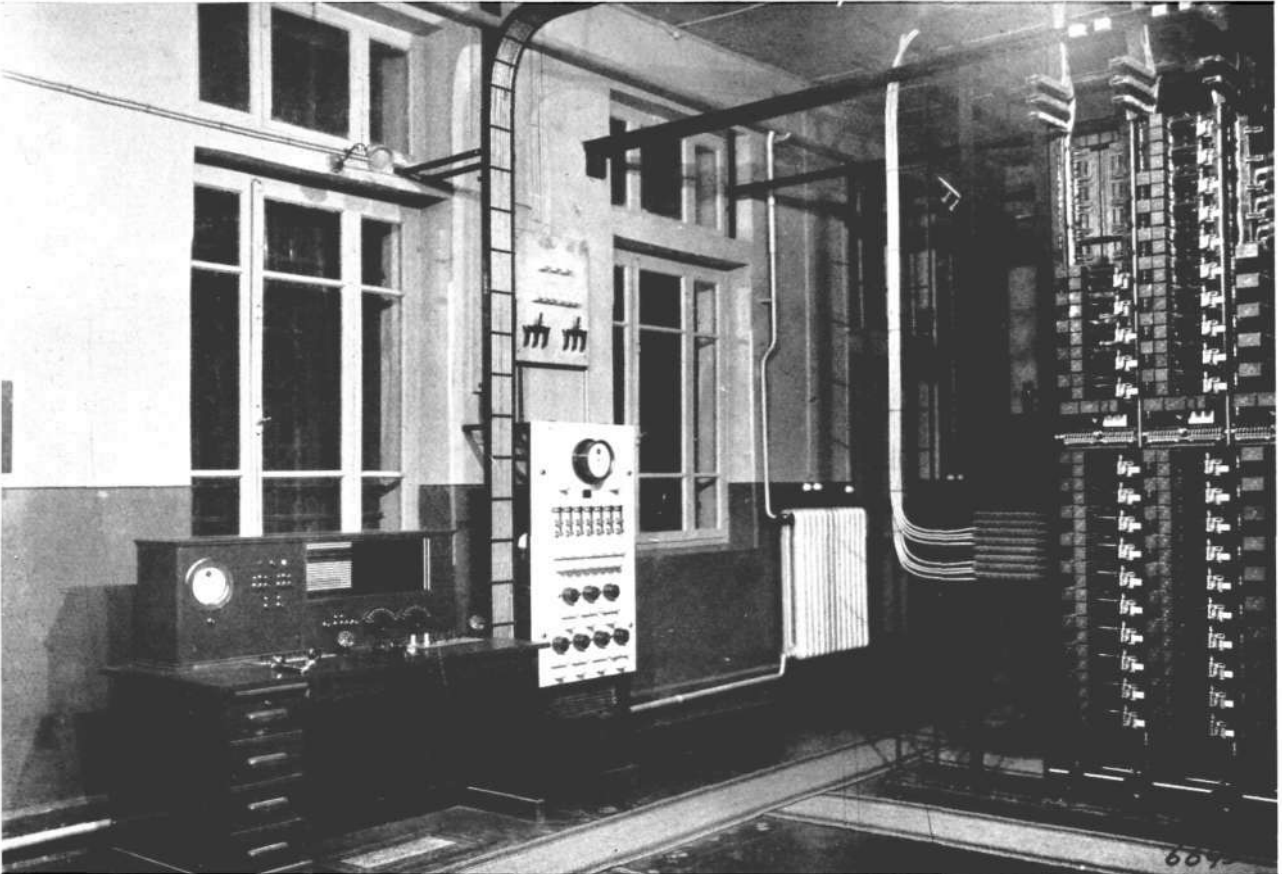
Fig. 4. Location Plan of the Automatic Exchange.

The automatic exchange in Angora (see fig. 3) is housed in a wing of the new post office building. A location plan of the automatic room is shown in fig. 4. The exchange has been designed for an ultimate capacity of 3000 lines. The designations in fig. 4 have the following meanings:

MDF = main distributing frame
LR = line relay rack
SM = subscriber's meter rack

i. e. 550 mm., and can therefore fit in very nicely between two bays of line relays, opposite the group selectors in the row of selector racks.

Ample floor space is provided in the automatic room. Not counting the main distributing frame, the floor space amounts to $14 \times 6.5 = 91$ sq. metres. Since it is possible to extend each row of racks with additional bays corresponding to another 500 lines, one can easily install equipment for a total of 4500



R 601

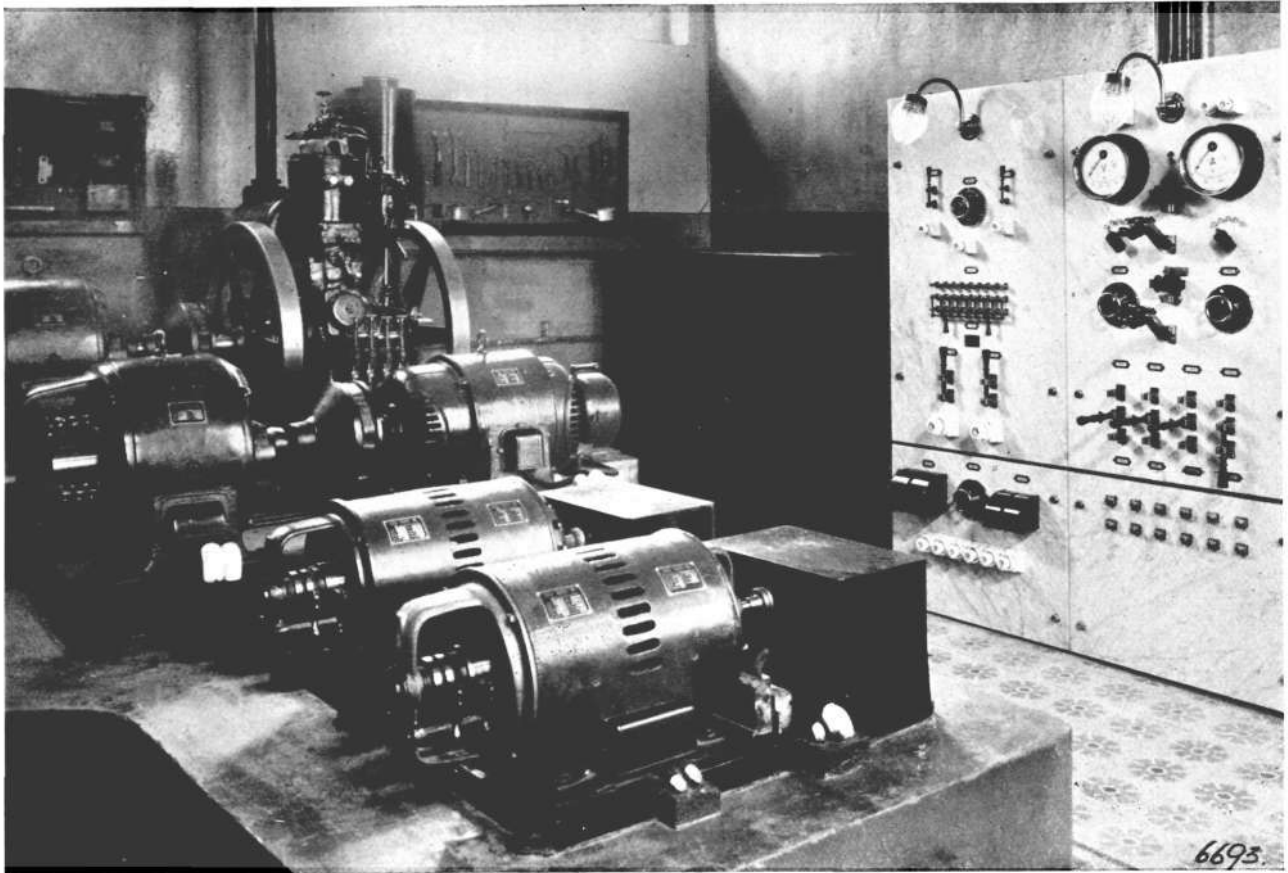
Fig. 5. Test Desk and Power Board.

LF = line finder rack
GS = group selector rack
C = connector rack
SO = sequence switch rack
REG = register rack
TDF = traffic distributing frame
DB = power distributing board
CD = test and control desk

The principle of placing the group selector racks in the same row as the line finder and connector racks is practiced to advantage in exchanges of this size, especially if the exchange is to be equipped with individual subscribers' meters. A rack for 500 subscribers' meters is about equal in length to a selector rack,

lines, which gives 20 sq. metres of floor space for every 1000 lines. This figure is about normal for the Ericsson system.

The power plant consists of two storage batteries, each one for 24 volts and with a capacity of 850 amp. hours, two charging machines, two ringing machines and a power board. In fig. 6 — which shows the power plant — the two ringing machines are in the immediate foreground, followed by the two charging machines, the one with electric motor drive while the other is driven by an internal-combustion engine intended for use in case of emergency should the feed current from the city service net be cut off.



6693.

R 602

Fig. 6. Angora.

The Power Plant.



R 604

Angora. On the Banks of the River.

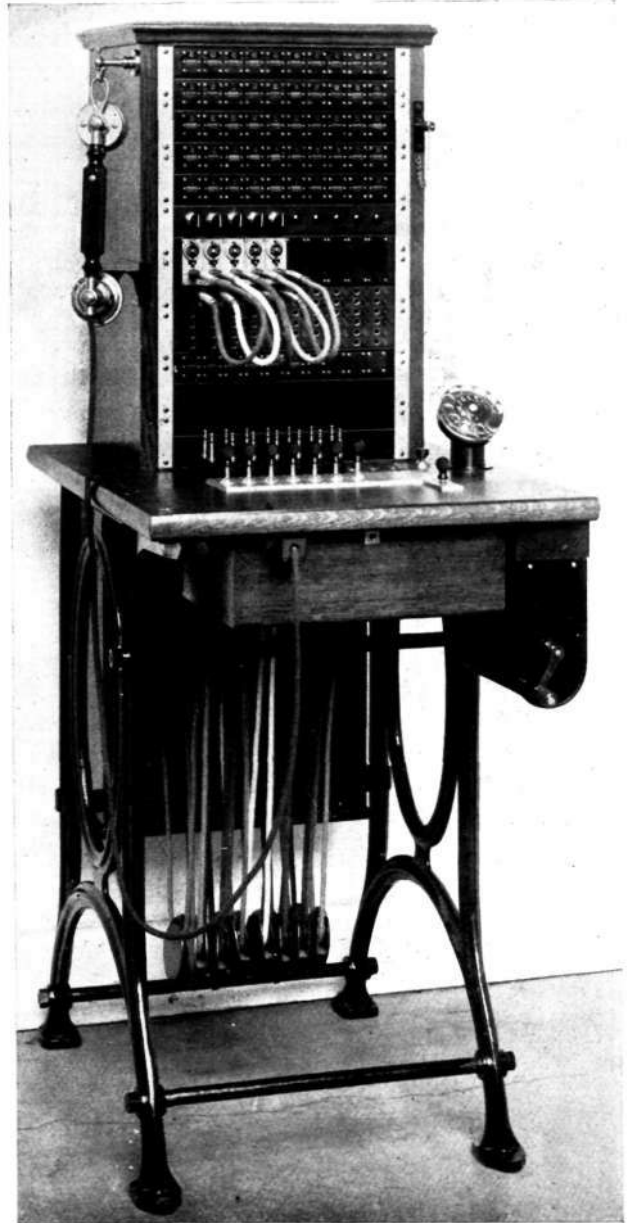
All of these machines are of Swedish manufacture. To the right may be seen the two-panelled power board. The left panel contains the instruments for the medium tension current (3 phase 380 volts main tension 50 cycles) and for the ringing machines, while the right panel contains instruments required for the charging and discharge of the storage batteries.

In addition to the automatic exchange, L. M. Ericsson has delivered two manual sub-exchanges, each one consisting of a C. B. switchboard for fifty subscribers' lines and five junction lines for junction traffic with the automatic exchange. Fig. 7 shows one of these boards executed in accordance with Ericsson's new standard type, the principle of construction with all indicators, keys and jacks in strips of five or ten units being one of its chief characteristics.

The erection, testing and putting in service of this plant was accomplished with native labour under the leadership of two expert erectors from Stockholm. Preparatory to taking up this work, two Turkish erectors were given the opportunity of going through a four months course of instruction at the Stockholm works. The extremely careful testing to which all the various parts are subjected before leaving the factory is responsible for the fact that the automatic exchange could be tested and connected up without the assistance of an engineer. As previously mentioned, the official acceptance took place on September 11th 1926 after one month's trial service, during which time the service was under the close observation of the Post Office officials.

The fact that the Angora automatic exchange is functioning to the entire satisfaction of the general public is amply corroborated by the following article, translated from the French original which appeared in «l'Echo de Turquie» for February 3rd of the current year.

»There is yet another thing, among so many others, which can give Stambul cause for envy of Angora, and that is the telephone. It gives simply wonderful service. There must certainly be a telephone god who is favourably inclined towards the telephones of our capital. No more nervous breakdowns or paroxysms of tears as when — in Stambul — you implore the young lady who is busy powdering her nose — 'en train de se graisser le museau', according to Molière's rather irreverent expression. No



R 603 Fig. 7. Manual C. B. Board for Tcham-Kaya.

more controversies with this same young lady whom it no longer is necessary to treat with the respect due some supernatural being even though you get the wrong number, for this telephone is automatic. The directors of the Stambul telephone company should come here (i. e. to Angora) and study the manner in which an operating company, jealous of its good reputation, should treat its subscribers.»

G. G.

The Automatic Exchange in Forli, Italy.

The following lines concerning the inaugural ceremonies which took place at the opening of the Forli automatic telephone exchange are taken from the Rome newspaper «Lavoro d'Italia» for November 18th of last year.

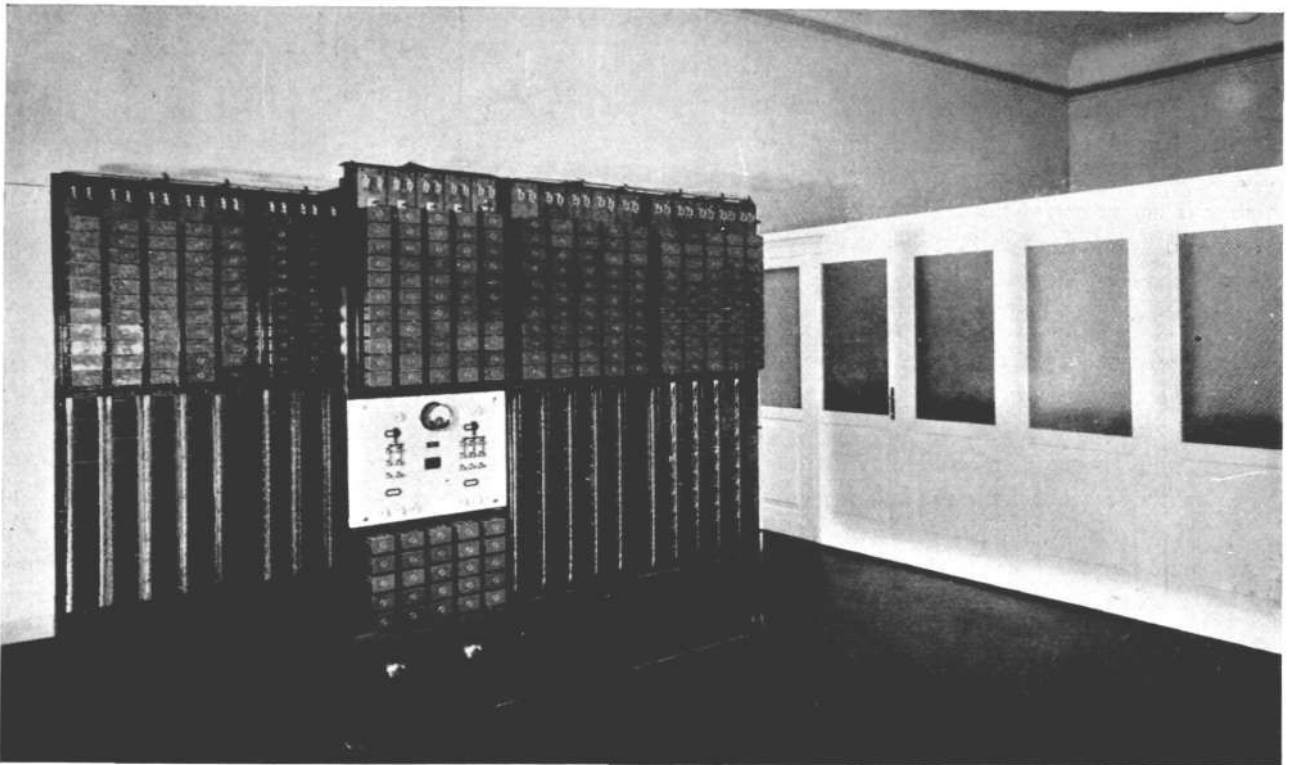
«Yesterday (Nov. 17th, 1926) the telephone company Società Telefoni Italia Medio Orientale (Timo) celebrated the opening of the Forli new automatic telephone plant with a simple and appropriate ceremony.

This event was greeted with extreme satisfaction by the citizens of Forli, who follow with enthusiasm the developments in the capital of our provins brought about by Benito Mussolini and his Fascist government».

The above mentioned event is noteworthy insomuch that this is the first instance where an automatic switchboard of the OL 500 system has been installed

in a city exchange. The OL 500 system, described in Nos 1 & 2, Vol. II, was originally designed for private branch exchanges, for which type of installation it still is imminently intended. However, the Forli plant proves the adaptability of this system for small public nets, the capacity of which does not exceed 500 subscribers.

The results obtained at Forli have been so satisfactory that the OL 500 system has been further improved upon with a view towards making it fully up-to-date for use in public nets. Thus, intermittent ringing has been introduced. One drawback with this system was that the number of simultaneous calls was restricted to twenty-five. The schematic upbuilding of the system has now been completed in this respect, permitting an increase in the number of cord circuits to between forty to forty-five.



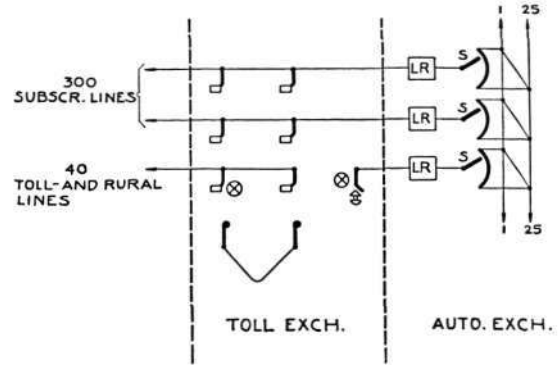
The Forli exchange is equipped for 300 subscribers' lines, the capacity of the main distributing frame being 500 lines. The power equipment is wholly of Italian manufacture and has been delivered through L. M. Ericsson's Italian subsidiary »Società Ericsson Italiana» in Genoa. Fig. 1 shows the automatic switchboards for 300 lines. The racks are erected in two rows, the front one containing equipment for 100 subscribers' lines, service equipment for twenty-five cord circuits, five registers, the necessary alarm devices and a power switchboard. The second row contains equipment for 200 subscribers' lines.

Within the near future, Forli will receive a new, modern toll exchange, also from the Ericsson works in Stockholm. This toll exchange will be equipped for twenty toll lines, twenty rural lines and necessary order wires, the initial equipment calling for three operators' positions, two of which will handle ten toll lines each, and the third one the twenty rural lines. The toll switchboards will be of an entirely new construction, designed especially for exchanges of this capacity.

Fig. 2 shows a skeleton diagram of the Forli plant. To the extreme right is the OL switchboard, each subscriber's line having its own line relay *LR* and cord circuit selector *S*. The subscribers' lines are multiplied through the toll boards. In this way the toll calls are kept clear of the automatic switchboards, the toll lines being connected up directly to the sub-

scribers' multiple jacks. Only the order conversations pass through the automatic local exchange.

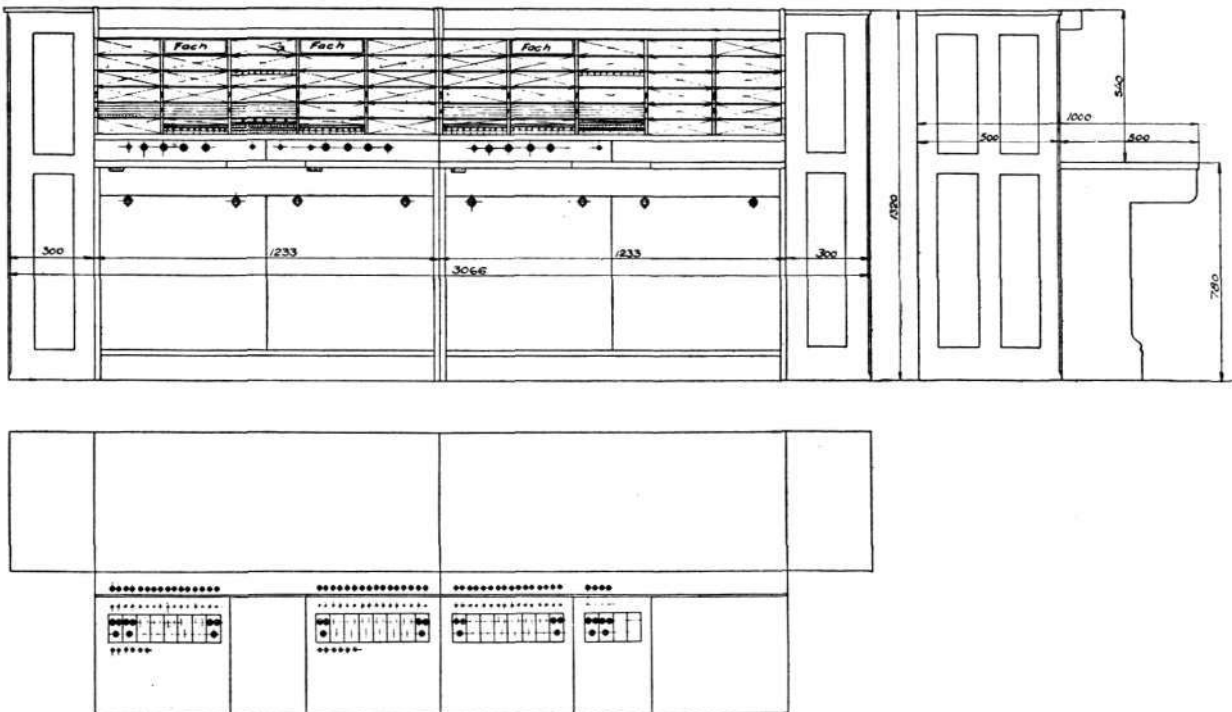
A drawing of the toll sections is shown in fig. 3. Each board has two positions, the last position being unequipped for the present.



R 656 Fig. 2. Skeleton Diagram of the Automatic and Toll Exchanges.

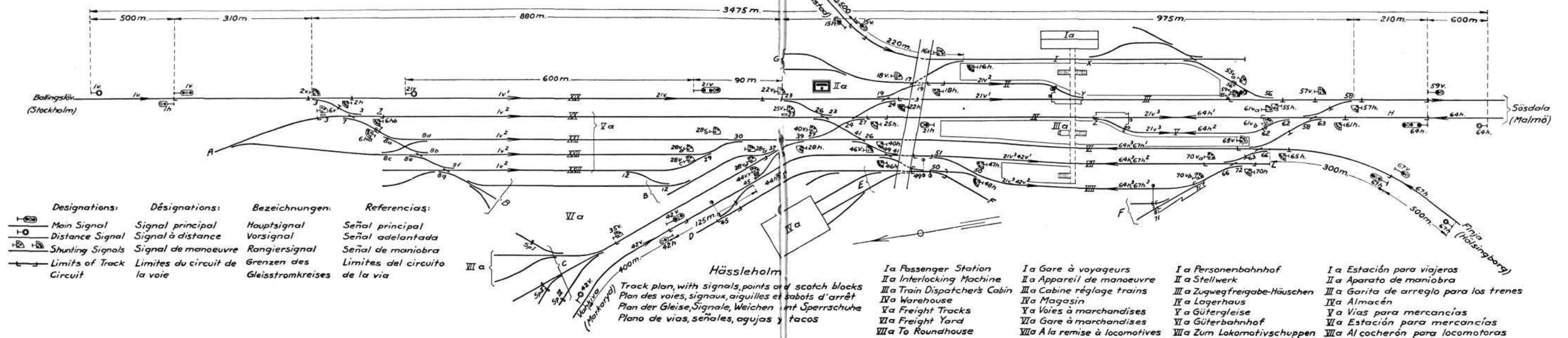
Forli is the capital of the fertile province of Romagna. It has a population of about 50,000 and can boast of many glorious anals of the past, in similarity with most of the provincial towns of central Italy. In the 13th century, Forli was a free city, sufficiently bold to take up war with such powerful enemies as Venice, Bologna, Florence, and even the pope. The city has some beautiful buildings, such as the St. Mercuriale cathedral and the City Hall, containing frescoes and other works of art of inestimable value.

G. C.



R 658

Fig. 3. Toll Board for Forli.



By Ivar Larsson, District Signal Engineer for the Swedish Govt. Railways.

At Hässleholm, one of Sweden's oldest railway junctions, private railways from Hälsingborg, Kristianstad and Veinge-Markaryd meet the government line Malmö—Stockholm. Already some years ago the growth of the traffic necessitated the rebuilding of the station yard. Since the available space did not permit of making the track yard sufficiently wide, its length had to be increased as well. This resulted in a railway yard of considerable length, as may be seen from the above plan, with a passenger station in front of the station building — adapted also for the dispatch of freight trains — and a freight station at the north end.

It was considered necessary to equip the new station with an interlocking plant partly to give the traffic necessary safety protection, partly to effect a reduction in the number of employees. The extreme length of the station excluded the use of anything but an electrical system. A preliminary project called for two interlocking machines, one for the south end and one for the middle portion and north end. However, an investigation showed that such a solution would not

make possible the desired reduction in personnel. It was then found that one single interlocking machine would be sufficient if certain newly developed devices and arrangements were used. These devices are the so-called track circuits which, among other things, permit the control of the cleared or occupied condition of a track; the illuminated track plan, by means of which the movements of the trains on a track system — located at too great a distance from the interlocking machine to make direct surveillance possible — can be accurately followed; and lastly, the systematic use of track blocking signals, thereby enabling the interlocking to control switching operations even in distant sections of the station yard.

The interlocking machine is located in that portion of the yard where switching operations occur most frequently, this location being most suitable also for the supervision of the movements of the locomotives to and from the roundhouse.

The track switches are divided up into three main groups: the south end, the middle portion and the north end of the station yard. These groups have been

treated differently with respect to their relative positions to the interlocking machine as well as to the varying traffic conditions in the different parts of the station yard.

All the track switches in the south group are manoeuvred from the interlocking machine only. Different switch positions are required for the clearing of the different tracks, making a centralized points control absolutely necessary. Switching of freight trains does not occur in this end of the station yard, only shunting of passenger cars and locomotives. These latter movements, however, are entirely controlled by the distant interlocking machine which can give or refuse permission for certain train movements by means of scotch block signals. Signals of this type have been arranged in sufficient number to regulate all possible switching operations. When set to clear, these signals lock all switches in the cleared track; also track circuits are made use of for locking the points during shunting operations in this section of the track yard, thus preventing the accidental laying over of points under a moving train even though a scotch block signal be set to stop before the train has passed all the points. The track circuits are also used to control the clearance of switching tracks.

The middle points group lies so near the interlocking machine that it can easily be surveyed by the men in the signal cabin. This fact made it unnecessary to arrange track circuits for the entire group, the locking of certain more distant points having been

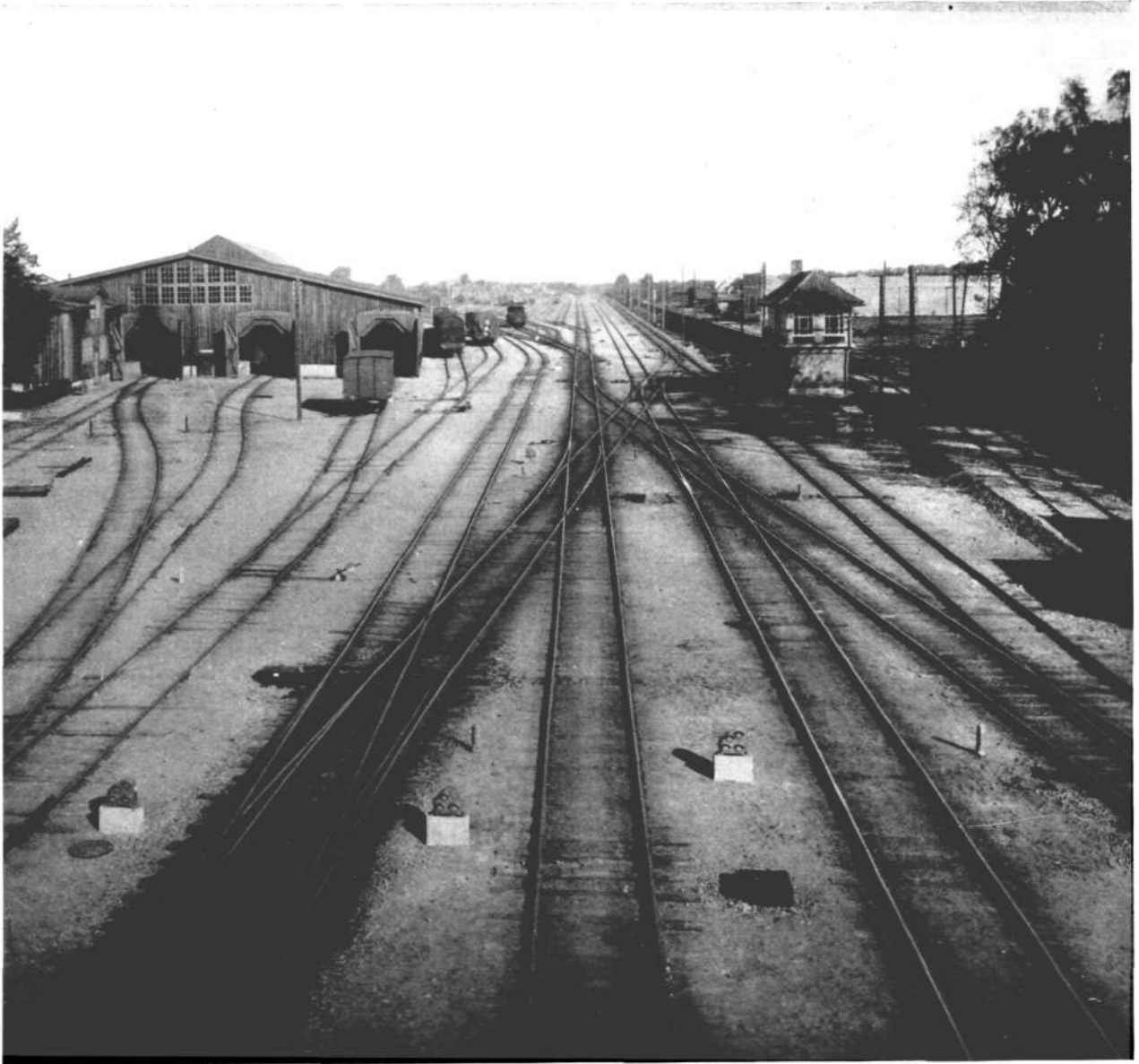
found satisfactory. However, scotch block signals for all shunting operations have been provided here also. As long as such a signal is set to clear, all points under its control are locked, thereby safeguarding the traffic to a certain extent against the laying over of points under a passing train even during shunting operations. The degree of safety is not so large as with track circuits, however, for if a signal is set to stop before the entire train has passed all the points under its control, there is nothing to prevent a point being laid over under the moving train. It was not deemed necessary, however, to introduce track circuits here also; they were therefore omitted for reasons of economy. Varying switching operations as well as the making up of freight trains may take place in this section of the yard.

It was found possible to give the north points group a much simpler formation. Most of the trains pass through on main track no. XIX, only a few freight trains being admitted to the freight yard through this group of points. Since men are always required to take charge of the freight trains immediately upon their arrival, it was found sufficient to provide local manoeuvring and locking for the points. Only a small number of points were put under central control, viz., those that enter the main track running through this group, and those that require setting when switching to or from track XX — the second main track for a future double track line. This track has a steeper grade than the present main track, thus offering

better starting conditions for north-bound freight trains from the passenger station.

The skotch block signals give the interlocking machine such complete control over all train movements within the station yard that it is possible to run the

can be directed to any of the tracks IV to VII, and southbound trains to tracks II to V, VII and VIII in the passenger station yard and to any of the four freight yard tracks; while northbound freight trains can be directed to the freight yard over either of



R 591

View of Station Yard with Signal Cabin at Right.

locomotives to and from the engine house without the aid of an engine pilot.

The number of shunting tracks which can be locked amounts to 128.

A comparatively large number of tracks have been provided, their use for different purposes being optional. From the Govt. Railway line northbound trains

tracks IV to VII in the passenger station yard. For trains entering from private lines the choice is not so large, depending on the limitations of the track system. One of them, however, has an incoming track leading to three passenger station tracks while its freight trains can pass in directly to any of the four tracks in the freight yard. Both of the others have one and two

incoming tracks respectively, freight trains being directed from these tracks to the freight yard by means of switching operations. Outgoing tracks have been provided to about the same extent as incoming tracks. The total number of track combinations amounts to twenty-six.

All the signals in this plant are arranged as light signals. The main signals are of the colour signal type, the skotch block signals being form signals.

The home signals in clear position show from one to three green lights. Since the number of incoming tracks passing certain signals sometimes exceeds the number of green lights, the track signalling system is not altogether complete, so that two or three green lights sometimes apply to several tracks.

The number of outgoing signals is restricted to one for all tracks leading towards the same line and, in addition, one starting signal for each of the main tracks III and IV (main line of the Govt. Ry.). Only these latter have been placed as has hitherto been customary in Sweden, i. e. in front of the points group to be passed by the outgoing train. The others are set on a level with the home signals. As a result, it is not possible for the locomotive engineer to ascertain whether or not the right track is cleared by merely observing the starting signal, partly because it is placed so far out that it cannot be observed from the point of departure of the train, partly because it shows the same combination of lights for several tracks. However, the engineer can control the outgoing track to a certain extent by means of the skotch block signals which in Hässleholm are so arranged that they show clear by means of two lights on the same perpendicular for regular traffic tracks, and two lights, one above and to the left of the other, for shunting tracks. As a result the skotch block signals play the role of a sort of dwarf starting signals. Thus, the combination of skotch block signals which has been applied in Malmö — described in Vol. III, Nos 1 & 2, page 6, of this journal — has not been duplicated in Hässleholm, neither is it needed, since switching operations occur to a much smaller extent. In cases where an outgoing track can be cleared to several lines from the same station track, it is impossible — by means of the skotch block signals — to ascertain whether the outgoing track leads towards the correct line, but mistakes are not possible since all outgoing tracks must be released by the station master before a signal can be set from the interlocking machine.

The signal cabin is built in two stories. In the first story are placed the power plant and storage batteries;

here, also, is a repair shop and boiler room for the heating plant. The interlocking machine, with the illuminated track plan standing free behind it, is placed in the upper story, the longer wall being lined with relay cabinets.

The interlocking machine comprises thirty-two point locking levers and twenty-five signal levers, with fifteen extra levers for future needs. Forty-four points and skotch blocks and thirteen main signals can be manoeuvred from this machine, while forty-one skotch block signals and ten locally set points can be locked by means of the point locking levers. As far as the



R 593

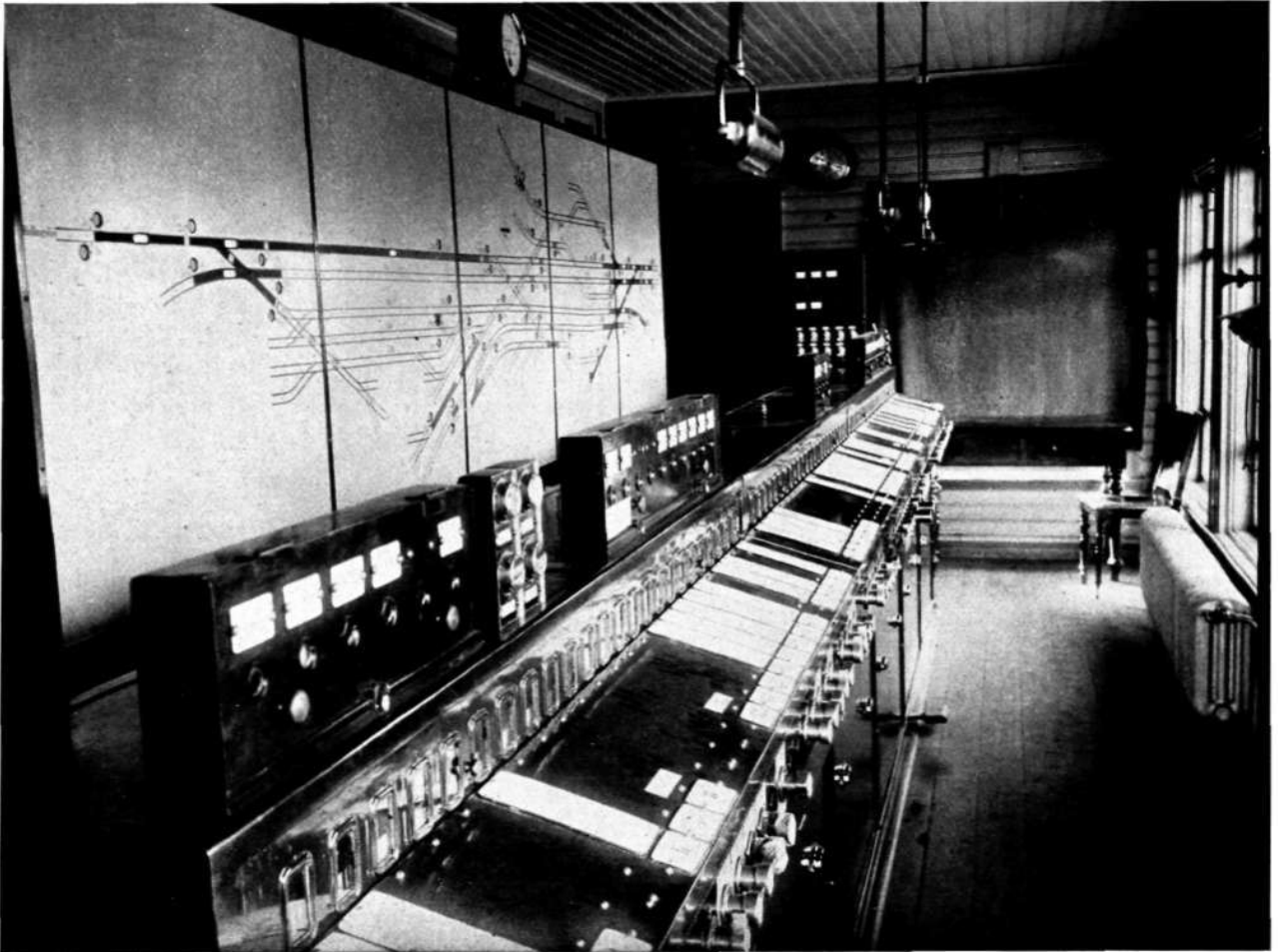
The Signal Cabin.

track system will permit, two points are manoeuvred by the same lever, the points being connected in parallel and functioning simultaneously. The interlocking machine is of an entirely new construction and differs considerably from the former Ericsson type, one of its most prominent characteristics being the absence of a mechanical interlocking gear. All necessary combinations of control locking between the various levers are accomplished electrically by means

of locking magnets which act directly on the levers. Control of the points is obtained by means of special A. C. relays mounted outside of the interlocking machine. The operating of the point levers is accomplished with two different motions — first, the knob is given a turn of 75° , which starts the motor or motors, after which the points must be completely laid over to their new position, in which they close a control cir-

tion of providing — in co-operation, with an insulated rail — means of preventing premature setting of a point under a train or car. These new functions have made it necessary to increase the angle of rotation of the lever knob from 90° to 140° .

The construction of the signal levers is similar to that of the point levers. In similarity with the older type of signal lever, it is constructed for movement



R 594

Interior View of Signal Cabin showing Interlocking Machine.

cuit and lift the locking magnet, before the knob can be completely turned, this last motion closing the contacts which form a part of the signal circuit and others controlled by this lever. The two locking magnets of the point lever have more functions to fill than in the former style of interlocking machine, since they must firstly take over the function of the mechanical cross locking gear as concerns locking, made necessary by the positions of other levers, secondly, prevent the complete turning of a lever knob until the point is completely laid over and finally retain its old func-

tion in two directions, each one with a 90° angle of rotation.

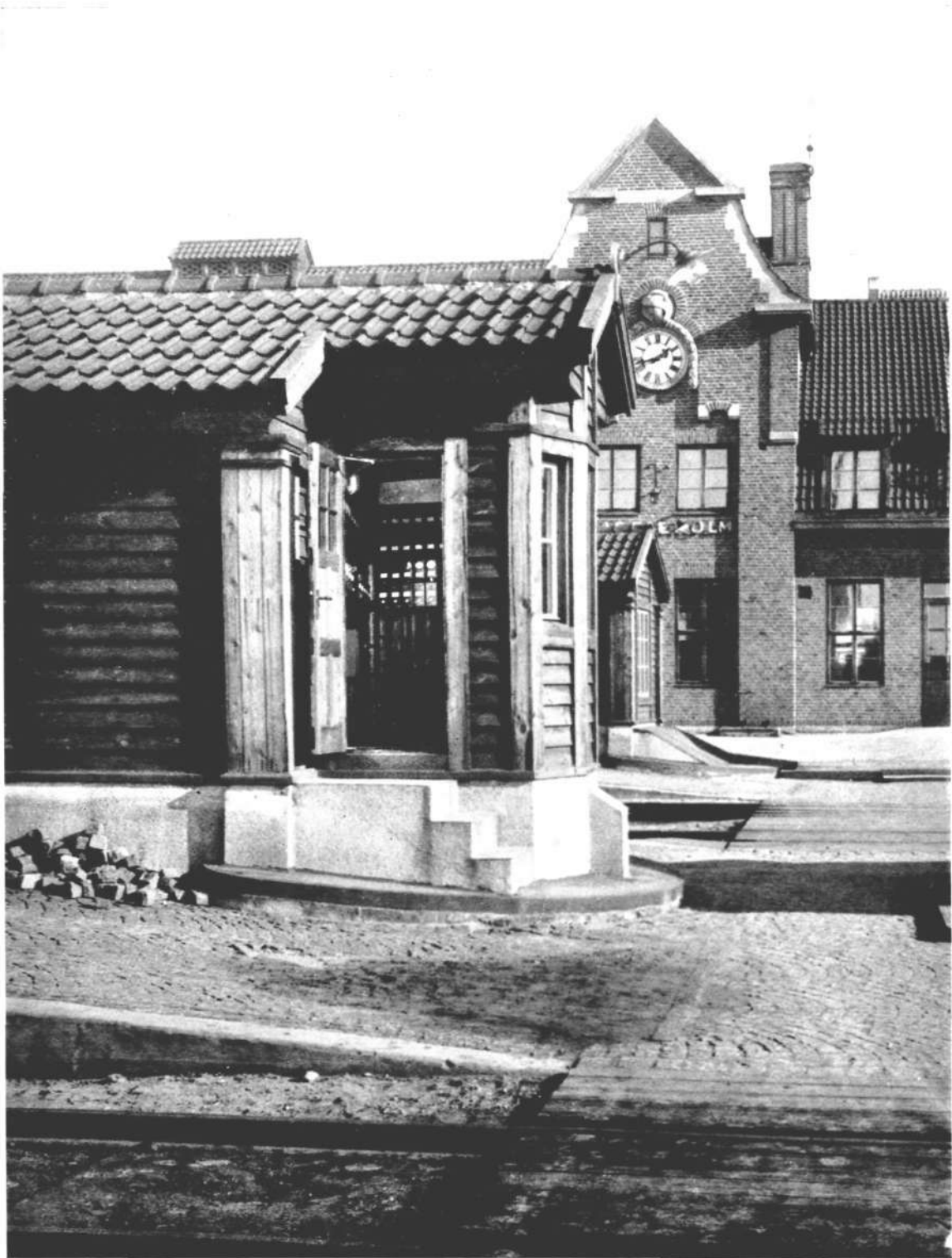
Special releasing relays with number plates have been arranged on the top of the interlocking machine. These are manoeuvred from special releasing devices in a dispatch shed, thus placing the outgoing and incoming tracks under the control of the train dispatcher. An engaged track is automatically locked by means of track locking, both incoming and outgoing tracks being released by the train itself.

The illuminated track plan repeats all the main

L. M. Ericsson

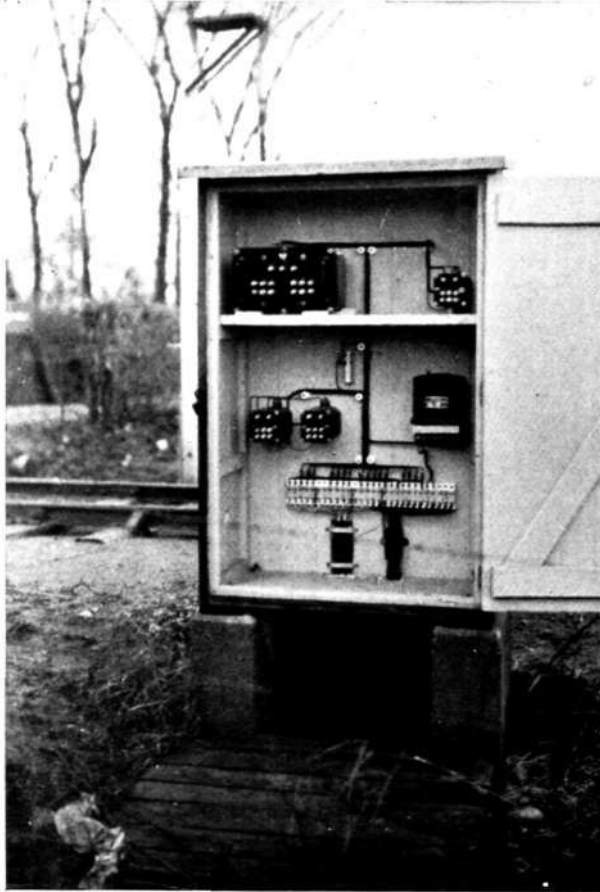
and skotch block signals, an engaged or free track, however, being indicated only for the south points group together with the tracks beyond the same, a small part of the north points group together with the

main track on both sides of the same and the track leading to the locomotive shed. All repeating is done by means of lamps, different signal combinations being indicated by means of varycoloured lamps; a clear



track is indicated by means of a glowing lamp in the window belonging to this track section.

The releasing apparatus are placed in a special dispatch shed on the middle platform. Repeaters in



R. 597

Transformer Cabinet.

the form of star indicators, giving the positions of the main signals, have been arranged in this cabin to enable the train dispatcher to ascertain whether or not the right track has been cleared.

Both alternating and direct current is used in the operation of this plant. The city service net supplies a 3-phase 50 cycle A. C. which is transformed down to 3×190 volts by means of a transformer placed within the station area. A feeder line runs from here to another transformer in the signal tower; from the secondary winding of this transformer is obtained a current of $3 \times 190/110/55$ volts. The tension of the lamps in the skotch block signals is 55 volts; in the main signals it is 12 volts, this latter tension being obtained by means of local transformers placed in the immediate vicinity of the signals. The track circuits are fed by an alternating current with a tension of about 2 volts between the rails, this current being transformed up to a tension of about 4.5 volts for feeding the track phase of the track relays in the signal cabin, the local phase being fed by a 110 volt current. Also the point control relays work with two phases, both of 110 volts. Direct current for actuating the switch motors as well as for signal relays, releasing relays, disengaging relays and locking magnets is obtained by means of a mercury-vapor rectifier for the motor current (about 130 volts) and two valve rectifiers for actuating the relays etc. (about 14 volts). Two Nife storage batteries have been provided for use in case of emergency, each one with a capacity of 60 amp. hours, another battery with a capacity of 100 amp. hours for the motor current, and still another consisting of 10 cells connected in series as buffer batteries for the relay actuating current. In case of a break in the city feeder circuit the entire plant can be run by means of a motordriven 3-phase 6.5 kw generator.

The installation of the plant was entrusted to Signalbolaget acting in the capacity of representative for L. M. Ericsson. Work was begun in the fall of 1925, the plant being ready for use in September 1926. Under present traffic conditions, not more than one man per shift is required to manoeuver the interlocking plant.



R 592

Home and Starting Signals.

Miss Constance Andersson 60 years.

On Nov. 22nd, 1891 Miss Constance Andersson entered the employ of the Ericsson concern — then known under the firm name of L. M. Ericsson & Co. — to that she is now able to look back over more than thirty-five years continuous service. Her unwonted energy and ability as well as a bright disposition spiced with both wit and humour have combined to give Miss Andersson a well-

earned popularity. On January 22nd, Miss Andersson's 60th anniversary, she had the pleasure of receiving the hearty congratulations of department heads and comrades alike, their sentiments being interpreted by a member of the office force who had composed some humorous and appropriate verses for the occasion.

Vad åren sväva framåt i livets lätta dans
och högtidsdagar firas — i dag går du Constance
nu uppför långa backen till 60 årens skans
och ständar se'n däruppe i all din ungdoms glans
och ger oss av den humor, som i ditt sinne fanns
och som du väl ju sköter vid varje leverans,
ty aldrig du förlorat din kända konvensans,
när som du slungar ut dina skarpa vitsars lans,
så att man puff kan bliva och falla uti trans,
för ingen kan ju veta var den träffar någonstans



men är repliken kraftig, som vore den en mans
och är den även saftig, så har du konvensans
att alltid söka ge den en fin och prydlig ans,
så ingen, som blir träffad, kan tappa bort sin sans;
och nu vi enligt vanan ha gått på vigilans
att få ihop som hyllning en gåva med substans —
fast inte någon villa, ty sådan sist ju vanns —
men blott ett litet minne, som köpts som det befanns,
och med detsamma följer nu denna reverans
i form utav en sirlig och hjärtelig romans,

som tolkar våra känslor för L. M. E:s CONSTANCE.

ANDERS LIGNELL,
superintendent of telephones,
Stockholm



R 660

*Member of the International
Consultative Committee for Long
Distance Telephone Commu-
nications*

American and European Toll Traffic.

By A. Lignell, Superintendent of telephones, Stockholm.

In the matter of telephones, public opinion has generally conceded America to be the great, dominating country. Also, in comparison with European conditions, the local telephone traffic of America is exceedingly heavy — about 62 % of all the telephones in the world are to be found in the U. S. A. and no European city except Stockholm can compete with the foremost telephone cities of America with regard to the procentual number of telephone instruments.

According to the statistical information at the writer's disposal, the figures in January 1925 for the largest telephone centres were as follows:

	Population	Telephones per hundred inhabitants
San Francisco ..	675,000	29.9
Omaha	218,000	28.5
Washington	468,000	25.3
Chicago	2,967,000	25.0
Minneapolis	443,000	24.9
New York	6,059,000	21.7

The corresponding figures for Europe were:

Stockholm	380,565	28.2	XII.31.25
Copenhagen	750,000	15.9	
Oslo	265,000	13.9	
Gothenburg	231,007	12.5	XII.31.25
Frankfurt a/M. ..	456,000	10.7	
Hamburg-Altona .	1,236,000	10.3	
Berlin	3,948,000	9.9	

	Population	Telephones per hundred inhabitants
Paris	2,980,000	7.6
London	7,354,000	5.9
Manchester	1,655,000	3.6

I would seem but natural to assume that the toll traffic between American cities held the same gigantic proportions, and that Europe was distanced by America even in this respect.

Such is not the case, however. In quite a number of the countries of Europe it will be found that the domestic toll traffic has been fully equal and sometimes of considerably larger proportions since many years back, and international telephone traffic in Europe is increasing rapidly since the *Comité Consultatif International des Communications Téléphoniques à Grande Distance* began to operate.

Proof for this statement is found in some tables published in the January 1927 number of *Europäischer Fernsprechdienst*. The figures concerning America are reported to have been submitted by the American members of the International Bureau of Commerce.

A compendium of these tables is given on page 21, to which certain data concerning the Swedish toll traffic have been added for the sake of comparison. Also, the population of the different cities as well as the number of calls per inhabitant and year over the various lines have been included.

The above table gives ample evidence of the fact that the United States does not hold a top position in comparison with Germany and Sweden, as concerns toll traffic, except in the matter of tariff rates.

If the necessary statistical information had been available, this condition would no doubt have been found to exist with relation to several other European countries.

As has already been pointed out, the international telephone traffic in Europe is experiencing a notable development, the establishment of new lines of communication being an almost daily occurrence, while the capacity of existing lines is being increased by the addition of new circuits.

The following figures are given to show that this traffic does not need to stand back for that of the United States in spite of differences in point of language and different executive administrations.

During the latter part of 1926 the following average numbers of conversation minutes and calls occurred per week-day:

	Conversation minutes	Calls
London—Amsterdam	1532	abt. 400
Paris—Berlin	832	» 200
Berlin—Amsterdam	1117	» 275
Germany—England ¹	1478	» 380
Holland—Switzerland ¹	480	» 120
Berlin—Prague		» 298
» —Vienna		» 346
» —Zurich		» 164
Stockholm—Berlin		» 122
» —Copenhagen		» 184
» —Oslo		» 182

Returning to the tables, we will find that the number of calls over the longer American lines with a length of 1400 to 4200 km. is of no great consequence, the maximum figure being 68 on the line New York—St. Louis and the minimum being 5 calls per day on the line New York—Denver. Lines of corresponding length have not yet been opened for international traffic in Europe, but when a number of direct lines of communication about 2000 km. in length are opened for traffic in the near future, it is safe to predict that the traffic on these lines will considerably exceed that of the American long distance lines, thanks to the very moderate European rates. For distances between 1400 km. and 128 km., this last being the shortest distance included in the

¹) New line.

table, the German as well as the Swedish toll traffic — the traffic between New York and Philadelphia being the only apparent exception — is larger than that of the U. S. A., especially if the widespread use of the telephone in America be taken into account.

Compare, for instance, the traffic between New York and Washington, a distance of 326 km., with the traffic between Stockholm and Gothenburg, an air-line distance of 403 km.

879 calls per week-day are exchanged between New York and Washington, with populations of 6 millions and 468,000 respectively, while between Stockholm and Gothenburg, with 380,565 and 231,624 inhabitants respectively, 1727 or almost the double are exchanged, but in the former case the rate amounts to 7.16 gold francs and in the latter to 1.25 gold francs.

Or compare the traffic Chicago—Minneapolis and Chicago—Cleveland — distances: 560 and 506 km., traffic: 231 and 278 calls per week-day respectively — with the traffic Stockholm—Malmö and Stockholm—Helsingborg — distances: 514 and 485 km., traffic: 806 and 352 calls per week-day respectively. The rates here amount to

Chicago—Minneapolis 11.93 gold francs
 » —Cleveland 10.87 » »
 while for

Stockholm—Malmö and Stockholm—Hälsingborg the rate for a 3-minute period does not exceed 1.53 gold francs.

The ratio between the toll traffic and the number of inhabitants is apparent from the figures given. For Sweden, these figures are much higher than for either America or Germany. The maximum figure for America is 1.2 week-day calls per inhabitant and year — and this for the record traffic between New York and Philadelphia — while the maximum for Germany is 1.4 on the line Stettin—Berlin, and for Sweden 10.7 on the line Falun—Stockholm. If we go below the distance limit of 120 kilometres given in the original table (for the line Berlin—Stettin) we will find that the traffic Uppsala—Stockholm with a distance of 65 kilometres and 2455 calls per week-day has 24.2 week-day calls per inhabitant and year. According to the table the minimum figures for Sweden are 2.0, for Germany 0.3 and for the United States 0.04.

The above shows what a beneficent influence the tariff and operating policies adopted by the Swedish Telegraph Administration have had on the development of telephone communications. It may be well

to state that in Sweden the quality of the connections — even over the longest distances — has been of the very best.

To one who has made a study of toll traffic conditions, it is not at all surprising that the United States have not been able to maintain their position of leadership with reference to the toll telephone traffic.

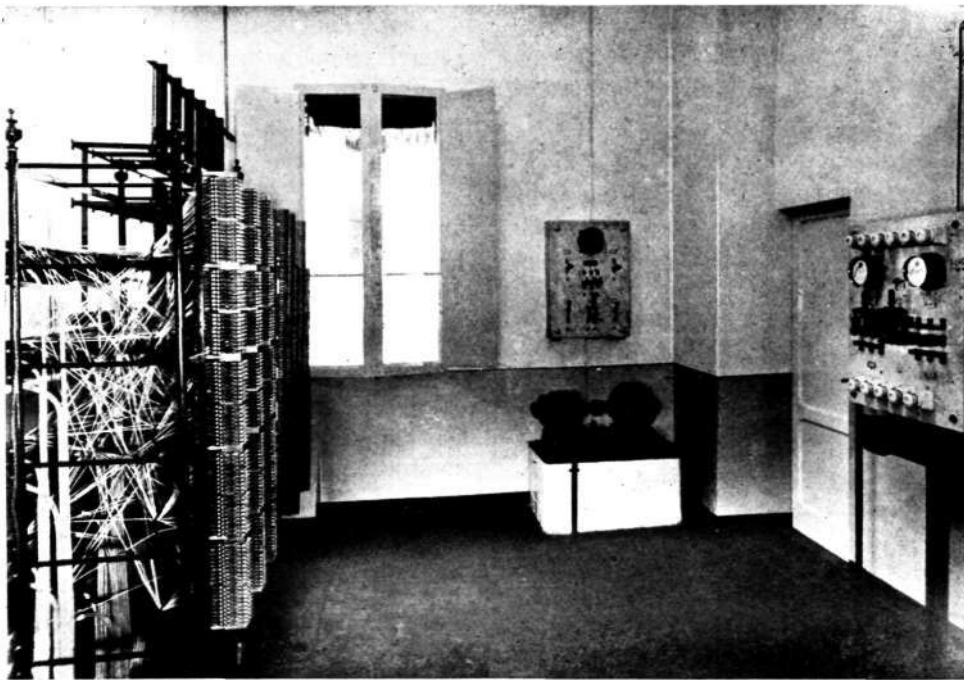
Quite naturally, it is the American tariff system which prevents the development of the toll traffic with the same speed as the purely local traffic. As a result, increased demands have been made on the telegraph. Leaving the shortest distances out of consideration, we find that the American rates are 3 to 5 times greater than the German ones and 6 to 10 times higher than in Sweden.

And where can the cause for these conditions lie?

One apparent reason is that the American tariff system is based on very short waiting times, of equal length for all calls. To obtain this result, the number of circuits in each line of communication must be large enough to permit these short waiting times du-

ring the busy hour for all calls occurring during this time. The natural result is that this great number of circuits is very inefficiently utilised when traffic is low, a very small amount of traffic having to bear the interest and amortization on the excessive cost of installation. The development of the toll traffic in Europe as compared with America is the best proof of the advantages of the European tariff policy. Quick promotion of really urgent calls with right of precedence over other calls against a special express fee and reasonable waiting times for other calls is most certainly of greater value to the general public than an equal waiting time for all calls — either urgent or not — and the resulting excessively high rates. By degrees, as the new European international traffic routes are widened to meet the growing demands, and subscription and personal calls become more general in international traffic, this tariff policy will prove as popular for international traffic as it has already done for domestic traffic in quite a number of countries.

* * *



R 709

Main Distributing Frame and Power Plant, Forli Automatic Exchange.

Dial Type of Impulse Transmitters.

When calling a number over an automatic exchange, the subscriber himself makes certain manipulations with an impulse transmitter which cause the switching devices at the central exchange to be set to their proper positions. This setting of the switching devices is usually obtained through the transmission to the exchange of certain definite series of current impulses by the calling subscriber, although it is not always the impulses themselves that actuate the switches. In the first automatic exchange, however, the selector was directly actuated by current impulses which the calling subscriber transmitted by means of push button keys, as many keys being manipulated as there were digits in the desired number. The first impulse transmitter of this type had four push button keys which were manipulated in turn, one after the other. Each key had a separate line terminating at a special driving magnet in the automatic selector. This device, however, was considered altogether too complicated and it did not take long before it was replaced by another device consisting of only one key, with an intermediate switch at the exchange for the purpose of connecting up the different driving magnets.

It soon became evident, however, that mistakes in the number of impulses transmitted were all too easily made. As a result, a new type of transmitter was adopted, having the form of a dial and by means of which the correct number of impulses were auto-

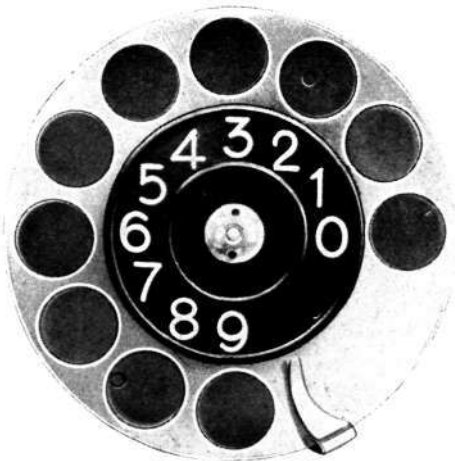
matically transmitted after it had been set to the positions corresponding to the separate digits of the desired number. A dial transmitter is rotated by hand a certain angle of a whole revolution — the length of the arc described depending on the number of impulses to be transmitted — after which it is released, a spring causing it to return with constant speed determined by a regulator to its normal position while sending out the desired number of impulses.

Actually, there are two different details of the dial mechanism that have been made the object of various inventions and modes of construction. The one is the device which prevents the sending out of impulses during the setting of the dial to the desired position, the other being the speed regulator. Also, in a few rare instances, attempts have been made to construct a device which would prevent all tampering with the dial during its impulse transmitting movement.

The speed regulator acts as a brake during the natural return movement of the dial, the principles adapted being those of mechanical friction brake, air friction brake, or pendulum of the clock pendulum type, used in clocks.

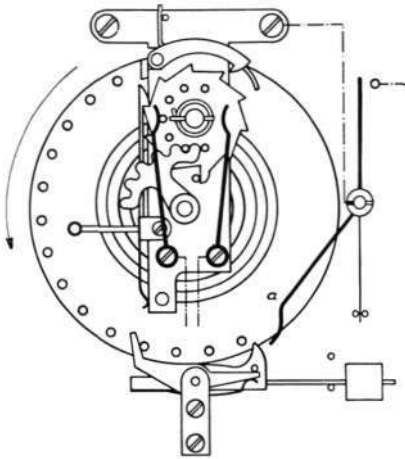
The first mentioned detail, i. e. for the prevention of impulse transmission during the setting of the dial, has, on the other hand, been the subject of numerous attempts on the part of inventors and designers to arrive at a satisfactory solution of this problem of construction.

The first — and also probably the most genial — solution of this problem is shown in fig. 1. In this construction the impulse wheel is provided with a number of pins fixed so that they stand out at right angles from the face of the wheel and so that they form an arc just inside the periphery of the wheel. An extension of the impulse contact spring is formed as an arm *a*, the extremity of which is spatulate shaped and bent at an angle. When the disc is actuated, the pins come in contact with the spatulate end of this arm and force it over to one side or the other, depending on the direction of the rotary movement. During the setting of the disc the arm is pushed over on the



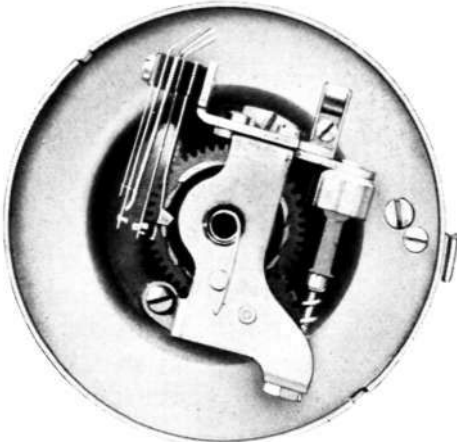
R 732

outside of the pins, causing the contact spring to move away from the point of contact; when the disc returns to its position of repose the end of the arm is



R 733 Fig. 1.

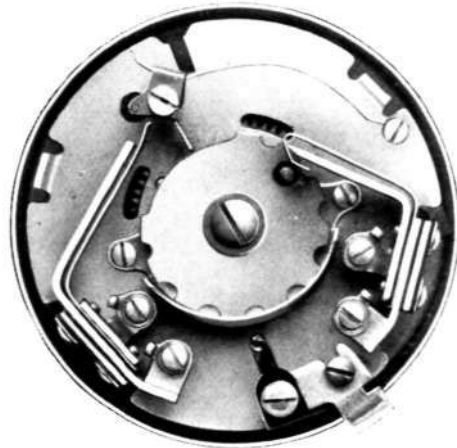
brought over to a position inside the arc of pins and the contact spring closes its contact each time the arm is pushed over by one of the passing pins, thus transmitting a number of current impulses equal to the number of pins that have passed. A number of diffe-



R 727 Fig. 2.

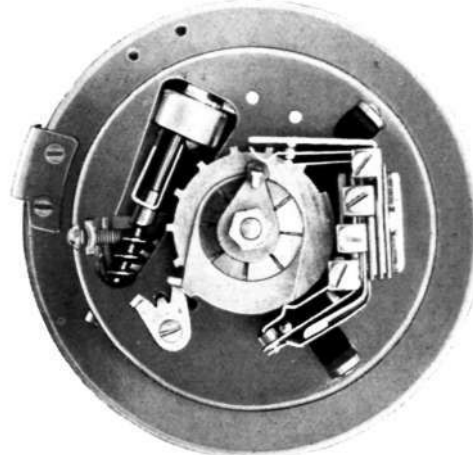
rent types of impulse wheels have since been constructed on this same principle with a view towards making them cheaper. Thus, they have often been made of pressed sheet metal with impulse teeth or pins placed at an angle, either in a radial or an axial direction. An impulse transmitter of this type is shown in fig. 2.

A very similar design is shown in fig. 3, the aforementioned arm being replaced by a pivoted tilting lever arm which moves away from the contact springs when the disc rotates in the one direction and actuates the springs when the disc rotates in the other direction, thus giving the desired number impulses.



R 726 Fig. 3.

A serious disadvantage with this type of construction is that the tilting lever can jam against the first impulse cam when the movement of the disc is reversed and it starts to return to normal. This can be avoided by fixing the pivot of the tilting lever to one of the impulse springs or to an intermediary spring, thus providing the tilting lever with a movable point of suspension.



R 730 Fig. 4.

In the impulse sending device shown in fig. 4, the transmission of impulses during the setting of the dial is prevented by means of a loose, protecting cam placed beside the impulse wheel and which is pressed against this latter by means of a spring. The movement of this cam is limited by two stops. The cam has the added function of preventing the transmission of impulses also during the first part of the return movement of the disc. This impulse transmitter has the advantage of an almost noiseless functioning during the setting as well as during the return movement.



R 729

Fig. 5.



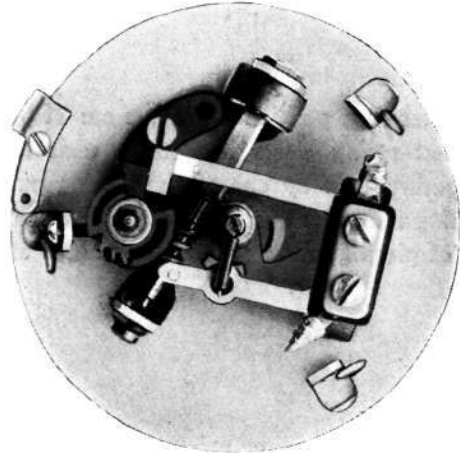
R 728

Fig. 6.

Fig. 5 shows an impulse transmitter which is an improvement of the foregoing although it functions on practically the same principle. The spring that presses the protecting cam against the impulse wheel also strives to give the cam a rotary motion in the same direction as the impulse wheel when its movement is reversed. This arrangement provides a certain guaranty for the immediate resetting of the cam to its new position.

All of the above mentioned impulse transmitters have one feature in common, i. e. the impulse wheel is attached to and follows all the movements of the perforated disc of the dial.

The impulse transmitters shown in figs. 6 and 7 are built on a different principle, the rotating movement of the impulse wheel being in one direction only. This construction permits the elimination of all devices for preventing the transmission of impulses during the setting of the dial, since the impulse wheel is at rest during this movement. Instead, it is necessary to equip the impulse wheel with a couple of locking devices, the one to prevent it from rotating during the



R 731

Fig. 7.

setting of the dial, the other to lock it to the disc of the dial during the return movement of the latter.

Besides the above described impulse transmitters there are others of entirely different types. Since these are very seldom used, however, they will not be taken up for discussion.

CONTENTS OF THIS NUMBER: To our Readers and Collaborators. — Swedish Telephones in Angora. — The Automatic Exchange in Forli, Italy. — The Hässleholm Electric Interlocking Plant. — Miss Constance Andersson 60 years. — American and European Toll Traffic. — Dial Type of Impulse Transmitters.

The L. M. Ericsson Review



VOL. 4

APRIL-JUNE 1927

Nos. 4-6



R 715

THE LATE LIEUT. COLONEL PATRICK WALTER D'ALTON.
Member Board of Directors of Ericsson Telephones Ltd.

ENGLISH EDITION

THE L. M. ERICSSON REVIEW

ENGLISH EDITION.

JOURNAL OF
TELEFONAKTIEBOLAGET L. M. ERICSSON, STOCKHOLM.

Responsible publisher: HEMMING JOHANSSON

Editor: WOLDEMAR BRUMMER.

Issued quarterly. ~ ~ ~ ~ ~ Yearly subscription rate: 7/-

All communications and subscriptions to be forwarded to the Editor.

In memoriam.

On April 10th 1927 Lieut. Col. P. W. d'Alton, member of the Board of Directors of our British subsidiary "Ericsson Telephones Ltd.", died at Westcliff, at the age of 71. He was a brilliant electrical engineer, and his undoubted authority and ability made him an outstanding figure in all parts of the engineering world.

After having completed his education at Dublin University and King's College, London, he first tried his hand at civil engineering, but speedily turned to the mechanical branch, where he became — among other things — a pioneer of submarine construction, acquiring merits as chief engineer to the Nordenfeldt Submarine Boat Company. In 1889 he entered the electrical industry, joining Mr. S. F. de Ferranti in the London Electric Supply Corporation. Here he served first in the capacity of assistant to Mr. Ferranti, taking charge of the Depford power plant in London. Shortly thereafter he succeeded Mr. Ferranti as engineer-in-chief to the corporation.

During the South-African war he served as major, after which he became chief engineer to the Central London Railway. In 1903 we again find him with an industrial enterprise in the capacity of chief mechanical engineer to Messrs Dick, Kerr and Co., Ltd., who carried out the electrification of the Liverpool-Southport Railway under his able leadership.

In 1914 Col. d'Alton retired and took up private practice as a consulting and inspecting engineer.

On the outbreak of the Great War, Col. d'Alton, whose age was against any active participation in the conflict, devoted his energies and experience to his country in "Work of national importance". In 1916 he was appointed chief engineer of the Valuation Advisory Committee, an office which he held until 1921.

Ericsson Telephones Ltd., then known under the name of The British L. M. Ericsson Telephone Mfg. Co. Ltd., had the privilege and pleasure of counting Col. d'Alton among the members of its board of directors since 1921. The loss to this company of his highly valued services is deeply felt and regretted.

Obituary.

R 66₃

Ir. P. de Vries D. zn.

We have to record with regret the death at Rotterdam of Pieter de Vries D. zn. on February 20th, at the age of 44. Mr. de Vries entered the employ of the Rotterdam telephone administration in 1915, advancing two years later to the post of assistant superintendent. The loss occasioned by his death is well depicted by director Boom, chief executive of this administration.

»The death of Mr. de Vries, after having served for nearly twelve years as my right-hand man, means an irreparable loss to the telephone administration. In the capacity of assistant superintendent, he filled his position as efficiently as could well be possible, and he always found time to lend an ear to those who sought his advice. His frank, unassuming and kindly nature made it a pleasure to apply to him for aid or advice, which was always generously given. In case of dissension, the work itself always received first consideration, no matter who the persons involved might be. His wide practical experience in the field of telephony together with his good judgement were invaluable to the telephone administration. Several departments of the administration — especially the shops and line division — will reap the benefits of his instructions and endeavour for a long time to come.»



R 714

The late baron C. d'Aulnis de Bourouill.

In the death of Baron d'Aulnis, the Amsterdam firm Koopman & Co. — L. M. Ericsson's general representatives in Holland and her colonies since several years past — has lost one of its shareholders and collaborators.

Baron d'Aulnis first took up the study of engineering in America and later on at the Karlsruhe technical college. The war forced him to break off his studies, however, and it was not until 1919 that he was able to take his degree, now at the technical college in Delft.

Since he did not associate himself with Koopman & Co. until September 1926, L. M. Ericsson has unfortunately not had the pleasure of benefitting by his services for more than a few months. Already at an earlier stage in his career, baron d'Aulnis had acquired merits within the Swedish industrial field in the capacity of president of »Kogellager», Dutch subsidiary of the Swedish ball-bearing works »Nordiska Kullagerfabriks Aktiebolaget».

He was carried away by death on April 9th, after a brief illness, while visiting Stockholm in the interests of his firm. His death in the prime of life is a loss deeply felt by Telefonaktiebolaget L. M. Ericsson as well as by Koopman & Co. who, judging by his previous record, had all reason to expect much of a continued collaboration with him.

Three semi-centenarians.



R 653

E. G. Windahl.



R 665

Per Edward Allén.



R 662

Gustav Wettermark.

After having graduated from the Royal Institute of Technology at Stockholm in 1897, Mr. E. G. Windahl entered the employ of the Swedish State Railway Administration and a few years later he became head of the then newly instituted signal and safety departments for this same administration. His keen interest for this new work together with his intense and conscientious labours in this line soon placed him among the foremost experts on the subject. When, in 1915 — soon after the outbreak of the world war — Telefonaktiebolaget L. M. Ericsson decided to start in with the manufacture in Sweden of railway signal material, Mr. Windahl was induced to take over the organization and leadership of this line of manufacture, and L. M. Ericsson's railway signal and safety department still has the advantage of his able guidance. The subsequent growth and successful activities of this department have recently been taken up in detail in N:o 2 of the »Ericsson News», these successes having been made the theme of a versified complimentary address read on the occasion of his receiving the congratulations and good wishes of his comrades and associates on March 29th.

Mr. Windahl's winning personality — characterized by modesty and unaffectedness in his intercourse with others — has made him both liked and respected by all with whom he has come in contact both in his work and in private life.

On March 25th a highly valued member of the Ericsson office staff, Per Edward Allén, passed the half-century mark.

As head of the company's shipping department, Mr. Allén has a long term of faithful service to look back upon. He has held this position for a period of over thirty years, during which time he has been in a position to witness the wonderful growth and development of this enterprise. Quite naturally, this growth has been responsible for a corresponding increase in Mr. Allén's duties and responsibilities but, judging from all appearances, the increase in work has been accompanied by an increased vitality.

His work has brought him in contact with a great number of persons both at home and abroad and

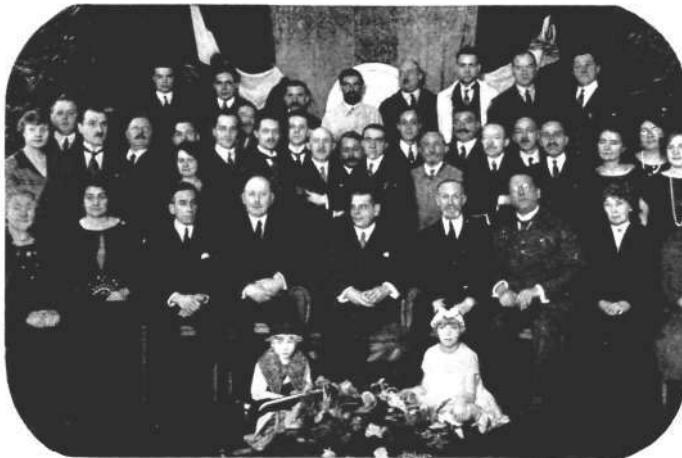
L. M. Ericsson

everywhere has his personality been valued and esteemed. His sound and loyal character, his constant readiness to be of help and assistance, his keen interest in a wide range of varied subjects, have all acquired for him a circle of friends which in number far

exceeds what is customary. The high estimation of his amiable character may to some extent be gauged by the many felicitations in various forms of which he was the recipient on this occasion.

After having taken his degree at the Royal Institute of Technology at Stockholm, Gustav Wettermark entered the service of the Swedish Telegraph Administration, in whose shops he was employed until 1907, when he transferred his activities to the Ericsson company, then known under the name of Aktiebolaget L. M. Ericsson & Co. When the company's French subsidiary — "Société des Téléphones Ericsson" — was formed in 1911, Mr. Wettermark was appointed technical director of this new branch, the works in Colombes being erected in 1912 under his leadership. In 1913 these shops stood ready, prepared to take up the manufacture of telephone material. At the outbreak of the war in 1914, however, they were forced to discontinue their normal activities and take up the manufacture of war munitions, returning to the telephone line in 1919.

This factory has made important deliveries to the French Post Office, Telegraph and Telephone Department. The official recognition in the form of the decoration of the Legion of Honour, conferred upon Mr. Wettermark in January 1926, gives sufficient proof of the satisfactory manner in which these deliveries have been made. This distinction was celebrated at the Ericsson works in Colombes on January 27th 1926 at a ceremony arranged by the personnel, and the speeches held on this occasion give testimony of the feelings of esteem and affection with which Mr. Wettermark is surrounded. These feelings together with the mark of honour bestowed upon him by the French Government prove that Director Wettermark has made the name of his native country honoured and appreciated on foreign soil.

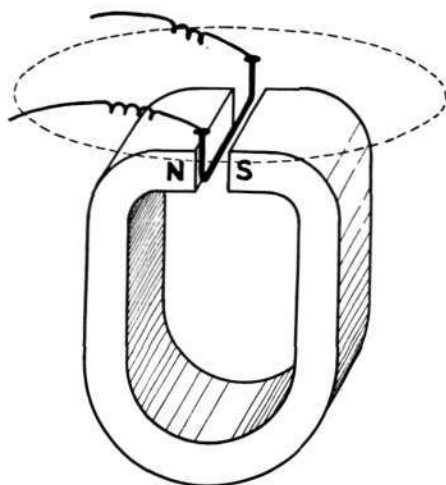


R 664 Director G. Wettermark Surrounded by Comrades and Friends, January 27th, 1926.

On Various Principles of Receiver and Loud-Speaker Design.

A treatise of some length on the above subject — intended to set forth all the more important principles of receiver design hitherto tried out — was begun in Nos. 7 & 8, Vol. III of *The L. M. E. Review*, in which number were treated the various forms of electromagnetic receivers, exemplified by a number of characteristic types. As a continuation of the above, this present article will attempt to give a perspicuous description of the different forms of electrodynamic receivers.

In similarity with electromagnetic receivers, the electrodynamic ones are based on the mechanical forces acting within a magnetic field. In principle, the main difference between these two types is that in the former it is the tension acting in the direction of the magnetic field that is put to use, while in the

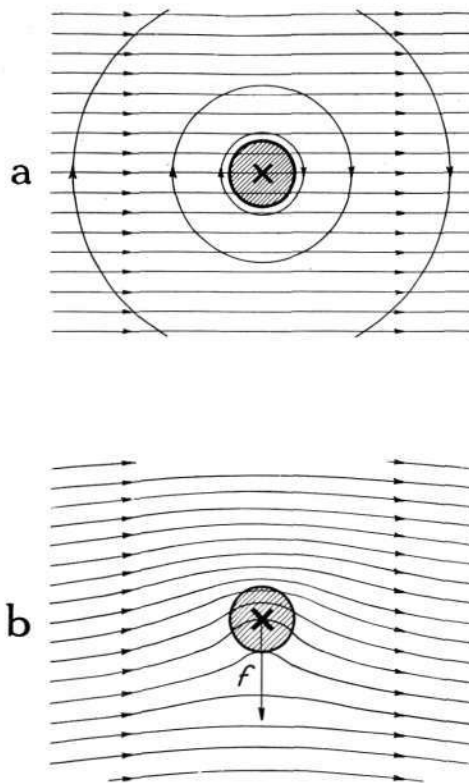


R 667 Fig. 23. Principle of Electrodynamic Receiver.

latter it is the pressure acting at right angles to the lines of force. In other words, it is the force acting on an energized conductor located within a magnetic field that is put to use in electrodynamic receivers. Two instances may occur, namely, either the speech current is led through the conductor and the magnetic field is permanent, or the current passing through the conductor is a permanent direct current, the magnetic field varying with the speech current. This last principle is seldom used, since the advantages it offers over the one first mentioned are more than outweighed by its disadvantages.²³ One might almost conceive a third alternative, with both current and field vari-

able, but this is without all practical significance, since the alternating force acting on the conductor would then have double the frequency of the speech current.

The basic type of an electrodynamic receiver can be schematically illustrated as in fig. 23, with a conductor attached to the diaphragm and placed in the air-gap between two magnet poles in such manner that it is at right angles to the direction of the magnetic field. When a speech current passes through the



R 668 Fig. 24. Straight, Energized Conductor in a Homogeneous Magnetic Field.

conductor, this latter is influenced by a force acting at right angles to the magnetic field and to the conductor itself. This force is directly proportional to the momentary value of the strength of the current and consequently closely follows the variations of the speech current as far as strength and direction are concerned. The direction of the force relative to that of the current is explained in the following. In the

cross-section taken at right angles to the conductor and shown in fig. 24, it is assumed that the magnetic field is directed towards the right and the current inwards, the magnetic lines of force created by this latter forming closed circles directed counter-clockwise. The synthesis of the permanent and homogeneous magnetic field and the circular field of the current gives a resultant field, the character of which is shown in fig. 24 b. On the one side of the conductor, where both fields have the same direction, there occurs a condensation of the lines of force; on the other side a rarefaction. For this reason the forces of pressure acting at right angles to the lines of force will predominate on the first mentioned side, giving the force acting on the conductor the direction shown in the illustration.

The strength of the force at a given moment is expressed by the formula

$$f = B i l$$

in which B = magnetic induction in the air gap,
 » » i = momentary value of speech current,
 » » l = length of conductor within magnetic field.

Generally, the conductor is not single, as shown in the illustration (fig. 23), but is laid up in a number of turns. With n turns in series the expression for the force will be

$$f = n B i l.$$

In addition, the following notations will be used for the mechanical part of the receiver:

s = momentary deviation of conductor from mean position, velocity of conductor,
 v = mass of the oscillating system reduced to the conductor,
 m = oscillating system,
 ρ = resistance of conductor against motion,
 k = elasticity of conductor.

The following notations will be used for the electric circuit of which the conductor forms a part:

e = momentary value of the driving e. m. f.,
 R_i = inside resistance of circuit,
 R_v = resistance of oscillating conductor,
 L_v = inductance of oscillating conductor.

Using the above notations, we obtain the following equation of motion for the conductor:

$$m \frac{dv}{dt} + \rho v + \frac{s}{k} + n B i l.$$

While in motion, the conductor cuts the lines of force of the permanent magnetic field, thus inducing an e. m. f. acting in the opposite direction:

$$e_i = n \frac{d\phi}{dt} = -n B l v.$$

The equation for the electric circuit is then

$$R_i i + R_v i + L_v \frac{di}{dt} + n B l v = e.$$

To simplify the matter, we will now assume that the electromotive force e is purely sinus-shaped, making it possible to use Steinmetz' symbolical method for the calculation of the stationary condition. The transition to complex figures takes place by substituting the vectors E , I and V for the momentary values e , i and v in the above equations — which vectors designate either the amplitudes or the effective values for the respective quantities — at the same time as the operator $\frac{d}{dt}$ is replaced by the factor $j\omega$. This gives the equational system

$$j\omega m V + \rho V + \frac{V}{j\omega k} = n B l I,$$

$$R_i I + R_v I + j\omega L_v I + n B l V = E.$$

The expression $R_i + R_v + j\omega L_v$ is the complex impedans of the electric circuit, denoted by the letter Z . In analogy with the electric notations one may define

the expression $j\omega m + \rho + \frac{1}{j\omega k}$ as the mechanical impedans of the mobile system, which we will call H . In this analogy the velocity corresponds to the strength of the electric current and the force to the electromotive force. Thus, both equations are simplified to

$$H V = n B l I,$$

$$Z I + n B l V = E.$$

If we consider the process electrically, V is eliminated, giving

$$\left(Z + \frac{n^2 B^2 l^2}{H} \right) I = E.$$

The second term of impedans represents the reflex action of the movements of the conductor on the electric circuit. If the mobile system is held stationary $H = \infty$, the term in question then being = 0.

Seen from a mechanical point of view the stationary condition can be expressed by the equation

$$\left(H + \frac{n^2 B^2 l^2}{Z} \right) V = n B l \frac{E}{Z}$$

The existence of a perfect reciprocity between the electric and the mechanical features of the receiver may be gathered from the both last equations. A

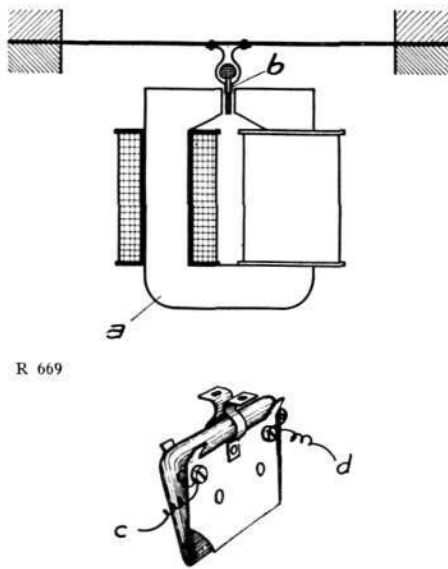
closer analysis of this subject would take more time than could be devoted to it in these pages.

The last equation gives

$$V = \frac{EZ}{nBl} + nBl$$

which expression can be made the basis of an investigation as to the most favourable dimensioning of the electrodynamic receiver.

In this connection it may be well to mention that the pressure of the air on the diaphragm manifests



R 669

R 670
Fig. 25. Single Acting Electrodynamic Receiver.

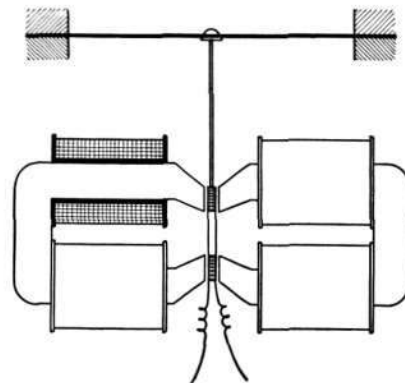
itself not only in the form of resistance to movement but also in the influence exerted upon the apparent mass and elasticity of the system. This influence, as well as the resistance to movement, is largely dependent on the frequency. That part of the total resistance to movement ρ arising from the pressure of the air and usually constituting the greater part of this same total resistance, is called the acoustic radiating resistance. If we denote this with q_s , the radiated effect is

$$w = q_s v_{eff}^2.$$

With the exception of the electromagnetic receivers, it is the electrodynamic ones that have attained the most widespread practical use. Compared with the former, they possess important advantages from a theoretical point of view although they do not lend themselves to practical constructive treatment to the same degree. Probably the most conspicuous advantage is that the mobile system is influenced by a purely

alternating force, on the assumption that the speech current itself is a pure alternating current, i. e. free from superimposed direct current, a condition which is easily obtainable. Thus, when there exists no permanent attraction, no considerable stiffness is required of the mobile system, thus permitting a reduction of the natural frequency of the same below the limit of audibility without any complicated arrangements. Consequently, even very low tones can be reproduced with a satisfactory force of sound.

Furthermore, an electrodynamic receiver of the most common type, in which the speech current passes through the mobile conductor, is free from distortion of the amplitudes, since the motive force is exactly proportional to the strength of the speech current.



R 671

Fig. 26. Double Acting Electrodynamic Receiver.

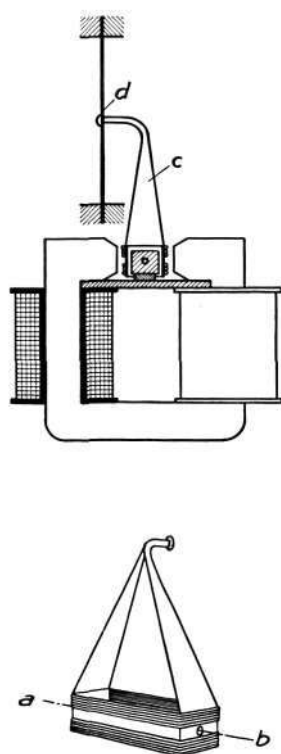
Also, since the natural direction for the movement of the conductor is along the magnetic air gap and not across it — as with the armature of the electromagnetic receiver — considerable amplitudes are permissible. Consequently, the electrodynamic principle is very well adapted for loud-speakers, especially when high stressing is required, as in very large halls or for open-air broadcasting of speech.

As regards the difficulties of construction, they concern mostly the centering of the conductor in the air gap in such manner that it will not come in contact with the pole surfaces, the reduction of the air gap to a minimum being necessary to obtain a sufficiently strong field with a magnet of reasonable proportions.

A form of construction for an electrodynamic receiver which comes very close to the schematic arrangement in fig. 23 is shown in fig 25.³⁴ The permanent magnet — as with most electrodynamic receivers — is here substituted by an electromagnet a , for the purpose of obtaining the strongest possible magnetic field in the air gap. The mobile conductor through which the speech current is led consists of a

flat, rectangular coil *b*, containing a large number of turns of very fine wire. The most suitable material for this wire is naturally aluminium, on account of its lightness, but copper and also magnesium are sometimes used.¹

On that side of the coil which extends into the air gap, the winding is flattened out into a thin plate, as may be seen in fig. 25 *b*. This is done with the specific intention of giving the air gap the least possible width, thereby also reducing to a minimum the number of ampere-turns required for the field. The current is led to the coil by means of two very flexible feed wires *c* and *d*. The diaphragm may be made of some light and yet sufficiently resilient



R 672 Fig. 27. Electrodynamic Receiver built on the Rotary Coil Principle.

material such as mica, paper, cork, wood or similar substances.

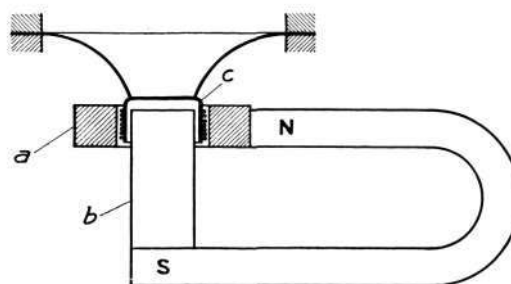
With the fact in mind that the mobile system must be as light as possible, the criticism may be passed against the arrangement shown in fig. 25 that only a small part of the conductor winding is subjected to the action of the magnetic field and therefore active. The remainder of the winding can only be considered in the light of a useless load on the mobile

¹ The product of the specific resistance and the specific weight of aluminium is 0.078, of copper 0.1555, and of magnesium 0.080.

system. The construction in fig. 26, in which each of the two opposite sides of the rectangular coil are in two different magnetic fields, is an improvement in this respect.³⁵ Since the direction of the fields as well as of the currents oppose each other in the two air gaps, the forces acting on the coil will coöperate with each other.

Another method of making use of both sides of the coil has been adapted in the receiver construction shown in fig. 27.³⁶ Here, the magnetic fields have the same direction in both of the air gaps, thus influencing the coil with forces in apposite directions, i. e. a moment of torsion. For this reason the coil is mounted so that it can rotate about its longitudinal axis by means of bearings or spring suspension, *a—b*. The oscillations are transferred to the diaphragm by means of a light lever arm *c*, consisting of two strips of aluminium attached to the end surfaces of the coil, their tapering outer ends being united and fastened to the diaphragm *d*.

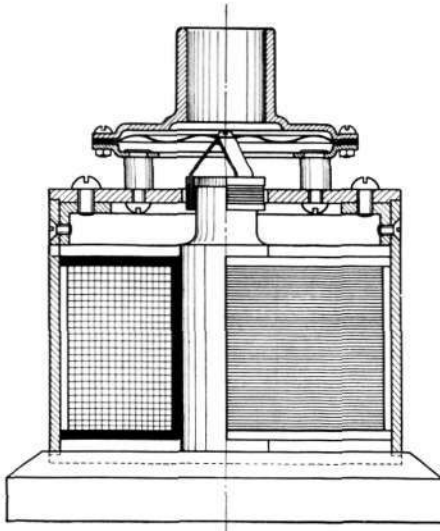
When it comes to making use of as much as possible of the mobile conductor for its intended purpose, neither one of the two last mentioned designs can be said to be ideal — although they are superior to the one previously mentioned — since here also a large part of the coil lies outside of the magnetic field. The receiver illustrated in fig. 28 shows that



R 673 Fig. 28. Cylindrical Arrangement of Magnet Poles and Coil.

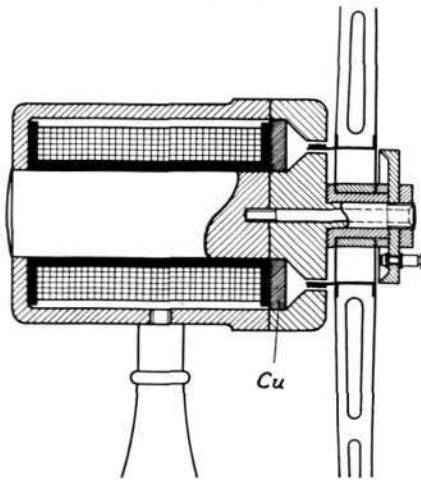
in principle there is nothing to prevent the construction of an electrodynamic receiver in such manner that the entire length of the mobile conductor is influenced by the magnetic field. The magnet is provided with concentric pole shoes *a* and *b*, the cylindrical coil *c* being placed in the radial field between the two pole shoes. This concentric arrangement of the magnet poles and the coil is very common in electrodynamic receivers and can well be said to constitute the standard type for one of this kind. Strange to say, it also seems to be the oldest form, almost as old as the common magnet receiver, fig. 28 being loaned from a German patent of the year 1877.³⁷

A modern loud-speaker of the same type is shown in fig. 29.³⁸ The magnet is an electromagnet of the pot type, the current being furnished by a storage battery. The outer pole shoe serves as a base for the resonance chamber with diaphragm and coil. This last has a relatively low number of turns, neces-



R 674 Fig. 29. Electrodynamic Loud-speaker with Cylindrical Coil.

sitating the use of a transformer between the amplifier and the loud-speaker for the purpose of transforming the current down to a lower voltage but to a higher intensity. Another advantage gained by this arrange-



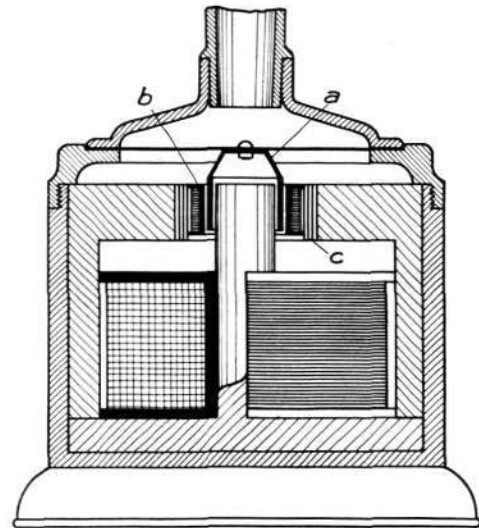
R 675 Fig. 30. Pot Magnet with Damping Device of Copper.

ment is the barring from the loud-speaker of the direct current passing through the anode circuit of the final valve, this being necessary — as already mentioned in the foregoing — to prevent the coil from being influenced by a permanent force acting in only one direction.

If the electromagnet is energized by a generator current, sound disturbances are liable to occur in the loud-speaker as a result of pulsations in the tension of the generator (segment tones). Several expedients have been suggested to eliminate this undesirable feature, the simplest being to place a heavy ring of copper around the inner core of the magnet, between the energizing winding and the pole shoes (fig 30).³⁹ Such a copper ring has the same effect on the magnetic circuit as a choke coil in a direct current circuit, i. e. it smooths out sudden variations in the strength of the field. This ring may suitably be arranged so as to serve, at the same time, as a centering device for the two magnet poles.

Should the natural rigidity of the diaphragm and coil be insufficient to hold the coil centered within the air gap, radial wires or bands fixed to the inner pole — or some such similar device — are used for this purpose (fig. 30).³⁹

Instead of admitting the speech current directly to the mobile conductor, the method of transferring it

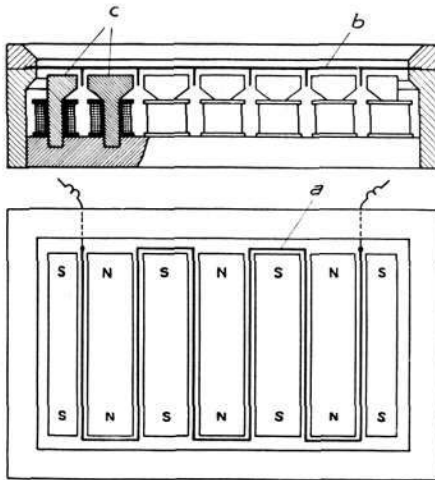


R 676 Fig. 31. Transfer of Speech Current to Mobile Conductor by means of Inductivity.

from a stationary winding by means of induction is conceivable. A simple though not very efficient receiver of this kind is obtained by substituting the iron diaphragm of a common magnet receiver by a non-magnetic diaphragm with high conductivity, as of copper, for instance.

The alternating field produced by the speech current induces comparatively strong eddy currents in the diaphragm, which latter is then made to oscillate by the component of the field of polarization directed along the diaphragm plate. A more rational adapta-

tion of the same principle is illustrated in fig. 31.⁴⁰ The mobile conductor is given the shape of a cylinder *a* of aluminium or magnesium, the stationary primary winding *b* being placed within the air gap, either inside or outside of the cylinder. *c* is a laminated pole shoe made of ring-shaped plates. The advantage gained with such an arrangement is that the mobile conductor is exceptionally simple and does not require any feed wires. The disadvantages are also fairly

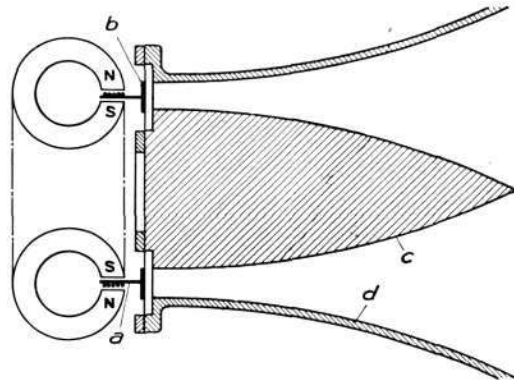


R 677 Fig. 32. Multi Air-Gap Loud-speaker with Distributed Driving Force.

great, however. Thus, the primary winding takes up much valuable space in the air gap, but can hardly be placed in any other manner. If it is placed below the air gap, it produces a radial component of the alternating field which gives rise to a second harmonic; besides, it will be induced on the feed winding of the magnet. Furthermore, the condenser formed by the cylinder *a* and the winding *b* is undoubtedly altogether too small for the lower frequencies, causing a suppression on the lower part of the musical scale.

If a force is applied on the diaphragm in one certain point of this mobile organ, the diaphragm will not vibrate with the same amplitude and phase over its whole surface, like a piston, even though the edge be yieldingly supported, but the vibrations will be transmitted out to the peripheral parts of the diaphragm from the point of application in the form of a damped wave. If the diaphragm is small, as is usually the case in loud-speakers with a megaphone, the difference in amplitude and of phases is naturally hardly discernible, but can be very deleterious with large diaphragms, causing a weakening in the radiations of energy of the diaphragm. As a means of preventing this, probably

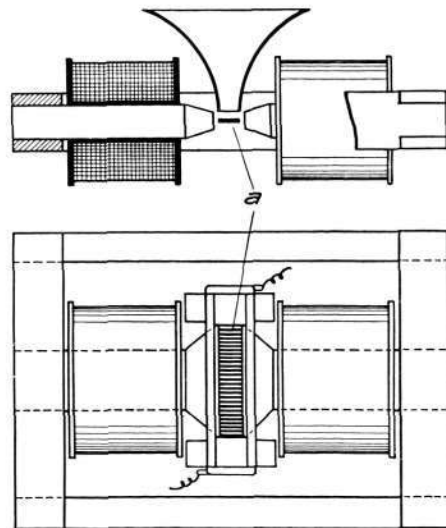
the first solution to present itself is to distribute the acting force more uniformly over the entire surface of the diaphragm. A couple of loud-speaker constructions designed with this aim in view are shown in figs. 32 and 33. In the former⁴¹ a ribbon shaped conductor *a*, simple or compound, is fastened on edge



R 678 Fig. 33. Electrodynamic Loud-speaker with Ring-Shaped Diaphragm.

and in long loops over a plane diaphragm *b* of pertinax, wood, or the like. A number of electro-magnets *c* are shaped so as to form long, narrow air gaps in which the conductor loops are introduced.

Fig. 33 is intended to show how the force acting

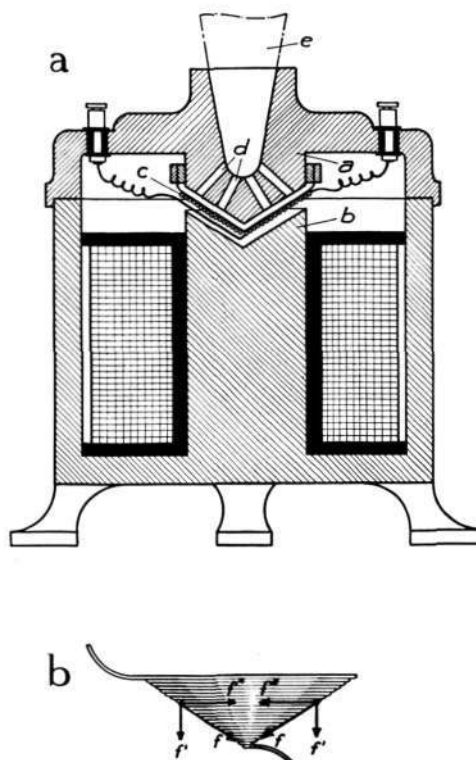


R 679 Fig. 34. Loud-speaker with Band Conductor.

on the diaphragm — with the usual concentric arrangement — can be more uniformly distributed over the diaphragm than in the loud-speaker shown in fig. 29.⁴² The mobile coil *a* has a comparatively large diameter and is attached to a ring-shaped diaphragm *b* with about the same mean diameter. If such a loud-speaker is to be furnished with a megaphone,

this also should be ring-shaped, which can be accomplished by introducing a cone shaped body *c* into the opening of a still wider funnel *d*.

A still more efficient method of getting the diaphragm to vibrate as an entity is to let the mobile conductor itself serve in the capacity of a diaphragm. A loud-speaker built on this principle and of a very simple design is shown in fig. 34.⁴³ The conductor consists of a very thin band *a* of aluminium placed cross-wise in the air gap so that its flat surfaces are at right angles to the direction of motion. A wide range of motion is obtained by folding the band, the natural frequency being simultaneously reduced so as to fall below the limits of audibility. The air pressure is increased to a suitable degree by means of a funnel adapted to the shape or form of the band, the speech current naturally being led in by means of a reducing transformer. The air gap must needs be comparatively wide on account of the position occupied by the band conductor, necessitating a rather large effect for the energizing of the electromagnets. As a result, this loud-speaker is only suited for large installations.



R 680 Fig. 35. The Mobile Coil is Conical in Shape and Serves in the Capacity of Diaphragm.

Another, more original, loud-speaker design — in which, also, the mobile conductor serves in the capacity of a diaphragm — is shown in fig 35.⁴⁴ The essential difficulty accompanying an arrangement of this type caused by the unfavourable direction of the motive force in relation to the air gap — made evident in the previously described construction by the necessity of placing the band conductor cross-wise in the air gap — has here been solved in a most ingenious manner. The magnet poles *a* and *b*, and the diaphragm *c* are all conical. This last consists of a winding of fine aluminium wire held together by means of a binding and insulating medium. The force acting on this wire is everywhere applied in the direction of the generatrix *f* of the cone (see fig. 35 b) but

since the radial components *f''* — acting in opposite points of the circle — neutralize each other, it follows that the resultant force acting on the diaphragm is at right angles to the base. In this manner the diaphragm will vibrate at an angle over the air gap instead of along it. The sound waves are admitted to the funnel

e through sound canals *d* in the upper pole shoe.
(To be continued.)

Reference notes.

- | | |
|--|---|
| <p>³³ French patent 506 817.
 ³⁴ U. S. A. pat. 1051 113 and 1266 988.
 ³⁵ Swedish pat. 36099.
 ³⁶ U. S. A. pat. 1088 283.
 ³⁷ German pat. 2355.
 ³⁸ Sw. pat. 56503. Compare Sw. pat. 29219; Fr. pat. 556 412, 570 476, 576 559, 579 614 and 588 714; and U. S. A. pat. 1105 924.</p> | <p>³⁹ Fr. pat. 570 746.
 ⁴⁰ Germ. pat. 430 784; Fr. pat. 579 614, 574 276 and 570 851.
 ⁴¹ Germ. pat. 410 114, 436 126.
 ⁴² Fr. pat. 588 714, addenda 29915.
 ⁴³ Germ. pat. 421 038, 434 855 and 438 333. Comp. Germ. pat. 282 855 and. Fr. pat. 609 853.
 ⁴⁴ Fr. pat. 558 037.</p> |
|--|---|

Automatic Section Blocking on the Line Stockholm Östra—Stocksund.

By H. Forsberg, telegraph superintendent.

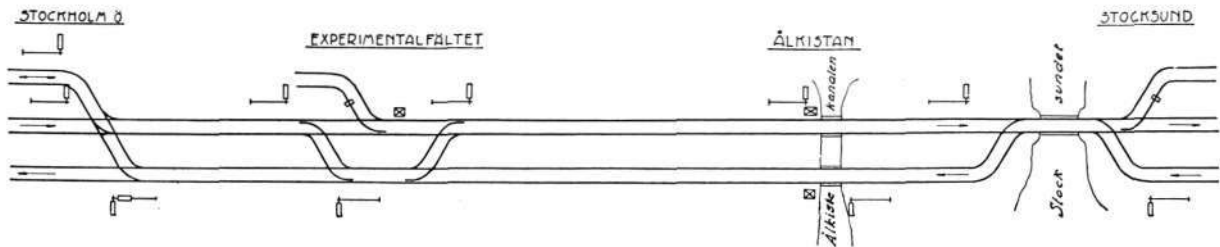
The line between the stations Stockholm Östra and Djursholm is the first stretch on the Stockholm Roslagen Railway. The traffic here is very heavy, with electric trains to Djursholm, steam trains to Roslagsnäsby, Täby, Vallentuna, Viggbyholm and Österskär, and some passenger and freight trains to upper Roslagen.

The stretch between Stockholm and Stocksund is

at Experimentalfältet and for the bascule bridges over the Älkiste canal at Älkistan.

The line is trafficked during about twenty hours of the entire day, the working hours at the block posts being divided up into three shifts with one man per block post and shift. Consequently, the personnel required at the two block posts amounted to six men.

The appearance of the line after the introduction



R 687

Fig. 1. The line Stockholm Ö—Stocksund.

4.5 km in length and is a double-track line except on the bridge over the Stocksund sound, which is single-tracked. This bridge is within the Stocksund station area.

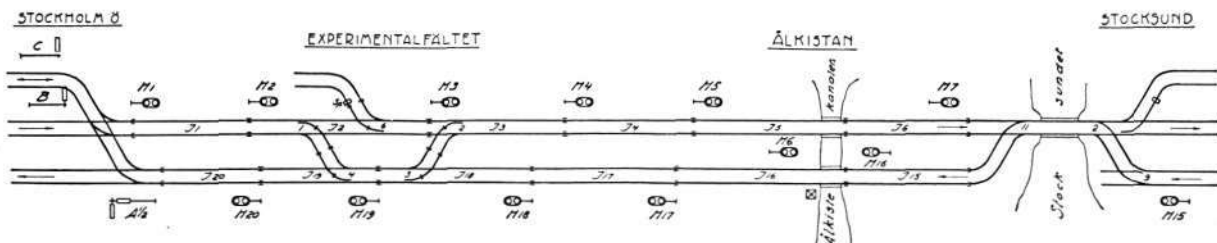
The appearance of the line previous to its being equipped for automatic section blocking is shown in fig. 1.

Blocking posts were arranged at Experimentalfältet and Älkistan and the line was divided up into three block sections. This sectioning of the apparently short line between these two stations was necessitated by the train frequency, which at times is very close — this line being trafficked daily by about seventy trains in each direction —, besides which the block posts served as protection for the switches in the main tracks

of automatic section blocking is schematically illustrated in fig. 2.

According to the new system, each track has been divided into six sections, permitting a doubling of the train frequency. The sections vary in length from 529 to 718 metres, the number of stopping places — three arbitrary stops being provided for the electric trains — as well as the curves on the line having been taken into consideration when determining these lengths. The block sections are denoted by the letter I together with the numbers 1 to 6 for the left track and 15 to 20 for the right track.

The system is built on the track circuit principle, i. e. with energized rails and with each block section insulated from the adjoining sections as well as from



R 686

Fig. 2. The line Stockholm Ö—Stocksund.

that part of the line not included in the system. This principle is illustrated in fig. 3, which gives the schematic diagram of a block section with the arrangements at its ends, and adjoining block sections.

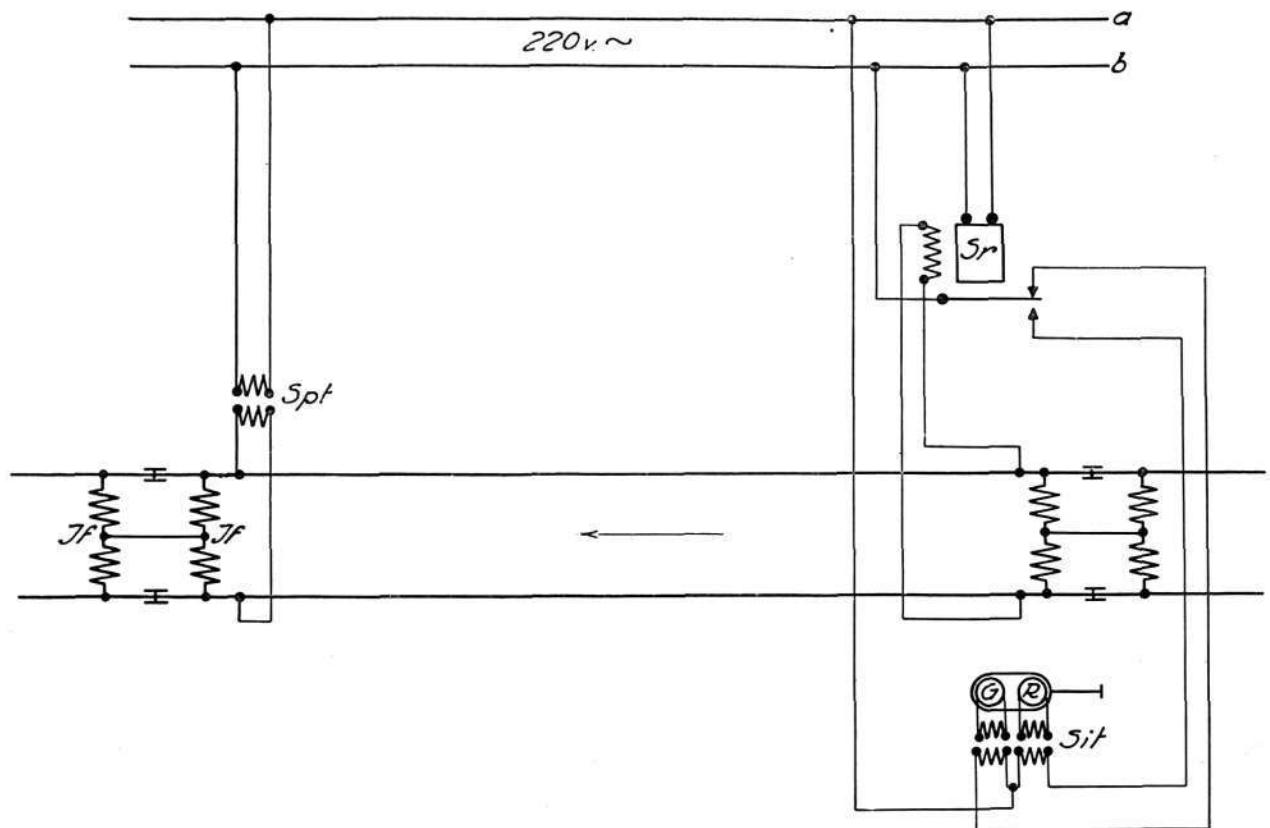
The track circuit current is obtained through a transformer *Spt* (220/1 to 12 volts). The connections of the track relay *Sr* being placed at the opposite end of the section.

The diagram shows how a contact group on this relay serves to switch on the different lamps of a light signal. Sit are two signal transformers for reduc-

ment — is obtained from the Stocksund power plant and delivered to the signal cabin in Stocksund, in which is mounted a switchboard with fuses, meters and switches. From here an underground cable — containing 2+6 conductors of 25 and 3 sq.mm. respectively — leads to the Stockholm Östra station.

Light signals and relay cabinets are placed at the ends of the block sections (see fig. 4).

The above-mentioned cable is led into all of the relay cabinets and connected with the terminals of the various instruments which they contain. Fig. 5



R 689

Fig. 3. Circuit Diagram.

ing the tension of the light current from 220 to 12 volts. The arrangements *I f* at the circuit limits are impedance bonds. The system is more closely described under the various subtitles.

In the foregoing we have already mentioned that this line is trafficked by electric trains, from which we have understood that it is electrified. The traction current is 650 v. D. C., all four rails of the two tracks serving as return conductors. For this reason A. C. has been chosen for the block system, so as to avoid disturbances from the traction current.

The necessary current for the block system — in the form of 2-phase, 220-volt, 50-cycle alternating cur-

rent — is obtained from the Stocksund power plant and delivered to the signal cabin in Stocksund, in which is mounted a switchboard with fuses, meters and switches. From here an underground cable — containing 2+6 conductors of 25 and 3 sq.mm. respectively — leads to the Stockholm Östra station.

Light signals and relay cabinets are placed at the ends of the block sections (see fig. 4).

The above-mentioned cable is led into all of the relay cabinets and connected with the terminals of the various instruments which they contain. Fig. 5

shows the placing of these instruments in a relay cabinet containing apparatus for two opposite block sections (I 6 and I 16), in which respect it differs from the other cabinets.

The light signals have two lights, the one showing green and the other red. Each light has an inner coloured lens and an outer colourless converging lens. The lamps are for 12 volts and have an effect of 12 watts, a special adjustment permitting the accurate focusing of the lenses so that a clear and strong light is obtained in spite of the low effect of the lamps.

led up inside the tube. The standard is provided with a ladder giving easy access to the signal.

The light signals are denoted by the letter H and one of the numbers 1 to 7 and 15 to 20 (see fig. 2).

The different apparatus of this plan are as follows:

Track transformer for 220/1 to 12 volts. The secondary winding has terminals for all the different

Track relays: two-position, two-element relays for a local tension of 220 volts and a tension of the track current at the relay of 1.1 volts. Both windings of these relays — for the local current and for the track current — must be calculated so as not to counteract each other. This arrangement with 2-phase current gives added reliability to the system, as demonstrated in fig. 6.



R 681 Fig. 4. Light Signal and Relay Cabinet.

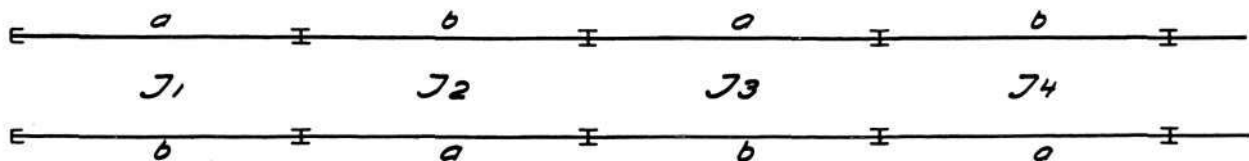


R 682 Fig. 5. Relay Cabinet.

voltages between 1 and 12, from which the track circuits are supplied with a 6 to 7 volt current. A safety device is placed between one of the transformer terminals and one of the tracks, while between the other terminal and the other track is placed a rheostat of 1 ohm and 8 amperes for regulating the track current. A certain portion of the resistance of this rheostat must always be in circuit to prevent the transformer being short-circuited at the same moment in which a train passes the feed points of the transformer.

The so-called *a* and *b* phases (see also fig. 3) are connected to the same rail at every other block section. If a phase were to be connected to the same rail in two adjoining block sections and the insulating joints should become faulty, the relay in one section would be actuated by the track current of the other section. This danger is eliminated by the above described arrangement, because the unduly admitted track current cannot energize the relay on account of its different phase.

The relays are provided with six back contacts and



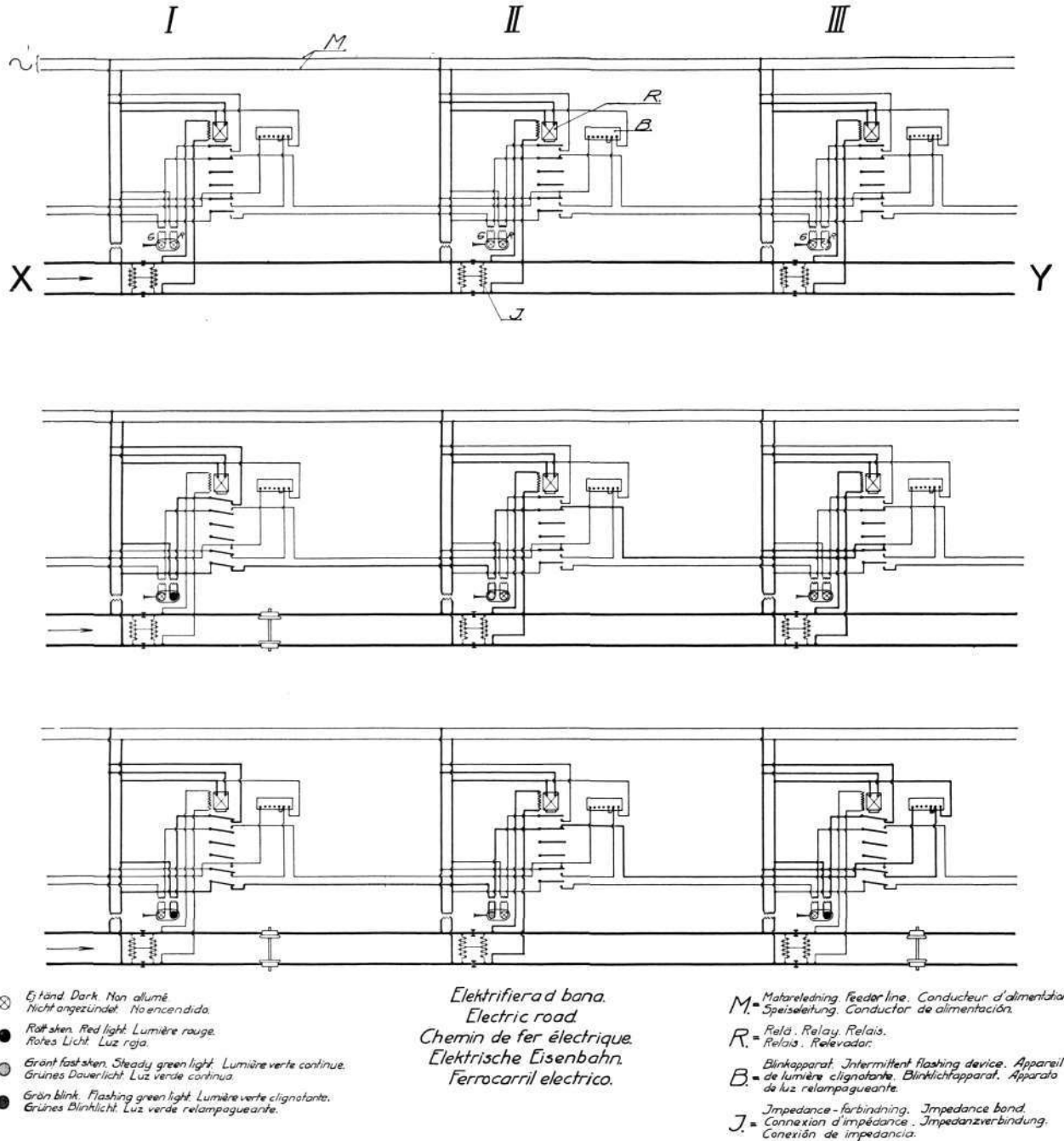
R 688

Fig. 6.

four front contacts, wherewith a large number of circuit combinations are obtained.

Signal transformers for 220/12 volts, mounted in the relay cabinets. As already mentioned, the signal

mittent flashing devices, working with a 220-volt current. The method of connecting up the flashing devices is shown in fig. 7. As indicated in the diagram, the flashing device for a certain signal is placed



R 699

Fig. 7.

lamp current of 12 volts' tension is obtained from the signal transformers, one transformer being provided for each lamp in the signal. The method of connecting up these transformers is shown in fig. 3.

Lastly, these relay cabinets contain electric inter-

in the relay cabinet for the following block section. Thus, the flashing device which produces a flashing light in the signal H 1 (see fig. 2) is placed in the relay cabinet at H 2. As soon as a train enters a block section, the working current to the flashing device for

the next signal to the rear of the train is connected up although this signal remains dark.

This block system differs from others previously installed in that the signals are dark when in normal condition.

This system affords a decided saving in electric current, as well as a longer life for the lamps, the total burning time per lamp being reduced to not more than 2.5 to 3 hours per day.

Fig. 7 illustrates the three different phases in the functioning of the block system. The upper figure



R 683

Fig. 8. Impedance Bond.

represent a stretch of track X—Y clear of trains, the relays being energized and the signals dark. The middle figure shows a train that has entered the first block section, the signal to the rear showing a red light and the signal in front of the train a steady green light, thereby indicating «clear». The lower figure shows the condition of the track with trains on the first and third sections, the first and third signals showing a red light, while the middle signal shows a flashing green light (caution). The heavy lines in the diagrams indicate the circuits in each special case.

As already intimated, special arrangements have been provided at the ends of each track section for the purpose of confining the track circuits to each respective section, at the same time providing a good metallic bond between adjoining sections for the return of the traction current. To accomplish this purpose impedance bonds have been placed at both ends of each block section and connected to the rails. Fig. 8 shows two impedance bonds, the cover of one having been removed to show its construction.

As may be seen in the illustration, four heavy copper cables — each with a cross section of 160 sq.mm. — are used for the connections between the bonds as well as for the connections to the rails. The ohmic resistance of the impedance bonds is negligible, the copper bands in the windings having a cross-section of about 200 sq.mm. In order to equalize the electric traffic load in the two tracks in case the traffic over one of tracks is heavier than over the other and so as to be able to utilize all four rails for the return current, equalizing connections — consisting of copper cables with a cross-section of 100 sq.mm. — have been provided between the pairs of bonds in the one track to the nearest pair of bonds in the other track, these connections terminating at the middle outlets of the impedance bonds.

The starting semaphores B and C and the home semaphore A^{1/2} are connected to the automatic section blocking system at the Stockholm Östra station. As concerns the starting semaphores, the connection is made in such manner that the wing couplings receive their current over the track relay for section I 1. Thus, if this section is blocked and the relay de-energizes, the wing couplings receive no current and it is not possible to set the semaphore to «clear». Wing contacts are also provided, over which current is fed to the green light of the signal H 1. Consequently, if the section I 1 is clear and one of the semaphores B or C is set to «clear», the green light of the signal H 1 is lit, thereby giving a «clear» signal. After the train has entered the section I 1, the wing of the starting semaphore drops to «stop» and H 1 shows a red light as long as the train remains in this section.

The home semaphore A^{1/2} is connected up with the block system in such manner that the light signal H 20 serves as an advance signal for A^{1/2}. Thus, if A^{1/2} is set to «clear», H 20 shows «clear» for an arriving train; on the other hand, if it is set to «stop», H 20 shows an intermittent flashing green light. Further, the semaphore A^{1/2} is provided with two wing couplings — one for each wing — actuated

over a rail contact situated about 20 metres inside of the semaphore. When the first wheel axle of a train passes this rail contact, the wings drop to »stop».

Controlling lamps, which receive current over the track relays for the sections I 1, I 19 and I 20, are mounted in the signal cabin and office of the train dispatcher at Stockholm Östra. These lamps glow when the sections to which the respective relays be-

cuit breakers. If any of the points should not be in the correct position for traffic over the main track, the track relays for the respective block sections are de-energized and the respective signals are set to »stop». For instance, if the switch to the siding (point 6) is open or the skotch block set over, H 2 will show a »stop» signal. Furthermore, the points and skotch blocks are provided with mechanical point



R 684

Fig. 9. Point Contacts and Control Lock.

long are occupied by a train. Their purpose is primarily to facilitate the dispatching of trains to and from the station for the steam trains.

*Special arrangements at Experimentalfältet
and Alkïstan.*

The one skotch block for the siding and the five points, all at Experimentalfältet, are provided with point circuit breakers in conjunction with the tongues of the switches. The track relays for the block sections on both sides of Experimentalfältet are furnished with current from the local net over these point cir-

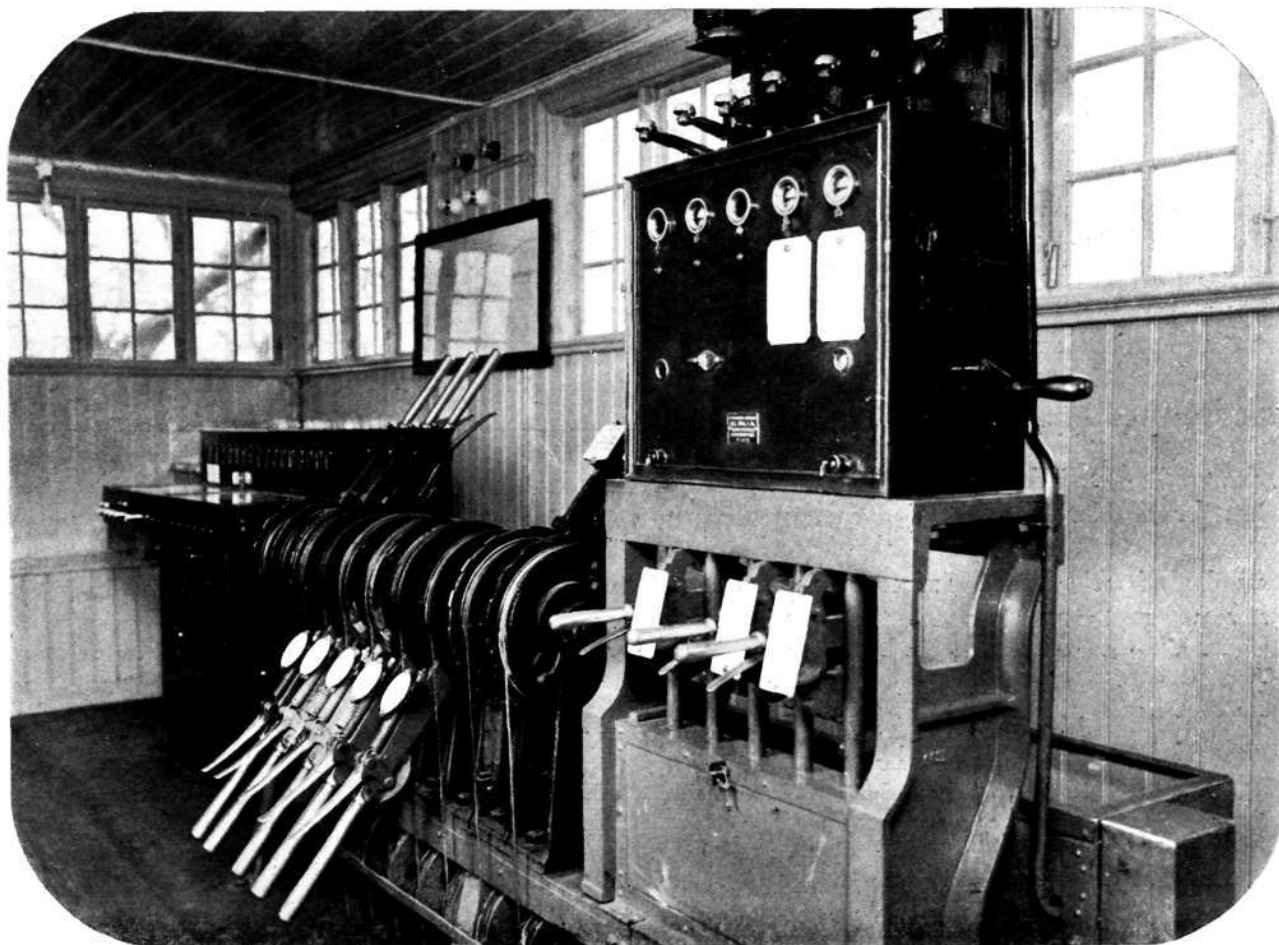
locks, the keys for which are kept sealed by the train dispatcher at Stockholm Östra.

The traffic over the bascule bridges at the Alkïste canal has been safeguarded in the following manner.

In the manoeuvring tower is placed a crank apparatus for the setting, partly of a locking disc which locks the knife switches for the bridge manoeuvring motors, partly of a blocking wheel, the bar of which actuates a toothed rack which, in turn, communicates with the wedged splice plates of the bridge rails. The racks and wedged splice plates are electrically manoeuvred. The crank apparatus is also equipped

with a track lever which must be set to permit the setting of the blocking crank. Before any measures whatsoever can be taken towards the opening of the bridges, permission is required over a lock and block apparatus placed over the crank apparatus and communicating with Stocksund, since the bridges at Ålkistan stand under the supervision of the train dispatcher in Stocksund.

stop, enabling the bridge-tender to control the signals. If one of the lamps of the red lights in H 6 or H 16 be put out of commission, causing indistinct stop signals to be given, an alarm bell rings in the signal tower as soon as the track lever is set, thus giving warning to the bridge-tender who immediately stops the preparations for opening the bridges and takes steps for the replacement of the defective lamps. The



R 685

Fig. 10. Stocksund.

When permission has been obtained from Stocksund, the circuits of the track relays I 6 and I 16 are cut by means of a switch on the locking rod of the lock and block apparatus at Ålkistan, causing the signals H 5, H 6 and H 16 to show »stop». The starting signal H 15 in Stocksund must be set to stop before permission can be given from there, and as soon as permission has been given it is impossible to set the signal H 15 to clear.

The controlling lamps in the manoeuvring tower glow as soon as the signals H 6 and H 16 show

signals H 5, H 6, H 15 and H 16 cannot be set to clear until everything is again in normal condition at Ålkistan and has been repeated at Stocksund.

The light signals H 1 to H 6 and H 16 to H 20 are fully automatic and are called block signals. The signals H 7 and H 15 — home and starting signals respectively for Stocksund — are manoeuvred from here by the aid of an electric interlocking machine, installed in conjunction with the automatic section blocking system. The interlocking machine contains also levers for the electrically set point where the line

L. M. Ericsson

passes from double to single track south of the Stock-sund bridge, as well as levers for the locking of some of the points in the station yard.

The section blocking installation was put in service on February fifteenth of this year and has filled every safety requirement for which it was intended.

The entire plant between Stocksund and Stockholm, including the lighting of the signal cabins and of some semaphores at Stockholm Östra, does not require more

than about 25 kilowatt-hours per day. With electric current at 0.10 Swedish crowns per kilowatt, it is evident that the cost of operation is very low indeed.

The project for this plant has been prepared and the material furnished by Signalbolaget, a subsidiary of L. M. Ericsson. The work of installation has been done by the railway itself, with the author as superintendent and under the supervision of railway engineer Hjalmar Ekholm.



Ericsson

INTERLOCKING MACHINES

Signal apparatus for all systems.

Traffic and warning signals for grade crossings.

Information and offers to be requested from

Telefonaktiebolaget L. M. ERICSSON

or its following subsidiaries: —

AUSTRIA: "Ericsson", Oesterreichische Elektrizitäts-
A. G. Pottendorferstrasse 25/27, Vienna XII.

Č. S. R.: "Ericsson", Elektrotechnická Komanditní
Společnost, Malé nám. 1, Prague.

ENGLAND: Ericsson Telephones Ltd.,
67/73 Kingsway, London W. C. 2.

FRANCE: Société des Téléphones Ericsson,
Boulevard d'Achères, Colombes.

FINLAND: Aktiebolaget L. M. Ericsson i Finland,
Norra Esplanadgatan 25, Helsingfors.

ITALY: Società "Ericsson" Italiana,
Via Assarotti 42, Genoa.

HOLLAND: Koopman & Co.,
Heerengracht 370, Amsterdam.

HUNGARY: "Ericsson" Ungarische Elektrizitäts-A.-G.,
Fehérvári út 70, Budapest.

POLAND: "Ericsson" Polska Akcyjna Spółka Elek-
tryczna, Al. Ujazdowskie 47, Warsaw.

ROUMANIA: Energia S. A. Românească,
Str. Smardan 13, Bucharest.

SPAIN: Sobrinos de R. Prado,
Principe 12, Madrid.

TURKEY: The Swedish Oriental Trading Co.,
P. O. B. 505, Stamboul.

MEXICO: Empresa de Teléfonos Ericsson S. A.,
2:a Calle Victoria 53 y 55, Mexico.

SOUTH AMERICA: Compañía Sudamericana de
Teléfonos L. M. Ericsson, S. A.
Esmeralda 1000, Buenos Aires.

Sociedade Geral de Telephones L. M. Ericsson Ltda,
Rua São Pedro 106, Rio de Janeiro.

EGYPT: Bergstrand & Ahlberg,
P. O. Box 1846, Cairo.

UNION OF SOUTH AFRICA: Rogers-Jenkins & Co.,
P. O. Box 654, Johannesburg.

BRITISH INDIA: Ericsson India Office,
15 Central Avenue, Calcutta.

JAPAN: Siber Hegner & Co.,
P. O. B. "F" Central 16, Tokio.

AUSTRALIA: Ericsson Telephone Mfg. Co.,
19 York Street, Sydney.

Manufacturers of

Modern Automatic and Manual Telephone Ex-
changes.

Telephone Instruments.

Amplifiers.

Telegraph Instruments.

Electric Meters.

Cable, Wire, Cords and Line Material.

Time Recorders.

Electric Light Signal Installation for the Electric Railway Stockholm—Djursholm.

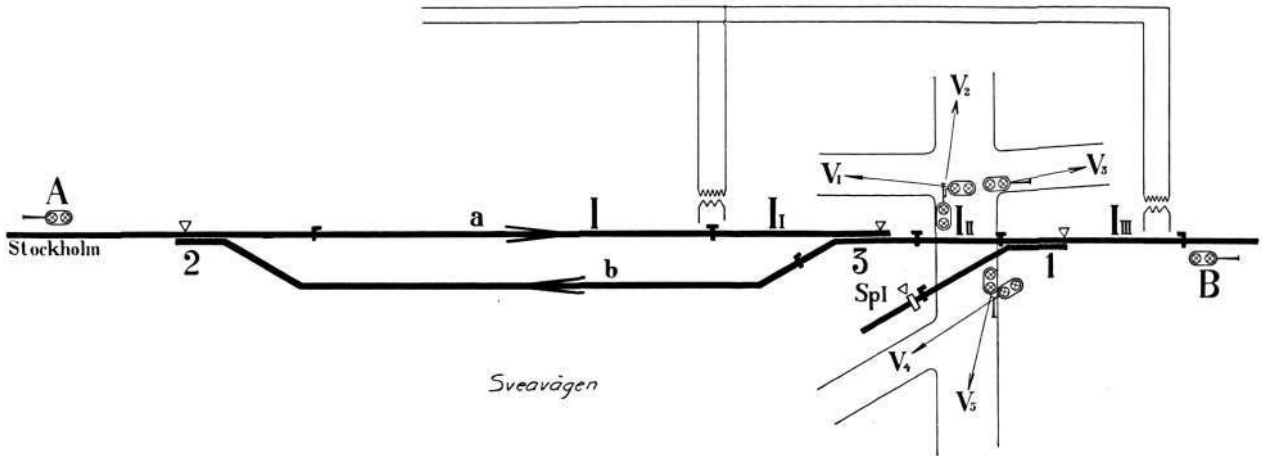


Fig. 1.

R 692

Telefonaktiebolaget L. M. Ericsson — through Signalbolaget — has furnished the Djursholm rapid transit company with an electric signal and safety installation of unusual scope for the Sveavägen station on this road. Formerly, a mechanical interlocking machine was used for the locking of points and signals. Also, the crossing gates at the grade crossing between points Nos. 1 and 3 were manoeuvred from this interlocking machine. All these arrangements have now been replaced by automatic devices, making it possible to reduce the force and leave this point of traffic unguarded. The tracks *a* and *b*, which are used for left hand traffic, are provided with automatic spring points (2 and 3) whose normal positions lead to the left hand track. Outgoing trains push over the tongues of the switch, a spring causing them to return to normal after the passing of the train. The incoming light signals A and B are day signals connected to contacts at the aforementioned points and, at point 1 and skotch block *Sp. I*, to a siding for the temporary parking of coaches. Normally, the signals show a green light which is changed to red as soon as the respective entering point or siding point and skotch block *Sp. I* are not in correct position. Trains from Stockholm usually drop a car on the track *a* before continuing on their way, this car being coupled to the train again on its return run. Thus when track *a* is occupied by a car, the incoming signal A shows red, this being

obtained by means of a track circuit. So as not to interfere with the traction current — which is D. C., the rails serving as conductors for the return current



R 691

Fig. 2.

— A. C. is used for the track circuit. This alternating current is obtained from a 220-volt local net and is admitted at one end of the circuit after having been transformed down to a suitable voltage. An A. C. relay is connected in the circuit at its other end, the signal current being led over contacts in this relay. The A. C. relays used in this installation

tion of five light signals V_1 to V_5 . These light signals (see figs. 2 and 3) show an intermittent flashing white light when the tracks may be safely crossed, which changes to an intermittent flashing red light as soon as a train enters one of the track circuits I_I or I_{III} and approaches the crossing. When the train has passed the crossing and left the disconnecting



R 690

Fig. 3.

are of the disc type and are not energized by the traction current.

The former crossing gates have been removed and are now replaced by regular light signals in conjunction with track circuits I_I and I_{III} on both sides of the crossing, and the disconnecting circuit I_{II} over the crossing itself. As shown in fig. 1, several roads come together at this crossing, necessitating the erec-

circuit I_{II} the signals again show a flashing white light. The flashing signals are obtained by means of a common intermittent flashing device fed with A. C. from the above-mentioned local net.

The saving in maintenance effectuated by this installation — resulting from the reduction in personnel — was so great as to permit the amortization of the total cost of installation in less than one year.

G. P.

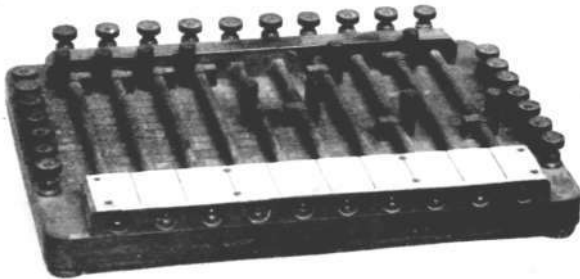
Field Telephone Switches and Switchboards.

Various principles of construction.

By Captain V. Gyllencreutz, Ordnance Officer in the Royal Swedish Signal Corps.

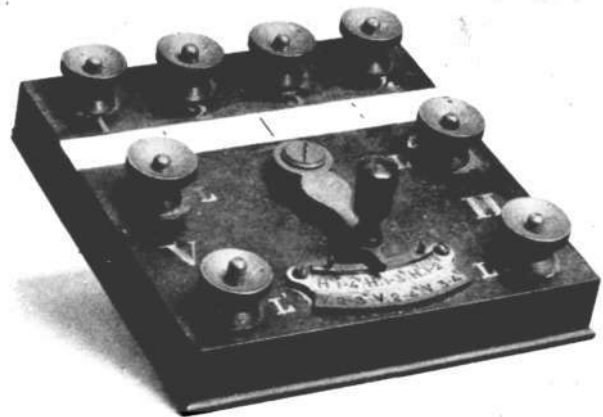
Switchboard facilities for military telephone communications became a necessity simultaneously with the introduction of microphones and local circuits. To begin with, attempts were made to utilize the existing telegraph switches and commutators, but their simple construction gave rise to serious inductive

The most simple forms of construction were used for the first commutators. The incoming lines were connected to a number of parallel strips of metal,



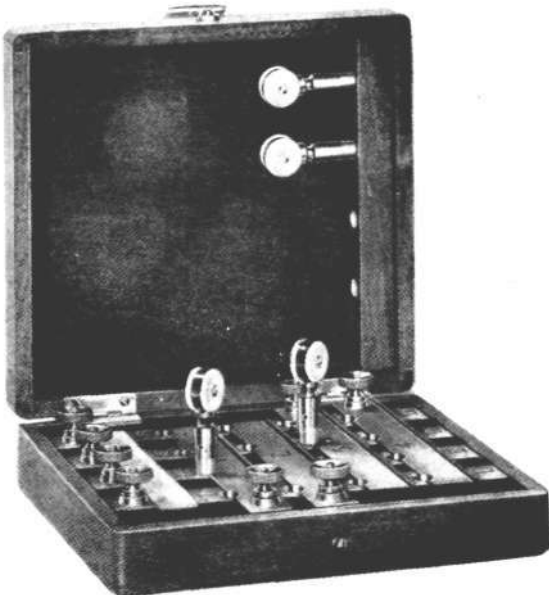
R 608

Fig. 1.



R 610

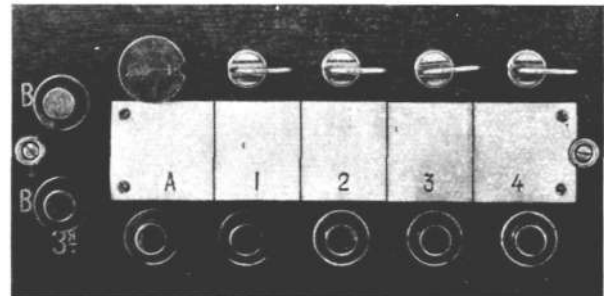
Fig. 3.



R 609

Fig. 2.

across which were placed round connection bars. Contact between the strips and bars was obtained by means of sliding runners or plugs. Fig. 1 shows a switch of this type with five connection bars (five switching possibilities). This instrument is of L. M. Ericsson's manufacture and is now included in the collections of the museum of the Royal Signal Corps.



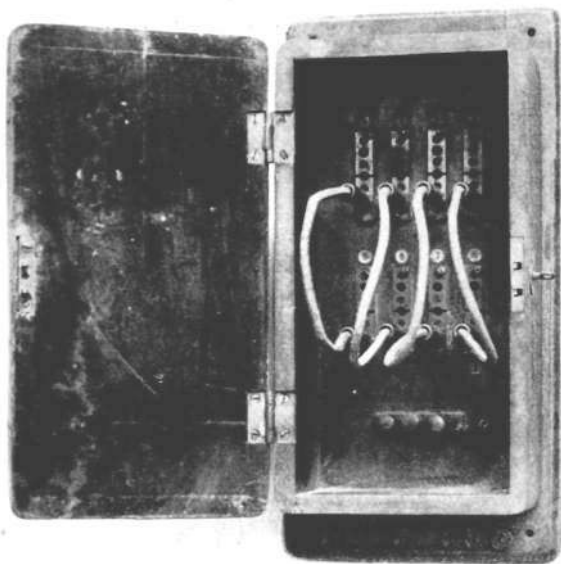
R 611

Fig. 4.

disturbances (superimposed conversations or cross-talk) between the lines. Since only earth circuits were used, these disturbances affected the entire net and made all switching operations impossible.

(Since most of the instruments mentioned in this article are of Ericsson's manufacture, the make of the instrument in question will be mentioned only when it has some other origin.) The field switch for four

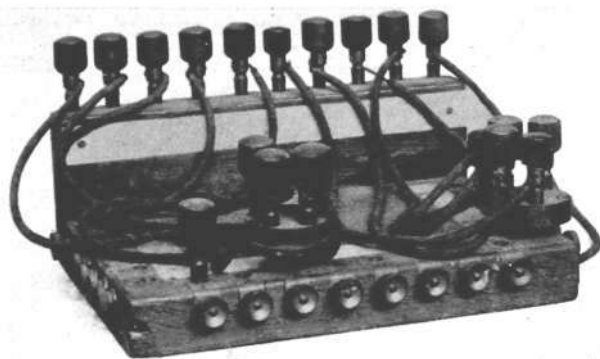
single lines (see fig. 2) which is still included in the Swedish army equipment is a relic from this stage in the development of field switches. It has been retained only as a switching device for use with telegraphic lines but is still mentioned in instructions and equipment specifications under the name of telephone



R 612

Fig. 5.

switch. Already during the 90's attempts were made to produce a more suitable type of switching instrument. Among the designs which date from this period, the following ones are of sufficient interest to warrant their being mentioned. Fig. 3 shows a lever switch for four single



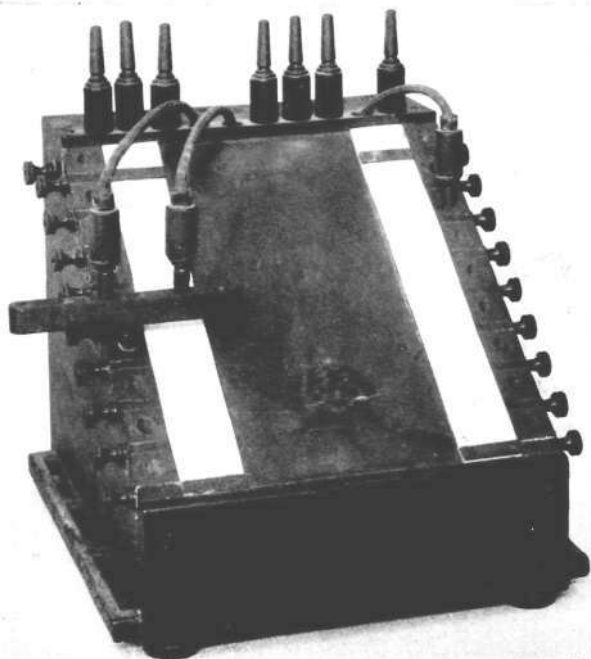
R 613

Fig. 6.

lines, the contacts forming segments of a circle. The switch is manipulated by moving the lever arm to the position representing the desired line. Fig. 4 shows a switching instrument originally made for the Russian army but which has also been in-

corporated in a Swedish field telephone. This switch appears to be neat and compact, but is practically useless on account of the almost perfect audibility of superimposed conversations. If this switch is used during a military manoeuvre, one cannot help hearing the continually recurring more or less amiable requests to other field stations to »get off the line», in spite of the fact that these stations are neither called nor intentionally connected up.

The difficulties which accompanied the use of these first plug and lever switches led to the construction of cord switchboards. The one illustrated in fig. 5 is one of the pioneers of this type. It is intended for



R 614

Fig. 7.

eight single lines, a more detailed description of the same being unnecessary.

There was one detail of construction, however, which caused designers and inventors of that day no small amount of trouble. That was the purely military requirement of being able to give orders and instructions simultaneously to all or a group of the subscribers' stations; so-called circular calls. Figures 6 and 7 show two types of switchboards in which the cord and strip principles are combined, circular call possibilities being obtained by means of special plugs so constructed as to permit the connecting of other plugs in parallel by means of jacks provided with discs or strips. To us these switches may appear very crude; however, their construction is not without interest.

When telephony was still in its infancy, the various types of switchboards were governed by the military requirements and — in the early stages of development — the military or field switchboards were predominant in Sweden, but no sooner had the telephone reached a stage of general usefulness than the requirements of the public at large took the lead and telephone instruments and switchboards were designed accordingly. It was thanks to the great economic resources resulting from the increased use of the telephone that the switchboard problem finally found a solution in keeping with the requirements of the public at large. Since then, however, switchboards for field use have been assigned to a second place where they are forced to get along as best they can with existing constructions and using standard parts.

The most difficult problem was to construct a suitable field switch for single lines. The metallic or double circuit system soon became general for permanent telephone nets, the military authorities — for natural reasons — stubbornly adhering to the single line system. The experience gained during the world war, however, showed to what extent single lines were exposed to the danger of unauthorized listening-in on conversations, and of late the question of adopting metallic circuits has been seriously taken up in military circles. This would greatly simplify the switching problem, since it is almost impossible to construct a switching device for single lines which will insure absence of cross-talk, and it can even be stated with a fair degree of certainty that a perfectly reliable switchboard of this type has not yet been built even though the theories have taken shape to such an extent that it is possible to approximately determine its construction. With a switchboard constructed for metallic circuits and absolutely free from cross-talk, there is always danger for this form of trouble if single lines are used. It does not avail much that each incoming line is provided with a separate earth line, and that these latter are earthed at a considerable distance from each other. Undoubtedly, a better way is to use only double lines within a distance of 200 metres from the field switchboard, and that the transition to single lines at this limit is effectuated by means of choke coils, care being taken that the distance between these coils is at least 150 metres. This method should prove effective if the earth connections are none too good, but is often difficult to effectuate and requires powerful ringing generators.

Benefitting by these experiences, it is possible to

set up the theoretical requirements for a single line switchboard as follows.

The switchboard itself shall be constructed for double lines and be devoid of all trouble from cross-talk, the subscribers being connected up as usual by means of double lines. Incoming single lines are connected to the switchboard over permanent choke coils placed in the switchboard, these coils being variable both as to induction and resistance. In addition, adjustable resistance coils shall be inserted in the earth connections from each choke coil and it should be possible to use but one common earth line.

These few lines on the subject of single line field switches should prove more than sufficient, for which reason no further mention of the same will be made in the following.

Up to the present time field telephone switchboards have been for manual service only, also, since field nets have generally been operated on the local battery system, all field switches are constructed on this principle. It is true that during the world war the *CB* system has been used within certain limited areas — as at chief headquarters, for instance — so as to obtain a greater degree of secrecy, but this system requires short and well built lines, erected with a certain degree of permanency, all of which factors seldom exist in the field. Consequently, this system possesses no special importance from a military point of view, while — on the other hand — it happens quite often that inter-traffic is established between field exchanges and *CB* or automatic exchanges. Some suggestions as to the most suitable manner of arranging such traffic will be given further on.

Field switchboards can be divided into two groups depending on their size and purpose.

I. *Field switchboards without multiple*, for exchanges with small capacities not exceeding 100 lines.

II. *Field switchboards with multiple*, for exchanges with capacities amounting to several hundred lines.

Field switchboards without multiple can suitably be assigned to the following categories:

- A. Plug switchboards
- B. Push button switchboards
- C. Pyramid switchboards
- D. Key switchboards
- E. Switching cells
- F. Cord switchboards.

In similarity with numerous other small switches these types of field switchboards are composed of two main groups of devices, i. e. those that belong to the

subscribers' lines and the switching devices. The first group consists of call indicators — eventually combined with jacks —, one for each subscriber, the latter group consisting of a certain determined number of devices for making the necessary connections, including those for circular calls.

I. *Field switchboards without multiple.*

From a military point of view, a field switchboard must fill the following requirements:

1. It shall be of a sturdy construction so as to withstand the hard usage and rough handling to which it is subjected during a military campaign.

2. It shall be simple of operation so that no highly trained personnel is required for its manipulation.

3. It shall be comparatively light, so that one or two men, at the most, will suffice to transport the same.

4. It shall be manufactured to the greatest possible extent from standard parts obtainable from factories within the country.

5. It shall be easily accessible for repairs, which can be accomplished with the aid of such resources as are available in the field.

6. Each subscriber's line shall have its call indicator, i. e. a device actuated by a generator current emanating from a telephone instrument or switchboard at the other end of the line, in such manner that a signal is visible or audible until the signal circuit is broken by the operator.

7. Each incoming line must terminate in a contact device or *jack* by means of which the temporary connection is accomplished.

8. It shall be provided with a suitable number of *switching devices* by means of which an incoming line can be connected to any of the others. When speaking of the traffic handling capacity of a switchboard it is customary to give these devices the comprehensive appellation »switching possibilities«. The number of switching possibilities required in field switchboards is greater than usual on account of the heavy traffic loads in field nets. As a general rule, half as many possibilities as there are lines are required in switchboards for ten lines or less, with eight to nine possibilities for twenty-line boards and sixteen to eighteen possibilities for forty-line boards.

9. During a conversation, a clearing indicator must be in circuit for the purpose of notifying the operator that the conversation is finished when the subscriber gives a clearing signal with his generator. In

small switchboards the call indicators can also serve as clearing indicators, but this should not be the case with boards for more than ten lines.

10. The switchboard shall be equipped with a transmitter and receiver for the operator, as well as with a signalling device, each one of which can be separately connected up with and disconnected from the different switching devices, thus enabling the operator to answer a call and send out a signal to the desired number; also, the operator shall be able to speak with either or both of the connected subscribers.

11. The operator shall be able to connect himself or any one of the incoming lines to several or all of the subscribers at the same time (circular calls). This requirement is hard to fill, especially on cord switchboards, if the service is not to be disturbed (see under cord switchboards in the following).

12. When the operator answers a call, the call indicator shall be disconnected from the line so as not to form a shunt on the speaking circuit. If, for some reason or other, this cannot be arranged, the indicator will have to be connected in some other manner.

13. When the operator connects up a calling subscriber to a desired line, the call indicator of this line shall be simultaneously disconnected from the circuit, partly so as to prevent its shutter from dropping when the calling signal is sent out, partly for the reason mentioned under point 12. However, there are some small field switchboards in which the call indicator remains in circuit and gives evidence of the fact that the called subscriber has received the calling signal.

14. During a conversation, both of the wire connections to the call indicator must be cut so as to eliminate cross-talk over two adjacent indicator coils. If two call indicators remain connected by one of their connecting wires to one branch of the speaking connection established between two subscribers, the electric circuit will be unbalanced so that disturbances caused by high tension lines may be noticeable. This is evidently of greater importance with field switchboards than with others types because they must often be situated in the immediate proximity of power lines and also because such disturbances are much more noticeable when single lines are used, which is often the case in field telephone nets.

15. If the coil windings of the clearing indicators are branched over the two wires of the connected lines, arrangements must be made that will prevent

inductance between them. They shall let as much as possible of the generator current pass through while admitting as little as possible of the speaking current.

16. It shall be possible to connect the calling device to the desired line in such manner that both of the call indicators as well as the calling subscriber are disconnected from the switching device used for this purpose. This requirement cannot be strictly adhered to in small switches, however.

17. Every field switchboard shall be equipped with an alarm device so as to make both calling and clearing signals clearly audible. It may sometimes be advantageous to replace the audible alarm signal by a light signal, and many switches are provided with such facilities controlled by means of a key.

18. A control signal shall be provided, enabling the operator to ascertain whether the called line is faultless, broken or short circuited.

19. It shall be possible to accommodate junction lines from both *CB* and automatic nets.

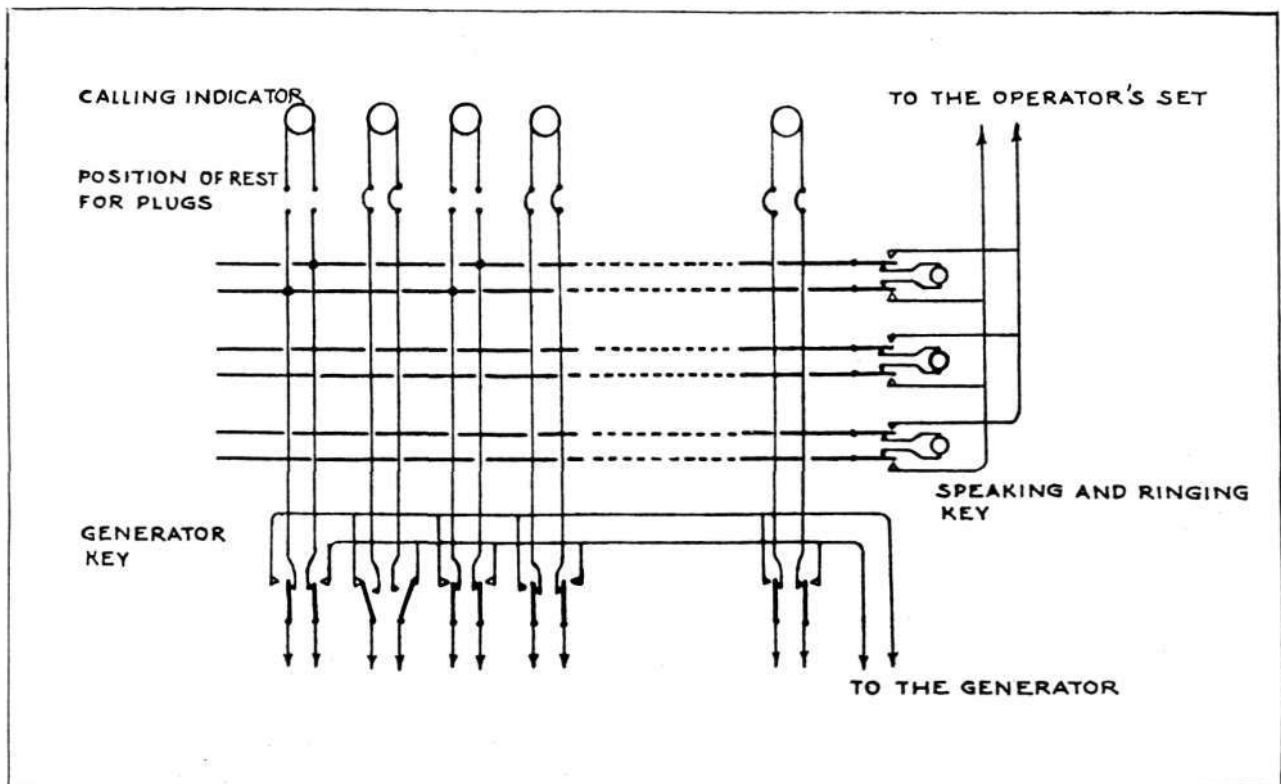
20. All field switchboards shall be provided with extension possibilities. It shall be possible to cut the lines over from a small switchboard to a larger one without disturbing the traffic, as well as to establish co-operation between adjacent switchboards.

21. It shall be possible to accomplish the mounting of the switchboard and the connecting up of the lines easily and quickly.

A. Plug Switchboards.

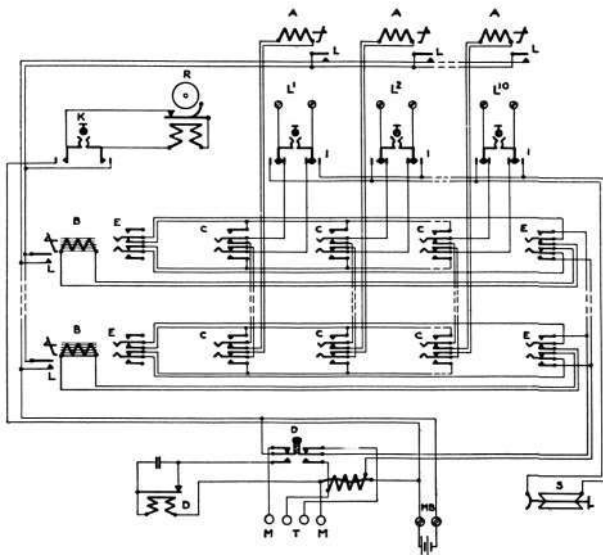
The short life of the cords as well as the uncertainty which accompanies their use in the field soon gave rise to other forms of construction with more reliable switching devices. Exceptionally good plug switchboards were introduced in most of the European armies already in the early nineteen hundreds.

The diagram in fig. 8 shows the principle for a plug switchboard. The incoming lines are connected to generator keys, the vertical lines representing the connections between these generator keys and the call indicators. The heavy horizontal lines represent the switching possibilities, these, together with the clearing indicators, constituting the switching devices. The squares formed where the vertical and horizontal lines cross each other represent jacks with the necessary four spring contacts which are open when in normal position, but when a plug is inserted in the jack (*L3*, denoted by two black dots on the diagram) the line springs come in contact with their respective switching springs. In this manner two subscribers' lines can be connected to each other (*L1* and *L3* in the top row),



the buzzer (*D*) by means of the service jacks. When the alarm key (*K*) is depressed, the dropping of a shutter closes the battery (*MB*) circuit over the alarm contact (*L*), causing the alarm bell (*R*) to ring until the drop is restored. An extra handmicrotelephone may be connected up on line 1, a service telephone being thus easily obtained. This switchboard is simple to operated, is exceptionally free from cross-talk, not very bulky and of an exceedingly sturdy and durable construction. One cannot but acknowledge the ingenuity of the designer when one realises that this type dates back to 1904.

Plug switchboards have certain undesirable qualities which make them more or less unsuited for field

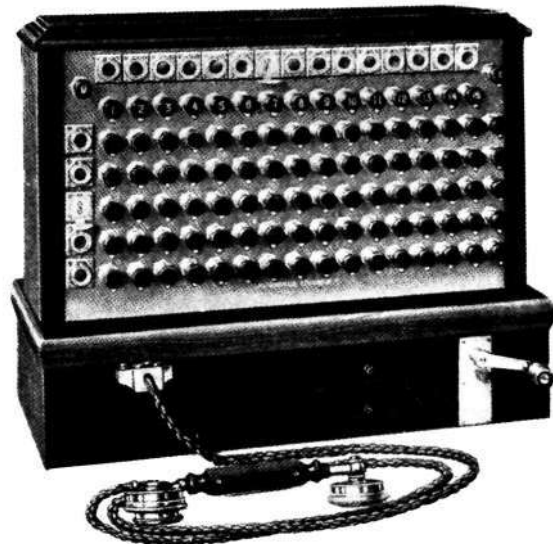


service, the most prominent one being their inability to resist the effects of dampness, which first manifests itself by an aptitude on the part of the plugs to fasten in the holes of the jacks. The reason for this is that the tip of the plug is made of fiber, which the moisture causes to swell. If ebonite is substituted the result is hardly more favourable, as this material becomes brittle in cold weather. Although celluloid offers the least resistance to wear, it is undoubtedly the most suitable material for this special purpose.

B. Push-button switchboards.

This type of switchboard was evolved as a result of the great susceptibility to moisture of the plug switchboards and of the difficulty of enclosing them in sufficiently weather-proof cases. The construction of push-button switchboards does not really differ so much from that of the plug type, the main difference

being that the plugs are replaced by push-buttons which are self-locking in their depressed positions. A switchboard of this type for fifteen lines is shown in fig. 13. Although it constitutes an important advancement, this type has also its disadvantages. In similarity with plug switchboards, it is often bulky, and a design for more than fifteen lines is hardly imaginable, as it is very difficult for the operator to observe which buttons are depressed already with a capacity of ten lines. They are very suitable for use in damp localities, how-



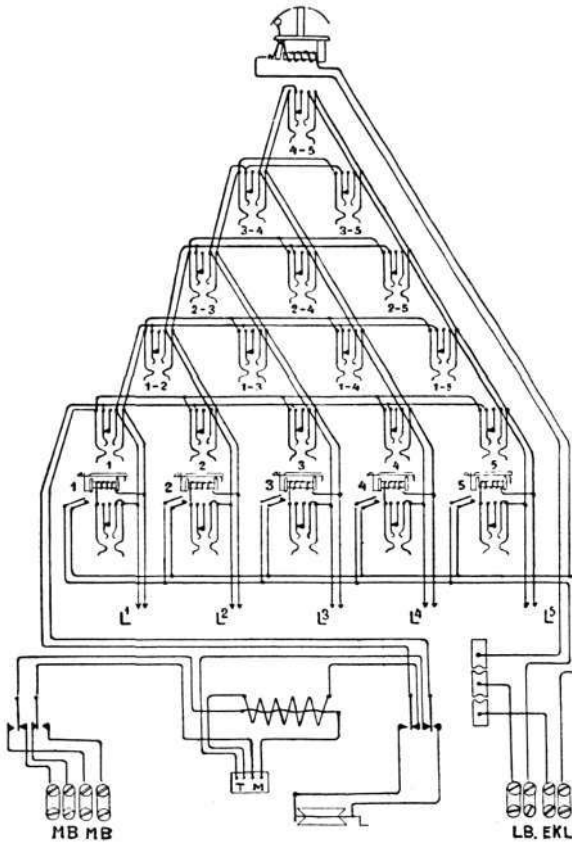
ever, such as forts and batteries, for which reason they will always form a part of the military equipment.

C. Pyramid switchboards.

The construction of pyramid switchboards differs considerably from that of the two foregoing types, the principle for the disconnecting of the indicators being the same as for the first-mentioned type of plug switchboards, however. The circuit diagram for a 5-line pyramid switchboard is shown in fig. 14, from which it may be seen that only two pairs of springs in each jack come into use. Since one jack or key is required for each connection, the number of connecting devices increases rapidly for each additional line, wherefore these switchboards are restricted to a maximum of ten lines.

The indicators are usually situated at the top of the board and serve as both call and clearing indicators, for which reason sheathed indicators which offer a large resistance to the speaking currents are used. The service jacks or keys are arranged in the form of a

pyramid, the answering jacks or keys being placed below them. If a plug system is used, the holes or jacks which serve as rest position for the plugs are placed at the lower extremity of the board. Two lines are connected to each connecting device, the one to the right springs and the other to the left ones, but the same pair of lines does not occur in more than one single jack or key. If a plug is introduced in a jack, or if the switching key (if the switchboard is of this construction) is manipulated, these two lines



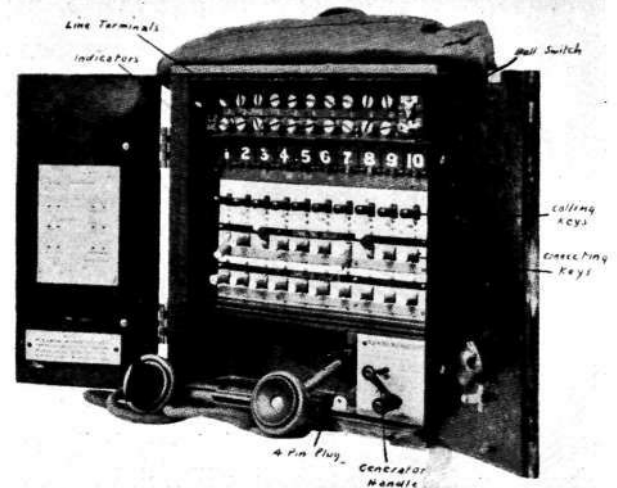
R 621

Fig. 14.

are connected to each other, the circuit diagram showing how this is accomplished. The principle advantage possessed by this type of switchboard is that a connection is obtained by means of only one plug or by the manipulation of only one key. In actual use, however, they are rather inconvenient, since the operator must at any rate send out a separate calling signal. They are specially suited for calling by means of a buzzer signal, however, in which case they are fitted with extremely sensitive drop indicators. All the later types are equipped with push button keys instead of with jacks and plugs.

D. Lever key switchboards.

The construction of lever key switchboards resembles that of push button switchboards, with the difference that in the former each row of keys represents one row of push buttons. As a rule, the call indicators serve the purpose of clearing indicators as well, an alarm device being usually provided. Fig. 15 shows an English type of field switchboard with only two positions for each key, and with a capacity of ten lines. The terminals for the incoming lines are situated at the top of the board, with the alarm key at their right. Under the terminals are located the drops, placed in one single row, the next row containing the combined speaking and ringing keys, the upper position for speaking and the lower for ringing. The two lower rows contain lever keys with one upper and one lower position. The handset and ringing generator are of the usual types. An incoming call causes the



R 622

Fig. 15.

corresponding call indicator to drop; the operator places the speaking and ringing key directly below it in speaking position, i. e. so that the lever handle points upwards. This disconnects the winding of the electromagnet, the handset being brought in circuit in its stead, after which the drop of the call indicator is restored by hand. If the calling subscriber then asks for another line, the operator calls this line by placing the speaking and ringing key of the calling subscriber in ringing position and actuating the generator after which the speaking and ringing keys are brought to their normal positions, i. e. with the handle pointing



R 623

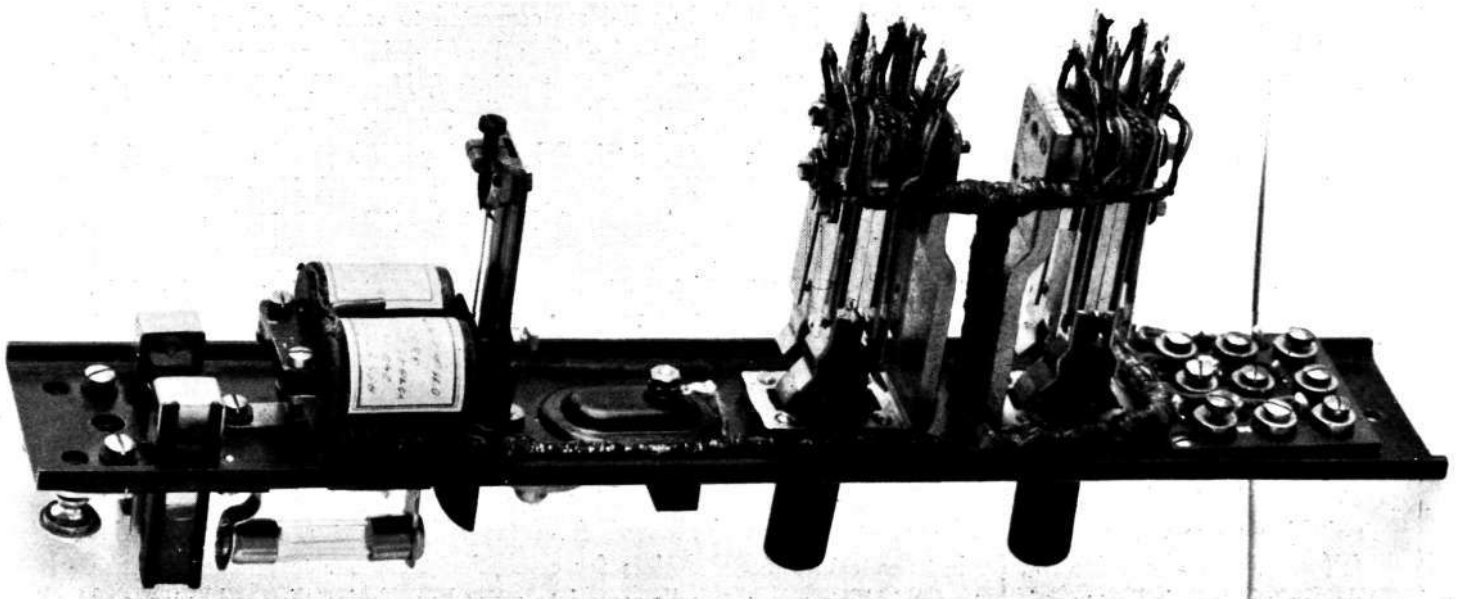
Fig. 22.

straight out. The two subscribers have previously been connected up by placing their two lever keys — located in the same row — in the same corresponding positions, i. e. either both up or both down. In

fig. 15, numbers 1 and 7, and 3 and 8 are connected to each other. The operator can listen in by placing the speaking and ringing key under any one of the lines in question in speaking position. Thus, there are only four switching possibilities, but a fifth possibility might be obtained by using the row of combined speaking and ringing keys. This type of field switchboard is very simple to operate, although no great speed can be attained with the same; besides, cross-talk is very liable to occur.

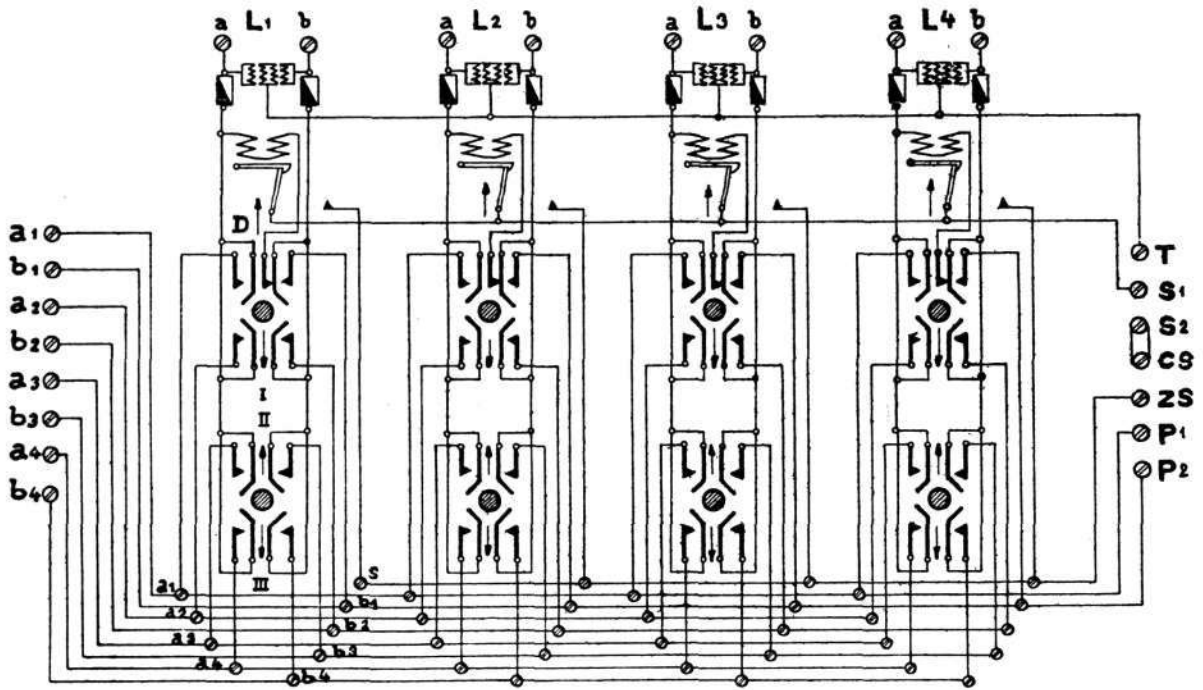
The *Tarazona switchboards* may be said to form a separate group among lever key switchboards. They have received their name from D. Joaquin Tarazona, member of the Spanish engineering corps who, together with a colleague D. Eugenio Ondovilla, is the designer of these switchboards. A special descriptive article covering this group will appear in an early number of *The L. M. Ericsson Review*.

The field switchboard illustrated in fig. 22 and manufactured by the Ericsson works in Vienna occupies a special position among lever key switchboards. It is made up of separate sections of a similar construction. Fig. 23 shows one of these sections, removed from the switchboard and laid face down, while fig. 24 shows a circuit diagram for a four-line switch. The drop indicators are extremely sensitive, the shutters falling at the slightest current impulse, while their construction is somewhat similar to that of a buzzer. This is a great advantage from a military point of view, since they can be used with weak ringing generators and transformed currents with a considerable damping



R 624

Fig. 23.



R 625

Fig. 24.

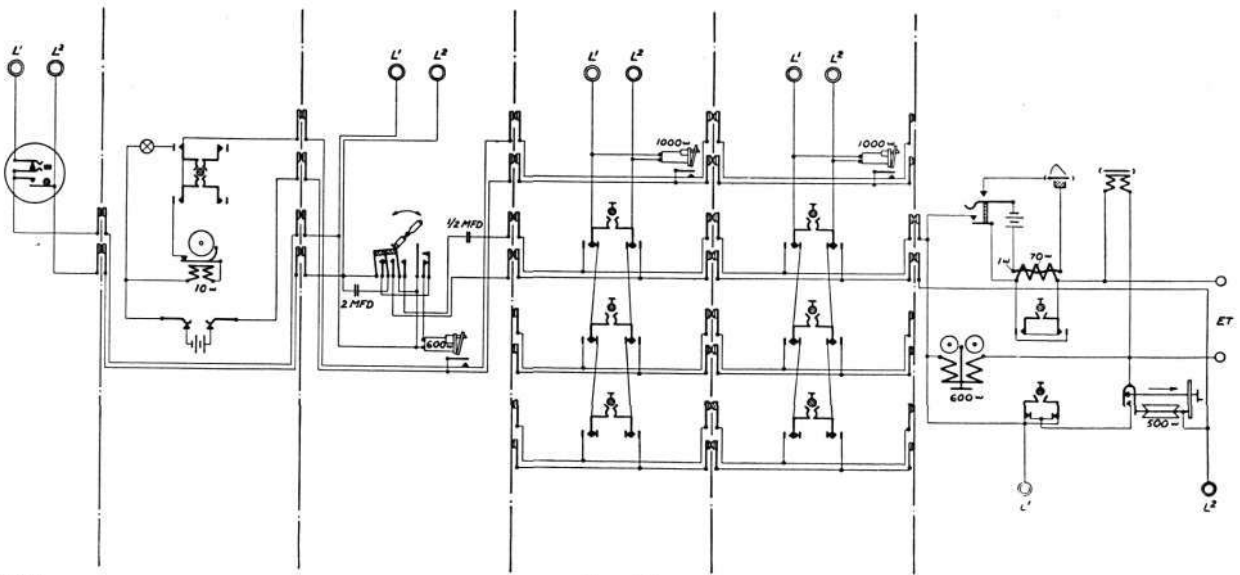
of the signal current, although this sensitiveness must not be secured at the expense of practical properties for field use. However, this does not seem to be the case with the Vienna model. Each incoming line has its own separate section provided with line terminals. Each section consists of a vertical steel plate on which are mounted the above-mentioned terminals, two fuses and carbon protectors for the two wires of the line, the sensitive drop indicator — locked during transportation so as to prevent its being damaged — and two line keys. The upper and lower positions of these keys are marked *D*, *I*, *II* and *III*. The sections are connected to each other by means of contact plates and are also connected to the terminals in the top of the case. When the switchboard is in use, a telephone instrument is connected to the terminals *P1* and *P2*, while an alarm bell with battery is connected to *S1* and *S2*, *ZS* and *CS*. The incoming lines are connected to *L1a* and *b*, *L2a* and *b*, and so forth, and earth to the terminal market *T*. If this switchboard is to be used together with another similar one, the terminals *a1* to *a4* and *b1* to *b4* are connected to the corresponding terminals on the other switchboard. The switching process for making a connection is as follows: A call from line *L1*, for instance, causes the shutter of drop indicator no. 1 to fall. The upper key in this section is placed in speaking position (*D*)

and the operator answers the call, at the same time restoring the drop indicator. Let us assume that the calling subscriber asks for line no. 4. The above-mentioned key is restored to normal and the upper key of section 4 is placed in position *D*, after which a signal is sent out over line 4 by means of the buzzer or the generator. When subscriber no. 4 answers, the key is restored to normal, after which subscribers 1 and 4 are connected to each other by placing the keys of sections 1 and 4 in the same position, i. e. either of the positions *I*, *II* or *III*. The clearing signals cause the drops 1 and 4 to fall. Circular calls are obtained by placing the keys of all the desired lines in any one of the positions *I*, *II* or *III*.

These switchboards are light and simple to operate, but are not suitable for larger capacities. On account of the buzzer signalling device, this type of switchboard occupies a position of its own among field telephone switchboards.

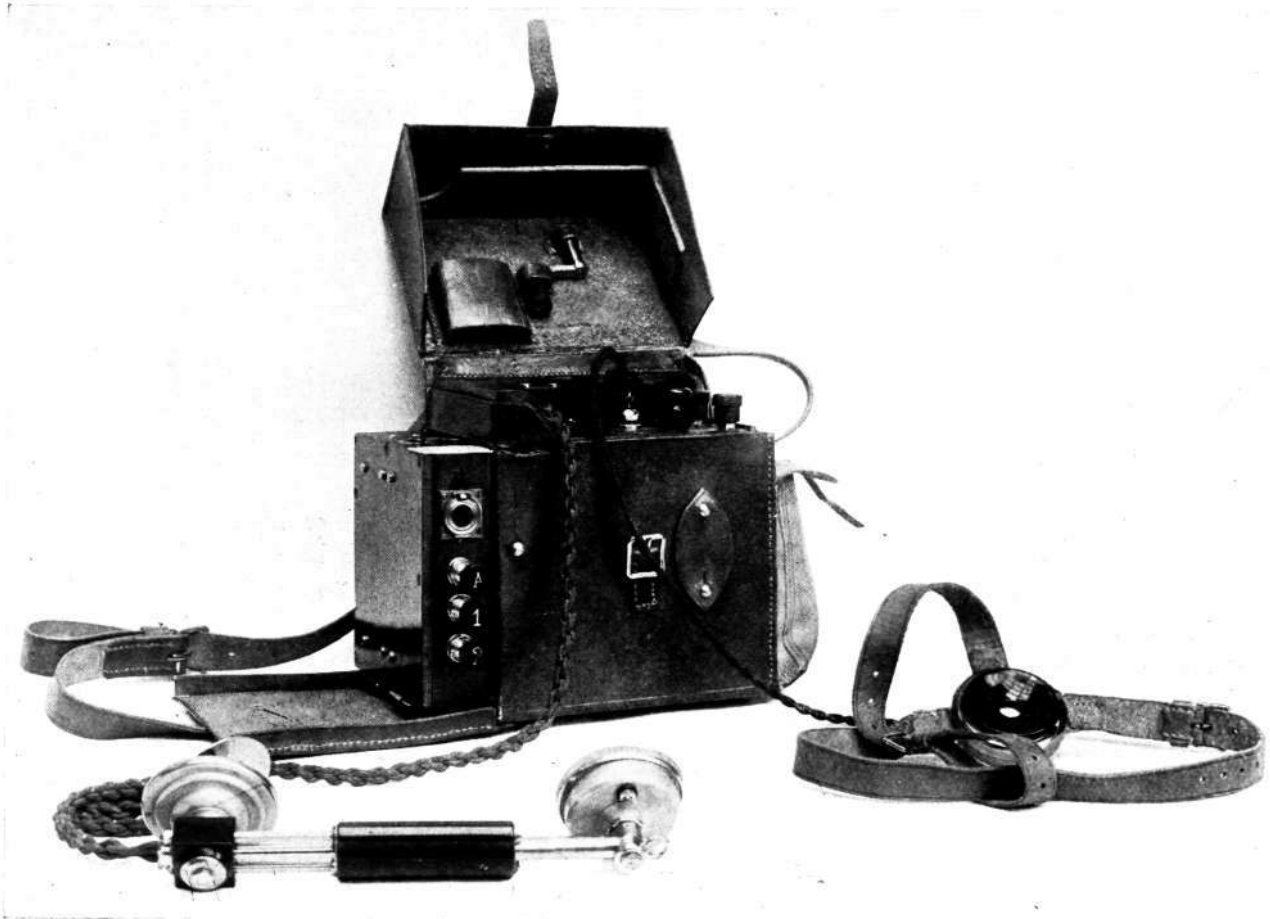
E. Switching cells.

Switching cells consist merely of the separate parts required to make a connection between two subscribers, removed from the switchboard and provided with devices for connecting them one to another. These cells came into general use during the world war, and various types were used by the participating armies.



R 650

Fig. 25.



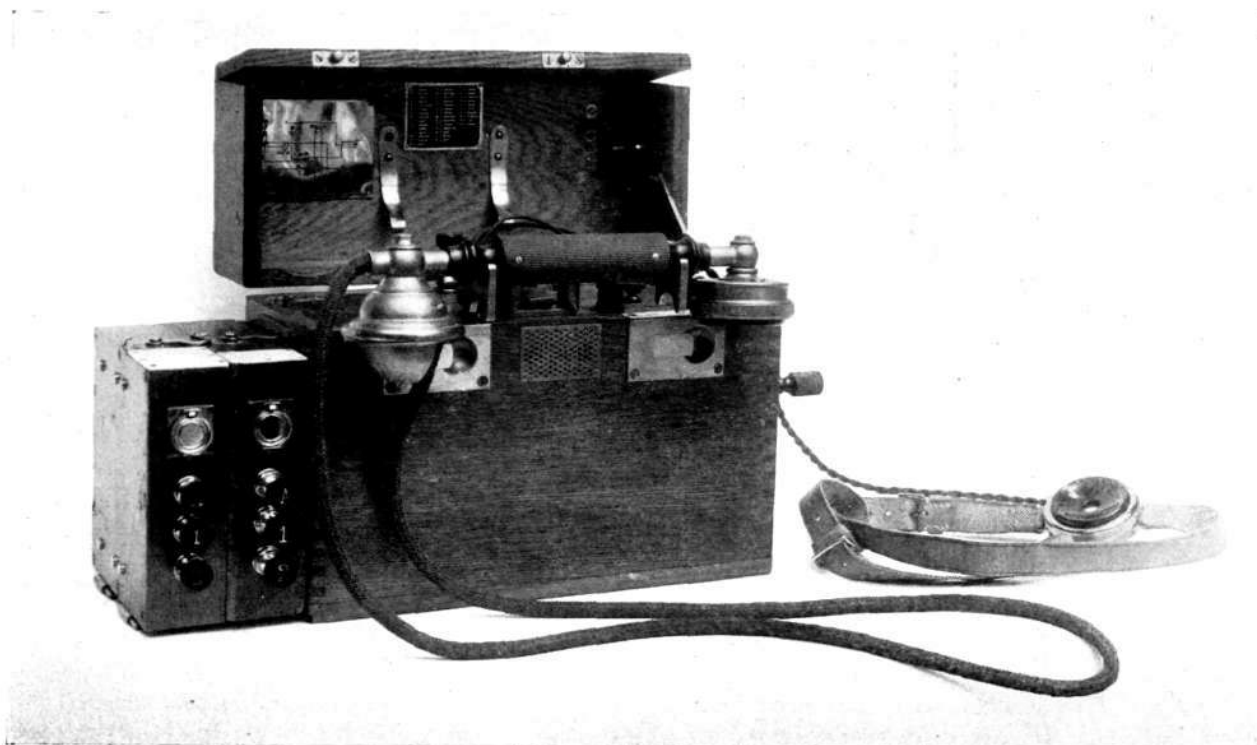
R 632

Fig. 26.

Their method of construction has developed along different lines. In some instances push-buttons have been used, in others, lever switches, while in still a third case the connections have been obtained by means of cords and plugs. L. M. Ericsson have developed the both firstmentioned principles, while Siemens Schuckert of Berlin have used the last principle exclusively. In Sweden, cord switchboards are generally conceded to be less advantageous than the other types mentioned.

The circuit diagram for a switching cell is shown in fig. 25. It is equipped with a high resistance drop

means of contacts similar to those on the sides of the switching cells or by means of wires or cords which are led from the telephone instrument to terminals on the back side of the cell, these being also marked »A». Fig. 26 shows a switching cell adapted to a field telephone and fig. 27 two cells adapted to another type of field telephone. Besides the »A» keys, each cell is provided with two more similar keys marked 1 and 2 which constitute the switching possibilities of the cell. The alarm devices are contained in an *alarm cell* (see fig. 25) containing a battery, an alarm bell, a lamp, and a 3-position lever key for connecting the



R 633

Fig. 27.

indicator which serves the double purpose of call and clearing indicator, and with three push-button keys. The drop indicator is combined with an alarm circuit. The push-button keys are connected to spring stud contacts on one side of the cell and to stationary stud contacts on the other side. When the cells are united by means of the hinge coupling at the bottom and a sturdy hook at the top the alarm circuits as well as the key circuits are automatically connected to each other by means of the stud contacts. This connection is very simple but has proved itself fully efficient, all faulty connections being entirely eliminated. The keys for the upper line are marked »A», and to this line is connected a field telephone instrument either by

battery to either the bell or the signal lamp. Further, the switching cells can be combined with so-called *automatic common battery cells* (*Au-CB-cells*) for junction lines from automatic or *CB*-telephone exchanges, the construction of which will be described further on. In addition to the »A» terminals, another set marked »L» for the incoming line is to be found on the back of the cell.

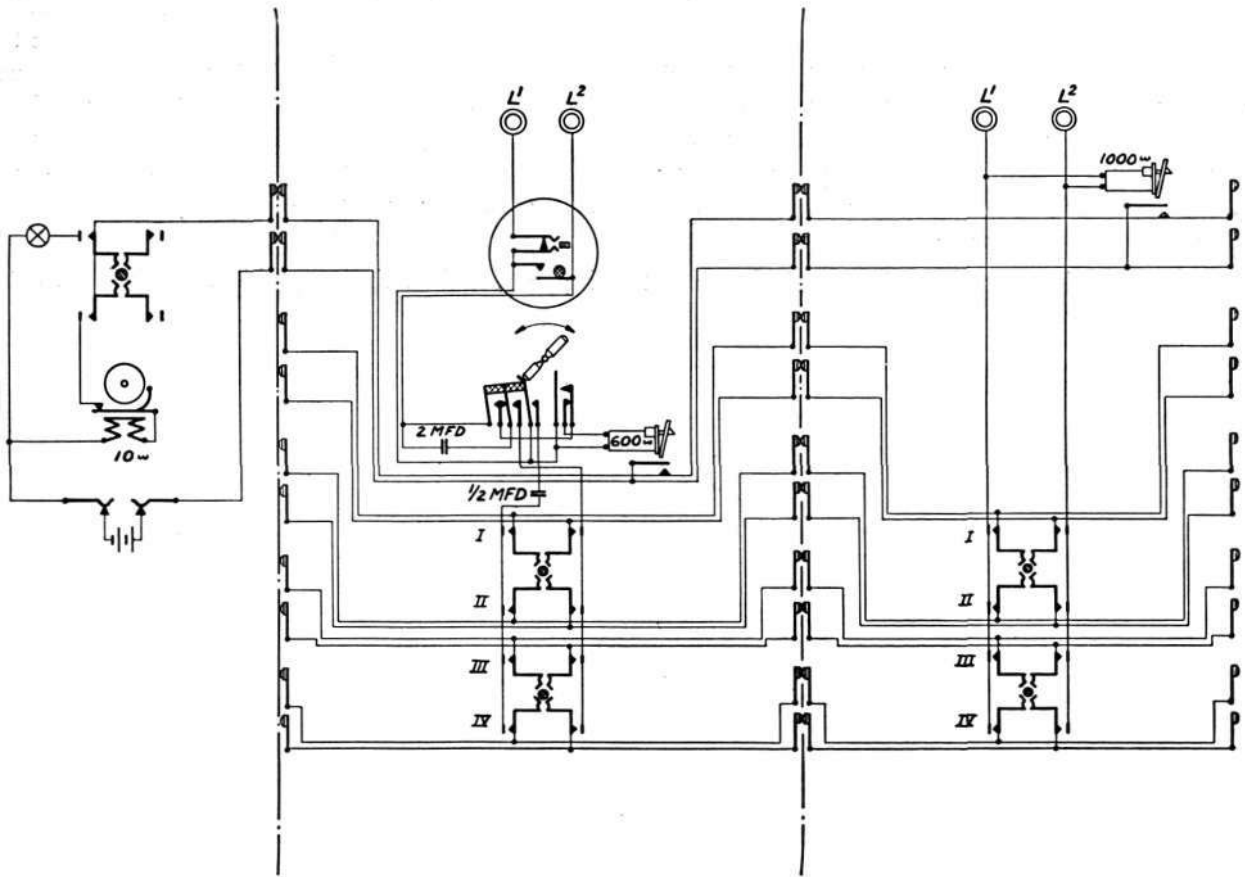
By successively connecting such switching cells to a field telephone — the number of cells depending on the number of incoming lines — a complete field telephone exchange with three switching possibilities is obtained. This number of switching possibilities generally restricts the number of incoming lines to six,

i. e. not more than six cells can be connected to the telephone instrument. If the cells are provided with one more switching possibility, however, the number of incoming lines can be increased to ten.

An incoming call actuates the drop indicator of the cell to which the calling line is connected. The operator depresses the »A» key, thus connecting the telephone instrument to the calling subscriber's line. After the calling subscriber has asked for the desired line, the above-mentioned »A» key is restored to normal

alarm signal is desired, an alarm cell is combined with the others and the lever key is placed in the desired position for connecting up the bell or the signal lamp.

With lever key switching cells, the switching process is practically the same, the main difference being that each position of the lever key corresponds to one push-button key. The circuit diagram for a cell of this type is shown to the right in fig. 28. Each cell is provided with two lever keys, each of which has



R 651

Fig. 28.

and the »A» key of the cell to which the desired line is connected is then depressed. The operator then sends out a calling signal to the desired number by means of the ringing generator of the telephone instrument. When the called subscriber has answered, the operator restores the last »A» key to normal after which the connection between the two subscribers is made by depressing either of the keys marked 1 or 2 in the two engaged cells. The subscribers' clearing signals actuate the drop indicators of their respective cells. The operator can listen-in on the conversation by depressing either one of the »A» keys. If an

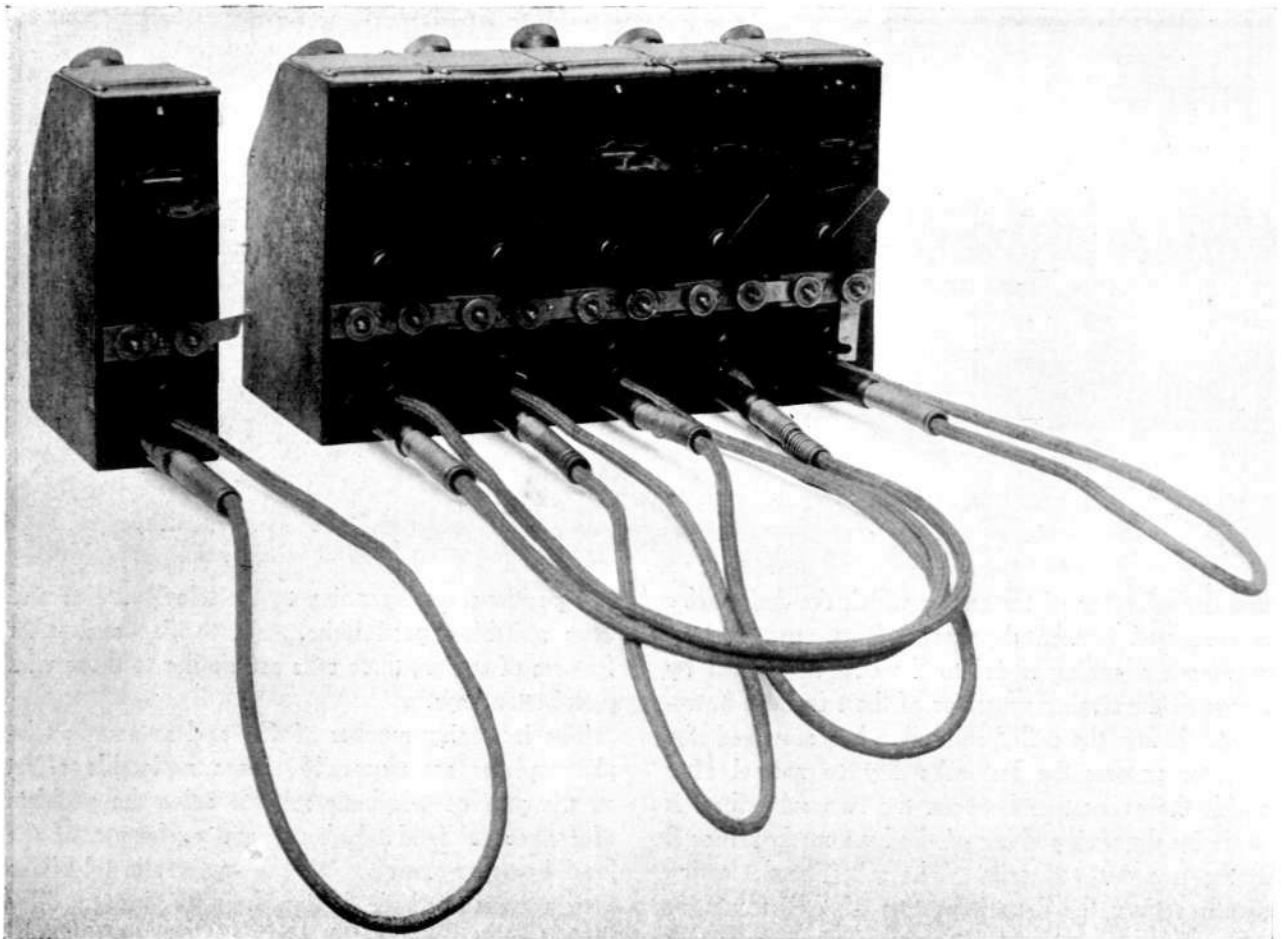
two positions corresponding to the telephone line and three switching possibilities. As to size and other features of design, these cells are similar to those with push-button keys.

The increasing number of CB and automatic telephone plants are responsible for a noticeable effort on the part of telephone men to solve the problem of connecting field telephones and exchanges of the local battery system to CB and automatic telephone nets, various methods having been tried out. The devices necessary for this kind of inter-traffic have been placed within the telephone instruments as well

as in special supplementary apparatus. In the former case the instruments become clumsy and the exchanges difficult to operate, while in the latter case the chances for wrong connections are greatly increased besides making it necessary to provide a much greater variety of such apparatus. The more recent designs of *CB* and *Au-CB* cells, however, have so many advantages that the disadvantage — from a military point of view — of extra supplementary appliances are easily counter-balanced. Fig. 25 shows the circuit diagrams for a *CB* cell and an *Au* cell intended to work in common, while in fig. 28 these two are combined to form a single *Au-CB* cell. The incoming line is connected to the terminals marked *L1* and *L2*, from where the line continues on through the calling dial to a combined speaking and ringing key, where the connections are made in such manner that when the key is placed in its left-hand position, as indicated by the arrows, the line is short-circuited (ringing position). When the lever stands straight out (speaking position) a direct

current circuit is formed from the calling *CB* or *Au* exchange and through the coil of the drop indicator; also, in both instances a circuit to the telephone instrument — passing over a $\frac{1}{2}$ mfd. condenser — is closed. The purpose of the DC circuit is to control the clearing signal at the *CB* or *Au* exchange. The key returns automatically from ringing position to speaking position. If the key is turned to the right (normal position), a condenser with a capacity of 2 mfd. is brought in circuit before the indicator, letting the calling signal from the *CB* or *Au* exchange pass at the same time as the DC circuit is broken. When an alternating signal current from a *CB* or *Au* exchange reaches the cell, the shutter of the drop indicator falls. The operator places the key in speaking position, the telephone being in circuit. On receiving a clearing signal at the end of the conversation, the operator restores the speaking and ringing key to normal.

If a *CB* or automatic exchange is to be called, the key is placed in ringing position. If it is an auto-



R 634

Fig. 29 a.

matic exchange, a register tone is heard in the receiver, after which the dialling of the number may take place, or, if it is a common battery system, an answer is received from the operator at the central exchange. Thus it will be seen that the operation of this *Au-CB* cell is very simple, the chances for making a mistake being reduced to a minimum.

By combining an *Au-CB* cell and a switching cell, we obtain an *Au-CB switching* cell. If junction lines from an automatic central exchange are to be connected to a field switchboard, each one of them is connected to a separate *Au-CB switching* cell, these last, in turn, being connected up with each other and to the switchboard so that the service and alarm lines of the cells respectively are connected to certain definite numbers and to the alarm circuit in the switchboard. An incoming call will actuate the drops of the cells as well as the corresponding drops in the switchboard. The operator then places the key of the corresponding cell in speaking position, the switching process being analogous to that of a *CB* cell combined with a telephone instrument. *Au-CB switching* cells and common switching cells can easily be combined.

Cord switching cells differ in construction from the above-mentioned types. Fig's 29 *a* and *b* show a front and rear view of six combined cord switching cells. The incoming lines are connected to terminals on the backs of the cells, as usual. Each cell is equipped with a drop indicator, below which is placed a combined speaking and ringing key. The ringing position is to the right, the key being automatically restored to normal when released. When the key is in ringing position, the drop indicator is disconnected. A ringing signal can be sent out over a desired line by means of a telephone instrument to which the cell is connected. Furthermore, the cell is provided with

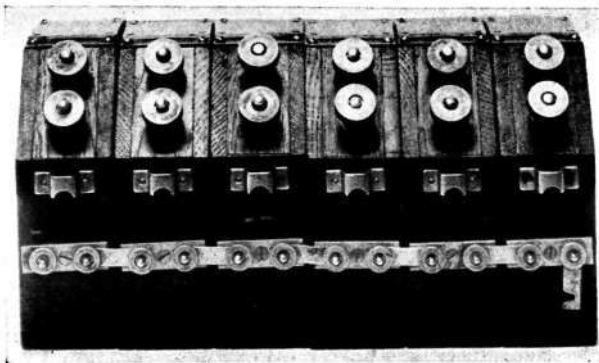
a cord and plug with a rest position for the latter and a service jack for the mutual connecting of two cells by means of the cord.

These cells are used together with field telephones or switchboards provided with similar switching devices (cord and service jack).

The cord system has serious disadvantages, however. The most noticeable are the wear on the cords, contact trouble in the jacks caused by moisture, dirt and earth, and the unprotected connections between the cells. They do not give any solution to the automatic common battery junction traffic question. These cells are used exclusively in the German army which is an ardent admirer of all forms of cord systems since many years back.

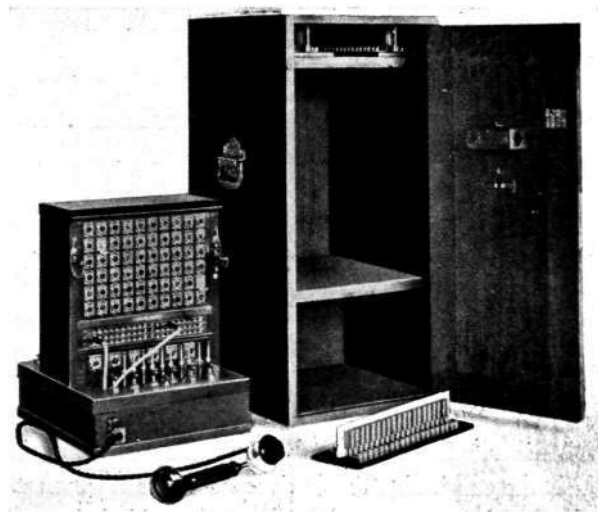
F. Cord switchboards.

Cord switchboards for field use date back to the early days of military telephone practice. Fig. 30 shows a board of this type for sixty lines constructed by L. M. Ericsson already in 1910, switchboards of the same type having been made with a capacity of 40 and 20 lines. Their outward appearance is similar to that of the plug switchboards. The incoming lines are connected to terminals on the back of the switchboard. The switching facilities consist of six pairs of cords, which seems to be altogether too little for a 20-line switchboard, and absurd for a 60-line switchboard. The plugs are let down into the top of the key-board, the combined speaking and ringing keys being placed in front of the respective pairs of cords. The call indicators are placed in the upper part of the vertical panel. Below these are the



R 635

Fig. 29 b.

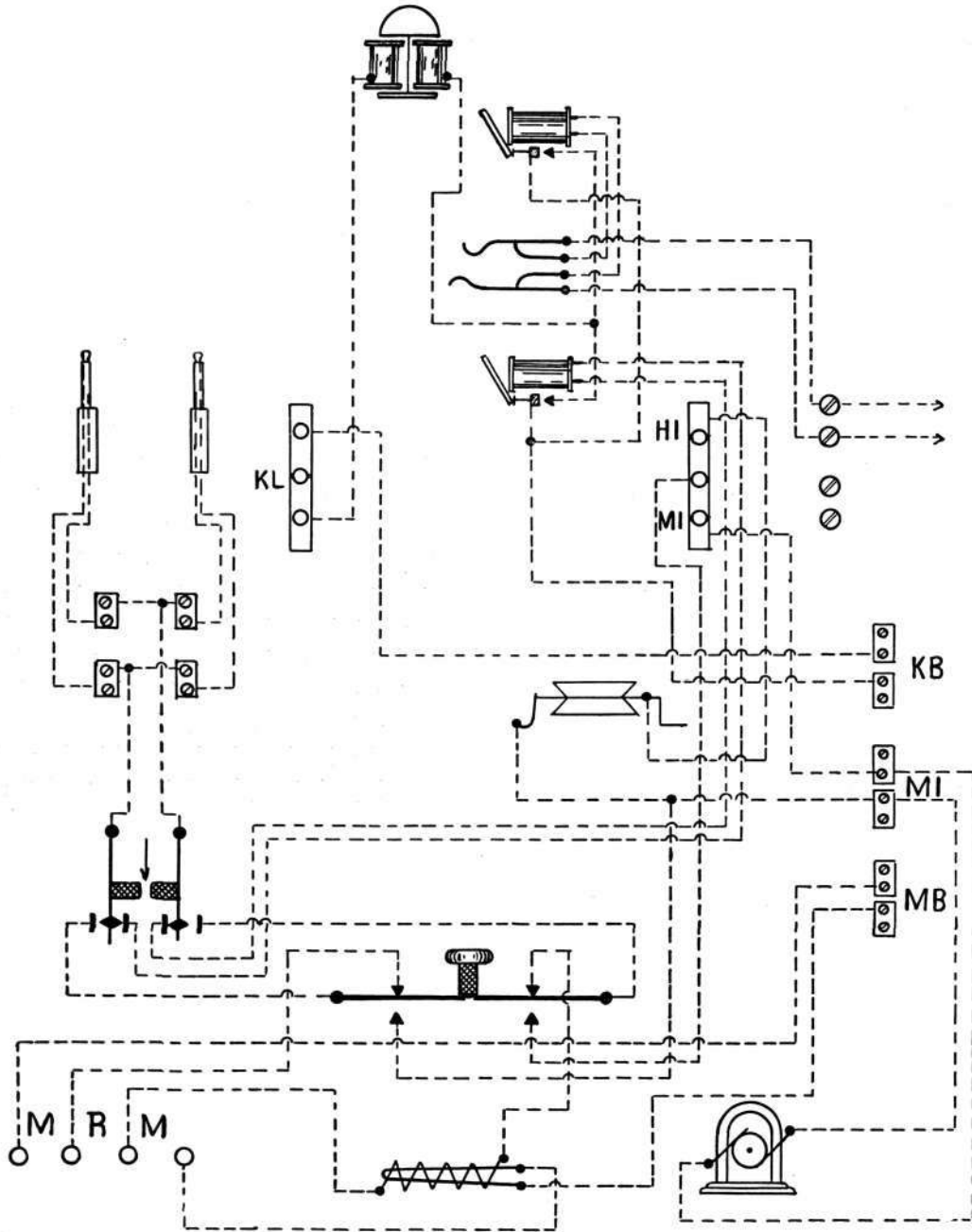


R 636

Fig. 30.

line jacks and, lastly, the clearing indicators. The pressing down of a key to its full depth (ringing position) disconnects the clearing indicator and closes the circuit from the ringing generator to the desired

responding pair of cords. The key is in normal position when it is fully raised. The clearing indicators are situated right in back of the corresponding keys. The cords are fastened to the reels over which



R 637

Fig. 31.

subscriber. On the introduction of a cord plug in a jack, the call indicator of this same line is disconnected. If a key is only pressed halfway down, it is in speaking position, and the handset is connected to the cor-

responding pair of cords. The key is in normal position when it is fully raised. The clearing indicators are situated right in back of the corresponding keys. The cords are fastened to the reels over which they run by means of spring clips, being held taught by means of coil springs which act on the reels. The circuit diagram for this switchboard is shown in fig. 31. The generator, alarm device and microtelephone

are — generally speaking — similar to corresponding parts of the plug and push-button types of field switchboards.

The switching process for making a connection is as follows:

An incoming call on say line number 2, actuates the call indicator. The operator restores the indicator and places the speaking and ringing key of a disengaged pair of cords in speaking position, and inserts either one of the plugs of this pair of cords in the jack of the calling line, thereby connecting his handset to this line. Let us say that the calling subscriber asks for line 5. The operator then switches the cord from jack 2 to jack 5, pushes the key down to ringing position and sends a ringing signal out on line 5 by turning the crank of the generator. When the speaking and ringing key is released, it returns of itself to speaking position. When the called subscriber answers, the operator plugs up the other cord of the same pair in jack 2 and restores the speaking and ringing key to normal, thus completing the connection between lines 2 and 5. A clearing signal actuates the clearing indicator, which is connected in parallel to the speaking circuit. The clearing indicator must be manually restored by the operator. This detailed description of the operation of the switchboard is given so as to make the advantages of the switchboard with combined jacks and indicators already described all the more obvious.

These switchboards have been modernized during latter years, mainly so as to make them serviceable for inter-traffic with CB exchanges. For this purpose, a condenser of 2 mfd's capacity is inserted before the indicator, enabling the alternating signal current from the CB exchange to pass through and actuates the call indicator. The condenser is cut out of the circuit when a cord plug is inserted in the jack which corresponds to the call indicator. Calls to the CB exchange from the field exchange and reciprocal clearing signals are obtained according to the principles customary for regular CB traffic. A condenser with a capacity of $\frac{1}{2}$ mfd. is included in each line between the LB part of the switchboard and the above described part for the CB system.

The German army uses nothing but cord switchboards, one of the types now in use being shown in fig. 32. This switchboard is for ten lines only. The circuit diagram and operation of the board are practically the same as for the above described cord switchboard, but the speaking and ringing keys are replaced

by push-button keys which, on being depressed, disconnect the call indicators below them.

In the top row are eight parallel-jacks for circular connections, and one alarm key. The cords are not attached to the board, and are packed inside of it during transportation. The necessary condensers and choke coils for inter-traffic with a CB system are mounted on the inside of the back panel.

Combined jacks and indicators represent an important step in the development of modern switchboard design, and it is but natural that their advantages should be applied to field switchboards as well. The main differences between this and previously described types are as follows:

All indicator drops are automatically restored; the call indicators by introducing a plug into the jack



R 658

Fig. 32.

immediately below it and the clearing indicators by placing the combined speaking and ringing key in speaking position.

The entire switchboard is built up of standardized parts, thus facilitating the construction of switchboards of varying capacities, and eventually their extension in the field.

Figs. 33 and 34 show a board with combined jacks and indicators designed in the shops of the Royal Swedish Signal Corps. In fig. 35 this switchboard is shown with case removed and with attached switching cell.

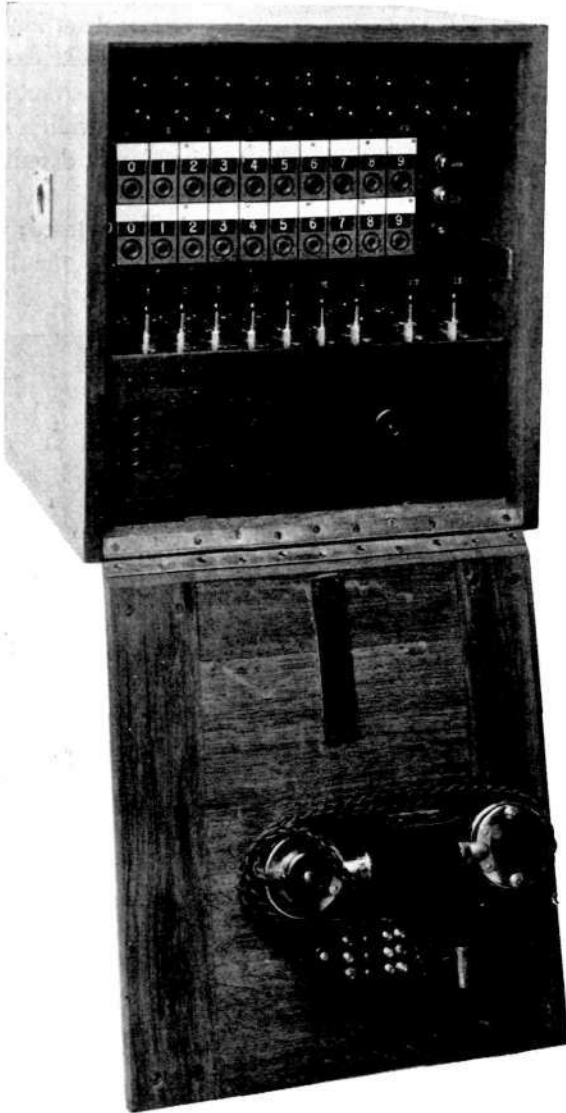
The plugs and cords are mounted in pairs in the top part of the board, the answering cords in the bottom row and the calling cords in the top row. There are nine pairs of cords, numbered with roman numerals. Below the cords are two metal strips containing ten combined jacks and visual indicators each.

The combined jacks and indicators consist of a magnet coil with armature and drop, a jack, and a device for the mechanical restoring of the drop shutter on the inserting of a plug in the jack. These various parts are sheathed. The magnet coil has a resistance of 600 ω . The drop of the indicator consists of a

circuit is closed when the drop of the indicator falls down. To the right of the indicators are two keys, the upper one — the alarm key — for connecting the battery to the alarm circuit. The use of the lower one — the reversing key — will be given further on.

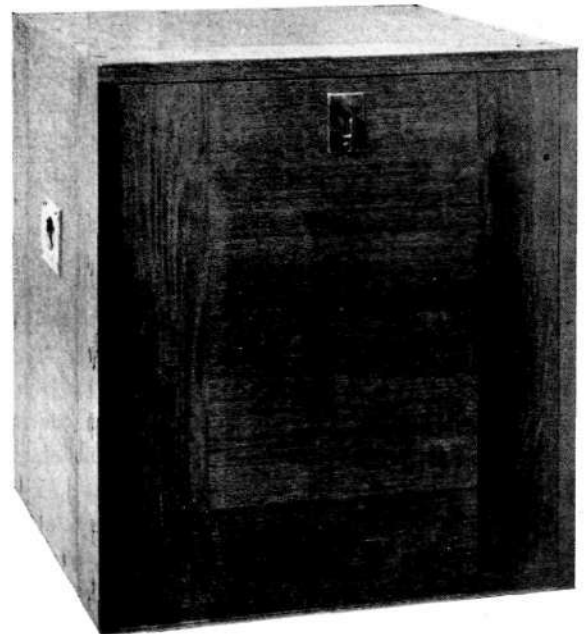
Below the reversing key is a bulls-eye visual indicator which enables the operator to see if a signal current goes out from the switchboard. This indicator is very cleverly constructed, so that it is extremely sensitive, even for very weak currents. Thus, if the outgoing signal current is not able to fully open the eye of the indicator, this is a sign that there is leakage on the line; if the indicator does not move, the line is broken. This little device is of great value on a field switchboard on account of the poor lines which so often occur.

The clearing indicators occupy the last row on the panel, below the combined jacks and visual indicators, one for each pair of cords. The coils are larger than is usually the case, i. e. the core contains



R 639

Fig. 33.

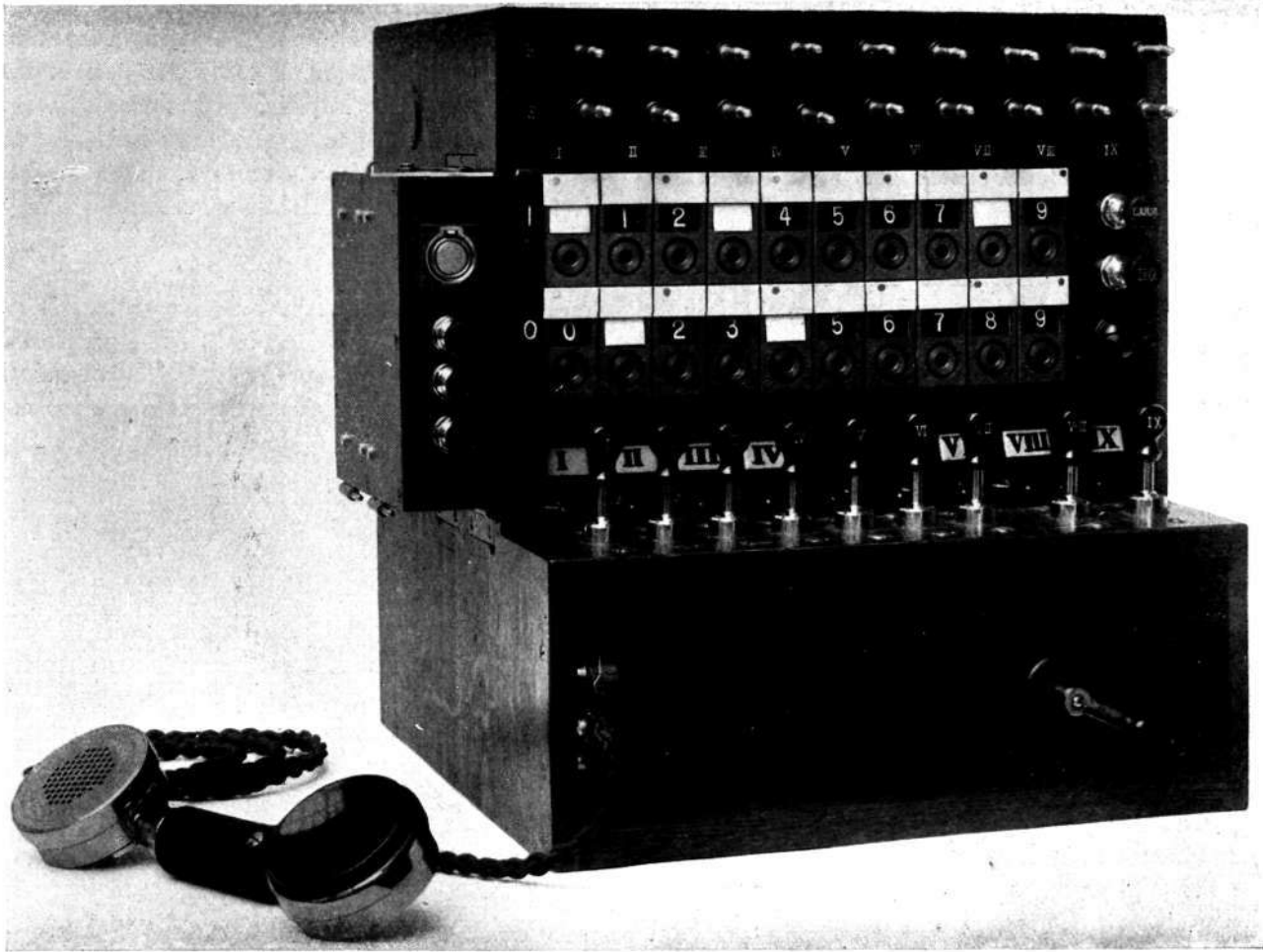


R 640

Fig. 34.

white enamelled shell which is lowered over the number of the indicator when this latter is actuated by an incoming call. In fig. 35, the shutters of indicators No. 1, 4, 10, 13 and 18 are down. When a plug is introduced into the jack, the drop above it is restored to normal. Further, the jacks are provided with alarm contacts over which the alarm cir-

cuit is closed when the drop of the indicator falls down. To the right of the indicators are two keys, the upper one — the alarm key — for connecting the battery to the alarm circuit. The use of the lower one — the reversing key — will be given further on. Below the reversing key is a bulls-eye visual indicator which enables the operator to see if a signal current goes out from the switchboard. This indicator is very cleverly constructed, so that it is extremely sensitive, even for very weak currents. Thus, if the outgoing signal current is not able to fully open the eye of the indicator, this is a sign that there is leakage on the line; if the indicator does not move, the line is broken. This little device is of great value on a field switchboard on account of the poor lines which so often occur. The clearing indicators occupy the last row on the panel, below the combined jacks and visual indicators, one for each pair of cords. The coils are larger than is usually the case, i. e. the core contains



R 641

Fig. 35.

Self-induction	abt.	2.5	henrys
Resistance to direct current . .		600	ohms
» » altern. » . .		3,200	»
» » speech » . .		16,000	»

When the electromagnet of the indicator is energized by an alternating current the armature is made to vibrate, causing the indicator drops to fall and closing the alarm circuit contacts. The indicators are mechanically restored by means of a rod device actuated by the combined speaking and ringing key when it is placed in speaking position. In fig. 35, the drops of indicators I to IV and VII to IX are down.

The horizontal key-board contains the nine combined speaking and ringing keys, one for each pair of cords. These keys, which are very sturdily built, have three positions, i. e. *normal*, straight up, *speaking position* when the key is pushed over towards the switchboard, and *ringing position* when the key is brought over towards the operator. When the key is in speaking

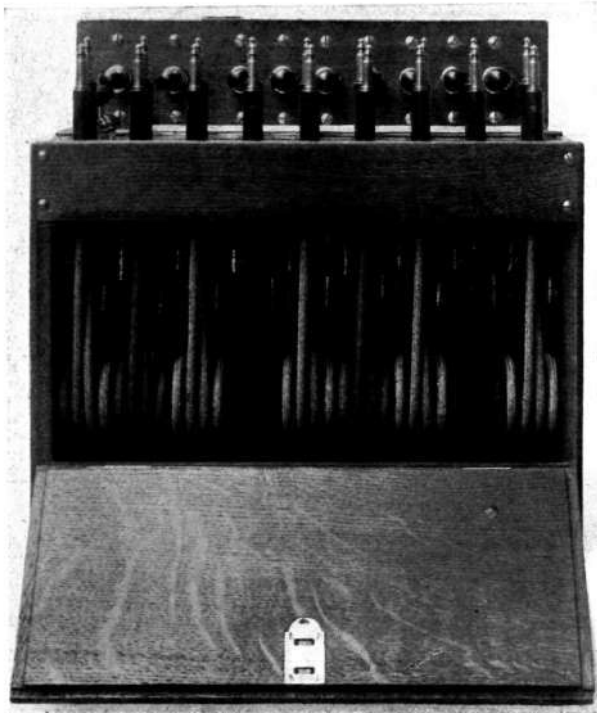
position, the corresponding pair of cords is connected up; when in ringing position the calling and clearing indicators are disconnected at the same time as the ringing circuit to the called subscriber is closed over the ringing cord which has already been plugged up in the jack of this subscriber. This holds good on condition that the reversing key has not been depressed, in which case the ringing current will go back to the calling subscriber.

In the lower front panel may be seen the generator crank and the jack and plug connection for the hand-microtelephone. This method of connecting the handset has been adapted to field switchboards for many years because of the ease with which handsets can be exchanged or replaced by head receivers and breast transmitters or by laryngophones.

On the left side of the switchboard are the hinge-like attachments for the switching cells, together with the contact studs. There are two such studs for each

switching possibility in the cells, the A-line being connected to incoming line Nr. 0 in the switchboard, the lines 1, 2, 3, etc. — for which there are keys in the cells — being connected to similarly numbered incoming lines in the switchboard. Thus, four incoming junction lines from an automatic central exchange are each one connected to its *Au-CB* cell, these latter then being combined with each other and connected to the switchboard. Each one of these lines is then permanently connected to a certain jack in the switchboard, but if it should be necessary to take in more junction lines than there are switching possibilities, a switching operation must also take place

block, from there over another pulley on the same axle as the first one, and out through the hole in the front panel of the switchboard, there to terminate in the plug. The spiral block springs keep the cords taut. The cords are kept separate from each other by means of aluminium partitions. These partitions are all riveted to a common plate of the same metal, whereby they are easily removed for the replacing or exchange of a cord, which can be done without hindering or troubling the operator. Above the hinged back is an ebonite panel for the line terminals. The panel contains jacks, the plugs being provided with a terminal screw for attaching the line wire. These plugs are

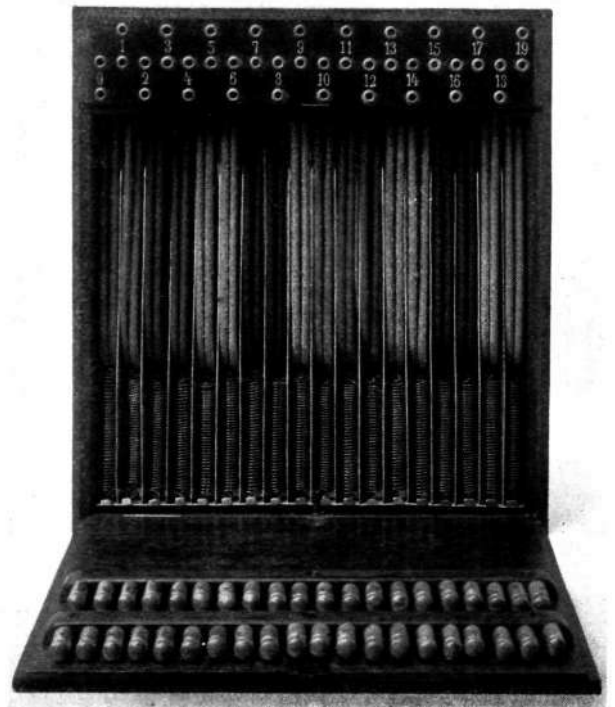


R 642

Fig. 36.

within the cells. In such a case, the operator must hold the A-line disengaged as long as possible.

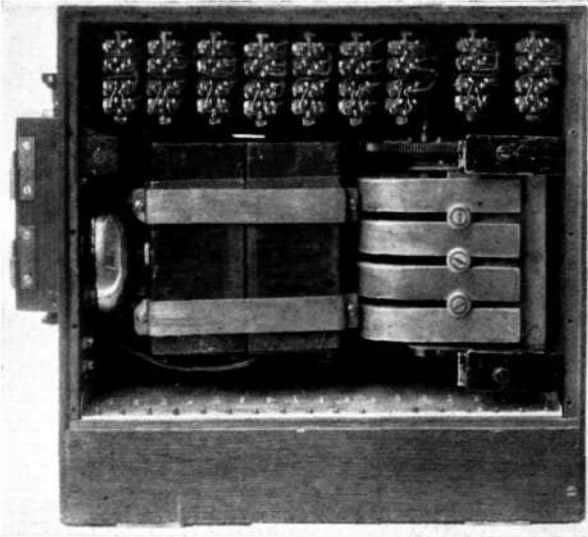
A top view of the switchboard, with the cover open, is shown in fig. 36. Behind the plugs is the key board with the combined speaking and ringing keys. A rear view, with the hinged back let down, is shown in fig. 37. The arrangement of the cords is here clearly shown. From the terminal clip a cord is led over one of the sheaves of a double, loose block, held by means of a spiral spring whose other end is fixed to an aluminium plate. From the block sheave the cord passes over a pulley mounted on a horizontal axle back over the other sheave of the



R 643

Fig. 37.

kept in racks on the inside of the hinged back (see fig. 37). Fig. 38 gives a view of the switchboard seen from underneath and with the bottom removed. At the top of the picture are the spring groups and soldering tabs of the speaking and ringing keys. To the left is the induction coil and below it the alarm bell. Under the iron strips are the two dry cells which are easily accessible for replacement, and to the right of these the ringing generator. Between the lower and upper parts of the switchboard is a horizontal partition on which are mounted the common terminal strips for the generator, speaking, ringing and transmitter circuits.



R 644

Fig. 38.

The circuit diagram for this switchboard is given in fig. 40, a cord circuit being shown in principle in fig. 39. The switching process for making a connection between two subscribers is as follows:

An incoming call actuates the call indicator of the line in question. The operator introduces the lower plug of a disengaged pair of cords in the jack located immediately beneath the call indicator — thus automatically restoring the shutter of the indicator — and places the corresponding speaking and ringing key in speaking position, after which she is given the desired number by the calling subscriber. She then inserts the other — or top — plug of this same pair in the jack of the desired number, places the speaking and ringing key in ringing position and gives a signal by means of the generator, after which the speaking and ringing key is restored to normal. The connection between the two subscribers is now completed.

Simultaneously with the plugging up of the speaking cord and the restoring of the call indicator, the disconnecting of the indicator coil from the subscriber's line takes place and the clearing indicator is connected up instead, with the result that this indicator is actuated when the subscribers give a clearing signal. The operator then pulls down the connection and the spiral springs cause the cords and plugs to return to their previous positions. The shutter of the above-mentioned clearing indicator is mechanically restored when — the next time this same pair of cords is used — the speaking and ringing key is placed in speaking position.

Combined jack and indicator switchboards are

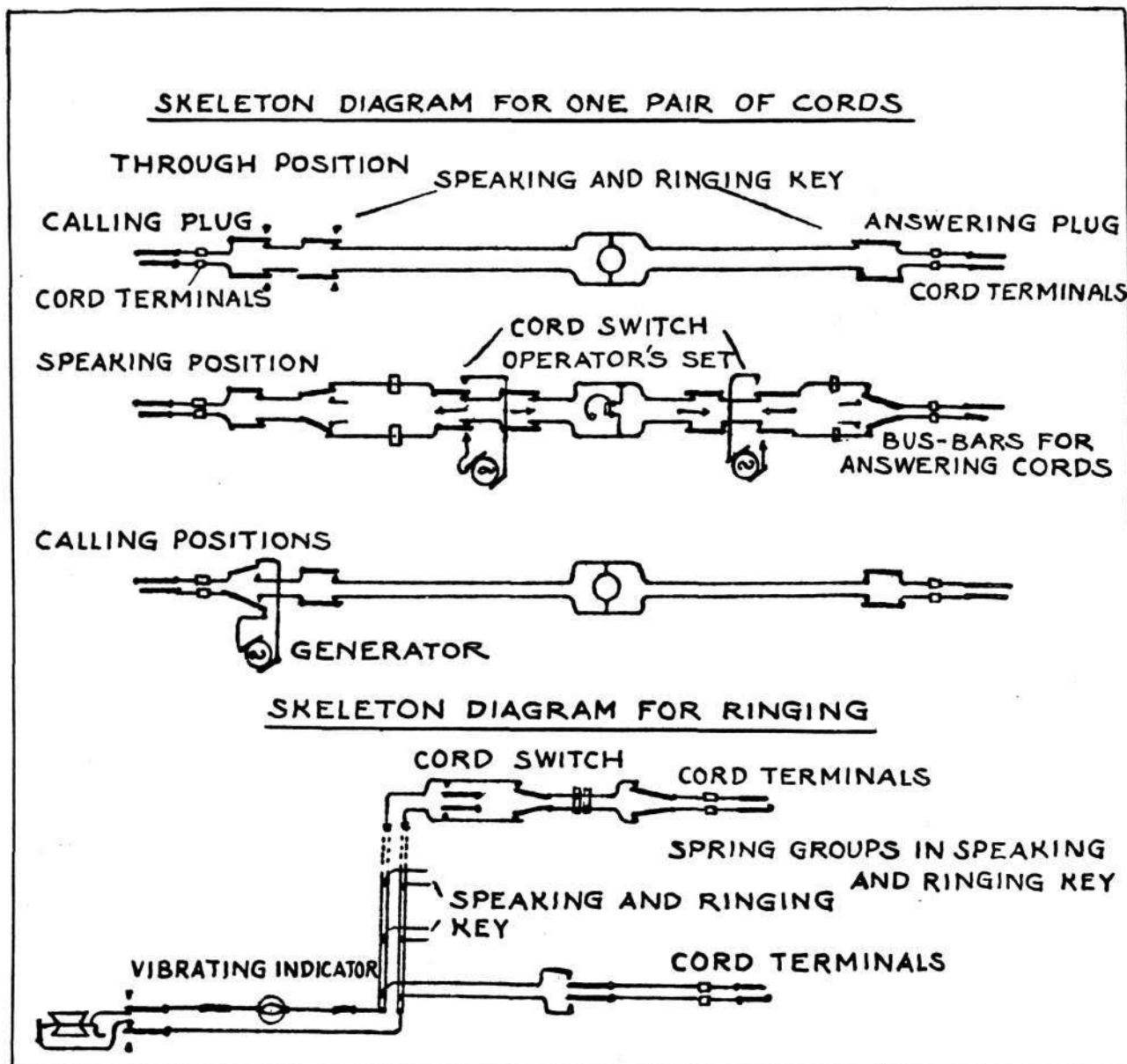
advantageous not only on account of the mechanical restoring of the call and clearing indicators, but also because the operator never needs to hunt for the jack which corresponds to the actuated call indicator. Besides, this type of switchboard is much less difficult to operate than other types, an advantage which cannot be too highly valued because of the difficulty of obtaining well trained operators for field service.

The operator can listen in on a conversation by placing the correct speaking and ringing key in speaking position. Circular calls are obtained by placing the speaking and ringing keys of all the included pairs of cords in speaking position. Should additional arrangements for this purpose be desired, one or two jack strips can be introduced above the combined jacks and indicators. Each of these strips is divided into two groups of six jacks, providing facilities — with two strips — for the interconnection of the subscribers in four groups with a maximum of six in each group. A group of subscribers can also be formed by means of switching cells, but their number depends on the number of switching possibilities in the cells and is rarely more than four. This is done by connecting these four subscribers' lines to the numbers 0, 1, 2 and 3 in the switchboard, the four switching cells being also connected to these numbers. The line keys of the cells are then interconnected and the subscribers are placed in communication with each other when the keys of the cells are placed in different positions.

It would seem, from what has been stated in the foregoing, that, among the smaller field switchboards, switching cells and switchboards with combined jacks and indicators offer the greatest advantages. This last type is more reliable and quicker in operation, although push-button or lever key switchboards are to be preferred in damp localities. No remarks can well be made against the adaptability to field service of any of these types, however, and the choice between them is often a matter of taste, this being undoubtedly the reason for the existence of different types in the armies of closely related countries.

II. *Field telephone switchboards with multiple.*

During the world war it was often found necessary to install field exchanges with as many as 600 lines. At the outbreak of the war, no material specially constructed for this purpose was available, but during the latter part of the war all the participating armies were provided with multipel switchboards so constructed as to be easily installed or demounted. These



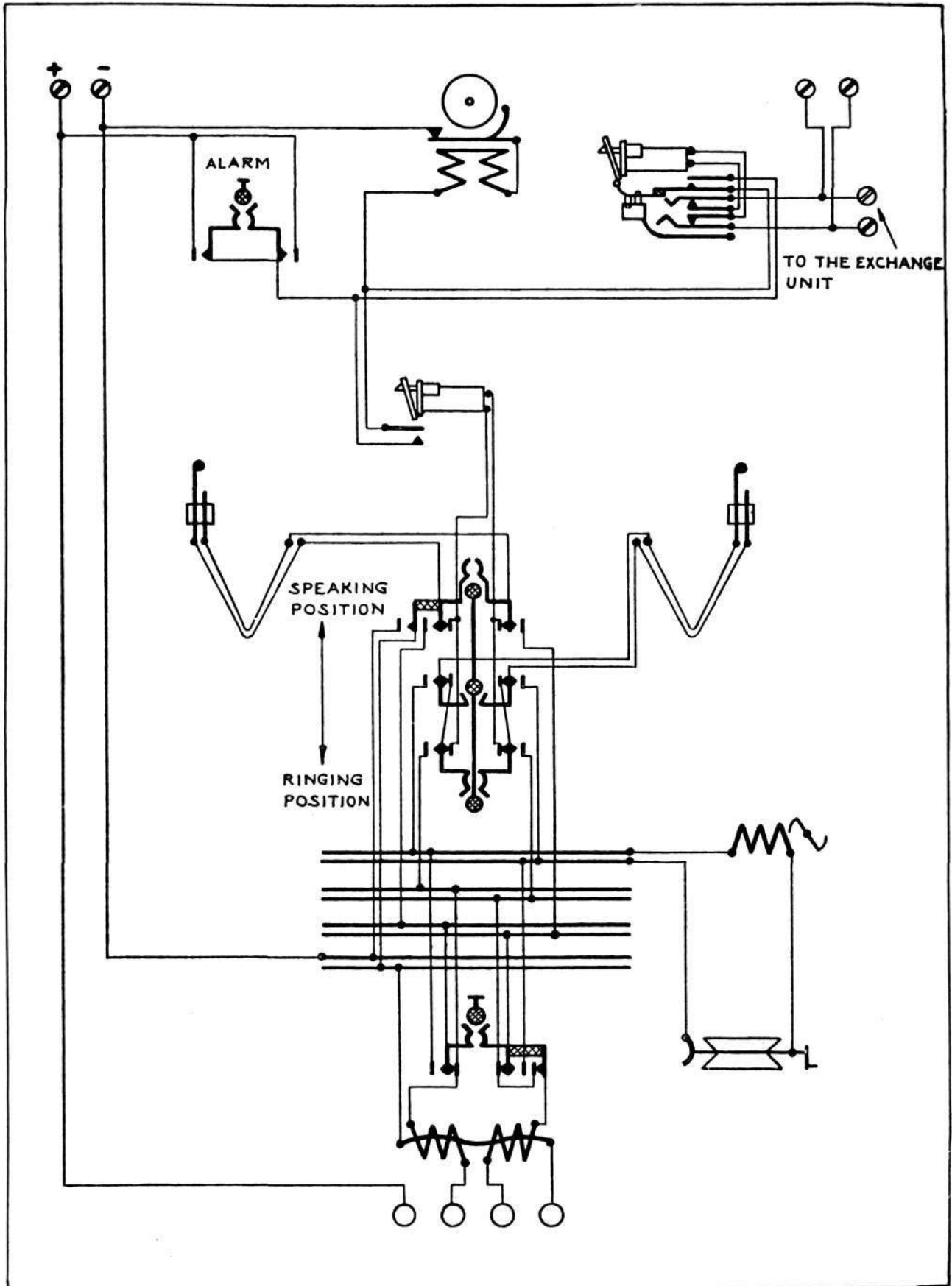
R 646 E

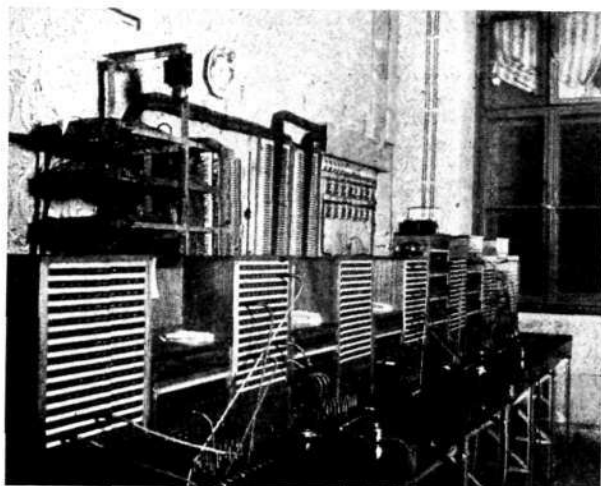
Fig. 39.

boards were not designed with a thought towards reducing the required personel to a minimum and one cannot help noticing the apparently small number of lines in each position. Fig. 41 shows a German exchange built in 1918 with multiple boards of type 1916. These boards are not constructed for a limited number of lines, but the capacity can be increased by mounting additional standard parts consisting of call indicators and answering jacks for ten lines. Also, this switchboard can be adapted for inter-traffic with others of similar construction by means of a special multiple addition. The main parts of this board are:

- a. Demountable iron foot.
- b. Keyboard, with cords, speaking and ringing keys, generator, microtelephone and batteries.
- c. Jack and indicator strips for ten lines each.
- d. Multiple.
- e. Incoming cable with connecting jacks.
- f. Connecting cables with plugs and jacks.

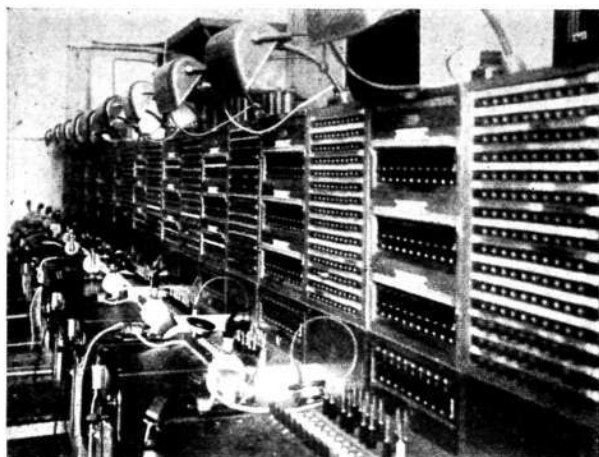
Nearly all of the switchboards shown in fig. 41 are for only twenty incoming lines. The multiple sections are placed on top of the board between two adjoining positions. These sections — each one with a capacity of 150 lines — are arranged so as to





R 647

Fig. 41.



R 648

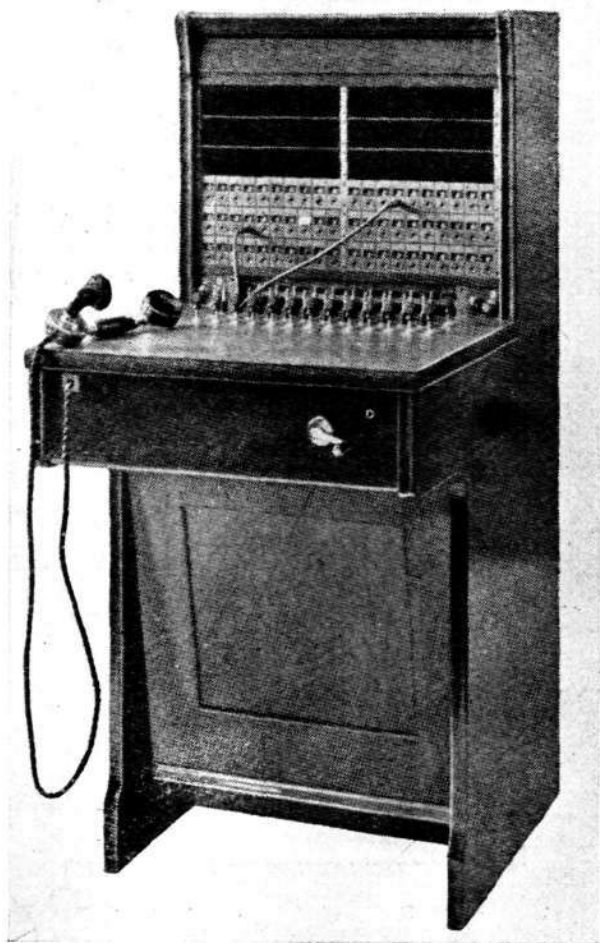
Fig. 42.

permit their being used by the operator either to the right or to the left of the same. If no extra arrangements are provided, such exchanges can be built for a capacity of not more than 300 lines. Fig. 42 shows another larger exchange according to the same system. When it is desired to increase the capacity above 300 lines special jack switchboards are used. The internal connections of these large field exchanges are usually accomplished by means of multi-conductor cables with plugs and jack strips, the tab strips with fuses and protectors being located outside the exchange. On later models one board is connected to another by means of a 300-conductor cable and a whole field of plug contacts which is pushed into the corresponding jack field in the other board.

In Sweden, larger field exchanges have been established on trial only, and with very satisfactory

results. During last year's large fall manoeuvres a 160-line multiple exchange was erected for General Headquarters by the Royal Signal Corps in three days, inter-traffic being established with the central telephone exchange in the city of Sigtuna. The two boards used for this field exchange were of the type shown in fig. 43, each one mounted with combined jacks and call indicators for a capacity of 80 lines, a multiple field in the top part of the vertical panel, and a cord annex.

It is said of a great number of things in our universe that they move in a circle, and it cannot be denied that such is the case at least in regard to field telephone switchboards. From what has been said in the foregoing it is evident that plug switchboards have been superseded by cord switchboards only to return to plugs and keys, and so forth. Tastes and opinions have

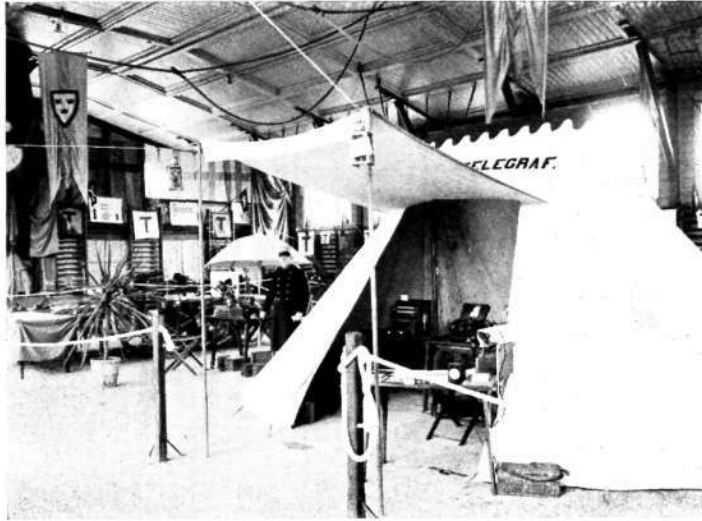


R. 649.

Fig. 43.

changed, but technical intellect has always found new ways and means to meet the ever increasing demands. What is now the very height of development may — in but a few years — be considered antiquated and condemnable. It may not be long before the requirements will call for field switchboards for direct inter-

traffic with wireless telephone plants, probably with the specific demand that all illegitimate listening in or picking up of messages be completely eliminated. To us it may sound fantastic, but will probably then be as natural as a crystal detector to the average school-boy of today.



R 713 Collection of instrument models of the Royal Swedish Signal Corps.

CONTENTS OF THIS NUMBER: In memoriam: Lieut.-Colonel Patrick Walter d'Alton. — Ir P. de Vries D. zn. — Baron C. d'Aulnis de Bourouill. — Three semi-centenarians: E. G. Windahl, Per Edward Allvén and Gustav Wettermark. — On various principles of receiver and loud-speaker design. — Automatic section blocking on the line Stockholm Östra—Stocksund. — Electric signal and safety installation for the Djursholm Railway. — Field telephone switches and switchboards. Various principles of construction.

L. M. Ericsson

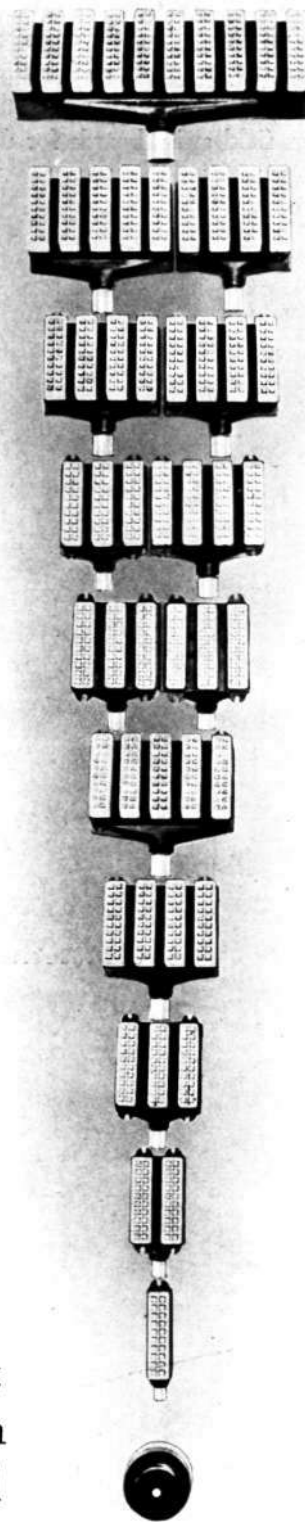


Ericsson

Line Material

Thanks to more than 40 years experience in the building and operating of telephone nets we are able to offer to our customers first class modern line material which covers all the details and tools necessary for a telephone installation.

Our construction department executes on contract all kinds of work connected with telephone lines as well as complete installations. — Complete plans, estimates and catalogues supplied on request to be addressed direct to us or to our agencies in various parts of the world



TELEFONAKTIEBOLAGET L. M. ERICSSON
STOCKHOLM, SWEDEN

The *L. M. Ericsson* *Review*



VOL. IV

JULY-SEPTEMBER 1927

Nos. 7 to 9

We have the painful duty of communicating that the Head
of our Sales Department

Director

Erik Oskar Sandberg

died on the 19th August.

By the decease of Director Sandberg our firm has lost not only one of its seniors in length of service but also one of its most capable collaborators, who has efficiently held important pioneer positions and executed numerous responsible commissions over a period of about forty years.

Telefonaktiebolaget L. M. Ericsson

ENGLISH EDITION

THE L. M. ERICSSON REVIEW

ENGLISH EDITION.

JOURNAL OF
TELEFONAKTIEBOLAGET L. M. ERICSSON, STOCKHOLM.

Responsible publisher: HEMMING JOHANSSON

Editor: WOLDEMAR BRUMMER.

Issued quarterly. ~ ~ ~ ~ ~ Yearly subscription rate: 7/-

All communications and subscriptions to be forwarded to the Editor.



R 792

Carl Johan Andersson.

In memoriam.

Carl Johan Andersson, former shop superintendent of the Ericsson company, died at his home in Upsala on August eleventh at the age of 77.

Mr. Andersson had devoted his energies to this company from the time it was founded in 1876 until 1908, when he retired and made his home in the above-mentioned city.

In the capacity of partner and collaborator, Mr. Andersson joined Mr. Ericsson in organizing this company and had the satisfaction of witnessing its growth from a very insignificant beginning to its present world encompassing proportions.

Mr. Andersson's quiet and considerate personality won for him a large number of warm friends. He performed his duties with care, judgement and energy, qualities with which he was highly gifted. His death means the passing of still another of the "old guard", remembered and mourned by former comrades and friends.



R 791

Erik O. Sandberg.

In memoriam.

Another veteran of the Ericsson organization has passed away, one of the pioneers who took part in the early struggles for recognition which resulted in establishing the company in the acknowledged first-rank position it has long occupied, and to which the inherent worth of its inventions and products entitled it. The ranks are thinning fast. It was only last December that we lost our Grand Old Man, the founder, and for a long time the director of the company, Lars Magnus Ericsson, and in August of this year he was followed by his first partner, Carl Johan Andersson. And now, only a few days after the last-named had been laid to rest in the quiet cemetery at Upsala, we have to report the death of Erik Oskar Sandberg.

Suddenly and without warning came the news of his death. Both of the men who had preceded him were well on in age having retired from the company many years ago, but Sandberg attended to his multifarious duties and responsibilities in the company's service with unbroken energy and seemingly unimpaired health up to the time of his death. Heart failure ended his life on the nineteenth of August, only a few hours after he had left the office.

He was not a veteran in point of age but in years of service. Although not yet 56 at the time of his death, he had been with the Ericsson company for

no less than 39 years. Sandberg was born at Glanshammar, in the Province of Närke, Sweden, on the 3rd September 1871, being only 17 years old when — in 1888 — he obtained employment with the Ericsson firm. The assiduous attention of the young man to his duties and his keen interest in the work soon gained for him the goodwill of his employer. The concern at that time was of comparatively small proportions, and he was given opportunities to acquaint himself with all departments of the business, opportunities of which he conscientiously availed himself. The ease with which he acquired a knowledge of languages, furthermore, made it natural that he should be the choice of Ericsson and the latter's commercial manager, Axel Boström, for important missions in connection with the energetic efforts made at that time to introduce the Ericsson products abroad.

England was one of the earliest and most important markets of the company. The expansion of the business in that country making it desirable to establish a branch office there, the London office was opened in 1898, and the responsible and difficult task of starting and organizing the English branch was entrusted to young Sandberg. He acquitted himself with great credit of this commission, and having brought the undertaking to a successful conclusion left the management in other hands and returned to Sweden.

L. M. Ericsson

His sejour there, however, was of short duration. The branch in Russia, where manufacturing had been started on a comparatively small scale already in 1897, was expanding rapidly. A factory of considerable size had been put up, and the growing business demanded the services of a man who not only was familiar with the manufacturing methods at the parent factory and the business principles of the concern, but who also possessed the personal qualities required for managing an enterprise of this kind under the peculiar conditions prevailing in Russia. Sandberg was chosen for this responsible position and entered in his new duties in 1901. Indomitable energy, unfailing patience and wide experience, together with the support of able collaborators, enabled him to overcome the difficulties with which the company had to contend during the years that followed, and which at times were so great as to suggest the advisability of shutting down the factory. In 1905, this concern was re-organized into a Russian joint-stock company, having up to that time been conducted as a branch of the Swedish parent company. From this time onward the development of this company was both rapid and unbroken under Sandberg's leadership. In proof of this statement may be mentioned that the number of workers when Sandberg was placed in charge of the branch was about 500, while during the war, up to the Revolution in March 1917, the factory employed 3500 workers. The industrial and economic upheaval in Russia which ensued upon the successive revolutions was the cause of Sandberg's return to Sweden. He has since been employed at home, during later years holding the position of sales manager at the Stockholm factory. In this capacity his intimate knowledge of all the branches of business covered by the Ericsson organization and of the company's business connections in all parts of the world made his services extremely valuable to the firm.

The company has suffered a serious loss through the death of Sandberg, not the least because his passing

away means the severing of a strong link between the present and the past.

Through his high character and fine intellectual attainments, Sandberg made himself liked and valued not only by his superiors, but by all who had opportunities to know him intimately. His unassuming and kindly disposition, his never-failing readiness to give advice and assistance, his optimistic views of life in adverse as well as prosperous situations gained him the staunch friendship of fellow-workers of all degrees. Especially characteristic for the man was the quiet strength with which he faced the many trying situations with which his life was richly interspersed, and a patience which could be subjected to the severest tests without giving way. It was Sandberg's good fortune to serve his apprenticeship in telephony under the guidance of such competent and exacting men as L. M. Ericsson and Axel Boström. He made good and faithful use of his own attainments and the knowledge he had acquired in the course of his career, and during his advancement to increasingly responsible positions he remained true to the ideals inculcated in his youth.

Erik Oscar Sandberg had colleagues and friends of older or younger generations scattered over the whole world, who received the news of his death with feelings of sorrow and loss. A strong and able man has been stricken down while he was still coping energetically and successfully with the many problems belonging to his office. An irreplaceable link in the chain of comradeship and friendship has snapped. It will be long ere his memory fades!



R 563



R 785

The Burial of Erik O. Sandberg.

The funeral service over Erik Oskar Sandberg was held on August 25th in the Solna church, which had been tastefully decorated with palms and the many floral offerings from both near and far. The service was opened with a solo sung by B. Arrhenius, followed by a moving sermon by rector A. Hagardt, who also performed the funeral service. This was followed by another solo, after which the burial took place in the nearby Norra Kyrkogården (North cemetery). In addition to relatives and friends the board of directors and personnel of the Ericsson company were present to pay a last tribute to the deceased. His life work in the service of the company was made the subject

of a short speech held at the grave side by Director K. F. Wincrantz, who also made mention — in words full of warmth and tinged with deep regret — of the serious loss suffered by the company through the death of E. O. Sandberg. Director H. Johansson brought the deceased a sincere and heartfelt thanks on the part of former comrades and friends. His unforgettable personality was held forth in a simple and touching manner by Alexander Johansson, one of the company's oldest employees, who finished by reciting some farewell verses written by himself, the last of which is here given in the language of origin:

*“Höstliga löven nu falla
Lätt på din fridsälla grav
Tag nu en hälsning från alla
Tack för det goda du gav.”*

ANDERS LIGNELL,
Superintendent of telephones,
Stockholm



R 660

Member of the International
Consultative Committee for Long
Distance Telephone Commu-
nications

THE L. M. ERICSSON AUTOMATIC TELEPHONE SYSTEM

Experiences from the Stockholm telephone net concerning
the efficiency and maintenance of the system.

By A. Lignell, Superintendent of telephones, Stockholm.

The first automatic telephone exchange in Stockholm built according to the Ericsson system was put in operation in the middle of January 1924.

This exchange — Norra Vasa — was then built for a capacity of 5 000 subscribers' lines, but the installation of additional equipment — for the maximum capacity of 10,000 lines — was begun already at the end of the same year, this extension being completed during the latter part of the year 1925.

It may be of interest in this connection to mention that a trial exchange with inter-traffic with the entire telephone net of Stockholm had been in operation for a considerable length of time before the placing of the order for Norra Vasa, and that the various tests with this exchange were successfully carried out to the full satisfaction of the Swedish Telegraph Administration. At the present time there are about 6 000 automatic subscribers' lines in service. Since Stockholm has about 100,000 subscribers, the system is planned

for a capacity of over 100,000 lines and with six-digit numbers for the automatic lines.

Inter-traffic between Norra Vasa and the other exchanges in the Stockholm net is handled as follows: to the eight manual exchanges within Stockholm — with a total of about 90 000 subscribers' lines — over junction positions with call indicators (carriage call),

to subscribers with so-called »name call» (250 subscribers) and for suburban traffic (no-charge traffic to 178 exchanges with about 1 000 outgoing junction lines and 25 000 subscribers) by dialling one figure (0 and 8 resp.) thus automatically connecting up the calling subscriber with a disengaged B-operator,

for placing orders for toll calls, by dialling the figure 9, thus automatically connecting up the calling subscriber to a disengaged record distribution operator. In Stockholm, orders for toll calls are recorded by the toll operator for the wanted route or, in event of large

toll routes, by special record operators, who generally also handle the incoming toll traffic over one line. Arrangements for co-operation between the record operators have been made.

The traffic to the automatic exchange is handled at Norra Vasa partly over semi-automatic key boards and partly over manual junction boards, the toll traffic being also directed over similar toll junction boards on account of the many advantages which accompany the manual handling of this service.

Now that this exchange has been in service for so long a time that the experience gained as to the traffic efficiency and maintenance cost of the system can be considered fully reliable, it may be of interest to place this information before the general public.

Traffic efficiency.

We may as well state once for all that our experience of the Ericsson system has been most satisfactory. The efficiency of the traffic has been supervised during the whole time the exchange has been in service by means of a special traffic control desk.

This desk puts the supervisor in a position to reach any of the registers and, by means of a control register, to follow the dialling of a number by the calling subscriber and thereafter to ascertain whether the subscriber obtains the desired connection or whether he has dialled the wrong number; also, during the subsequent conversation, she can observe any existing disturbances or irregularities in the connection. The registers can be blocked by means of a special key, thus locking a call connection for the purpose of establishing the nature and locality of a fault.

For the supervision of conversations, the supervisor switches in on a connection at the outset of a call, notes the dialled number, ascertains that an answer is received, that the calling subscriber is connected to the desired number and, finally, that the conversation proceeds without any interruption. If a faulty connection occurs, the supervisor locks the same and an investigation is made to discover the cause of the fault. The supervisory control period which ended in November 1926 included 31,507 fully supervised calls comprising 28,461 calls from automatic subscribers directed over call indicator junction positions at manual exchanges and 3,046 calls between automatic subscribers, whereby all the registers were systematically tested.

The results of this supervisory control are given in the following.

Table I.

Full automatic traffic.

(between two automatic subscribers' stations)

Number of supervised calls	3 046	
of which	2 772 or	91.01 % faultless
and	274 >	8.99 % faulty
		Total 3 046 or 100.00 %

In the faulty calls, the faults were assigned to the following categories:

a. Action on part of subscriber	234 or	7.68 %
b. Automatic system:		
localized	29 or 0.95 %	} 1.15 %
not localized	6 > 0.20 %	
c. Causes not referable to automatic system, but localized to outside line of calling subscriber	5 >	0.16 %
		Total 274 or 8.99 %

Table II.

Traffic from automatic subscriber's station directed over call indicator junction position at manual exchange.

Number of supervised calls	28 461	
of which	26 384 or	92.70 % faultless
and	2 077 >	7.30 % faulty
		Total 28 461 or 100.00 %

In the faulty calls, the faults were assigned to the following categories:

a. Action on part of subscriber	1636 or	5.75 %
b. Automatic system and call indicator positions:		
localized	196 > 0.69 %	} 0.96 %
not localized	78 > 0.27 %	
c. Technical arrangements independent of automatic system and localized to outside line	44 >	0.16 %
d. Action on part of operator	112 >	0.39 %
e. Causes of a temporary nature (installation work, etc.)	11 >	0.04 %
		Total 2077 or 7.30 %

The above figures show that the total number of faults which occurred in the traffic between automatic subscribers amounted to 8.99 % of the total number of calls while for traffic over call indicator junction positions the corresponding figure was 7.30 %.

A closer scrutiny of the distribution of the faults among the various above-mentioned causes shows that 7.68 of the 8.99 % and 5.75 of the 7.30 % were caused by the subscribers themselves. This large percentage of faults caused by the subscribers — a very large figure, according to our standards — has its natural explanation, however. It is clear that the correct use of the calling dial as well as the memorizing of 6-digit numbers has not yet become second nature with the subscribers. Furthermore, those of the subscribers

who do not themselves have automatic telephones but who occasionally use them when visiting the sections of the city where such instruments have already been installed are naturally still less trained in the manipulation of the dial; also, one must bear in mind that in Stockholm children start using the telephone at a very early age. However, this fault percentage is experiencing a steady decline. For instance, in May 1925, when about 300 subscribers' lines were cut over, it amounted to about 15 % compared with 7.68 % in November 1926.

It may seem surprising that the fault percentage on the part of the subscribers is about 2 % higher for full automatic calls than for calls over call indicator junction positions. It has been found, however, that for traffic within the Norra Vasa area, the subscribers often dial the digit 1 instead of the 3 of the Norra Vasa exchange as the first digit in the 6-digit telephone number. This, again, can be traced to the fact that most of the present manual subscribers with numbers that are not preceded by the name of an exchange have numbers beginning with the figure 1. Faults of this kind may also be classified as infantile diseases of telephone culture.

If we pass over to those faults that may be attributed to automatic apparatus and devices we find that for traffic between automatic subscribers the number is 1.15 % and for traffic over call indicator junction positions 0.96 % of the total number of calls.

The faults which constitute the former figure number thirty-five, of which twenty-nine were localized while in six instances it was not possible to lock the call in time or else the locality of the fault was not found in time.

The twenty-nine localized faults are distributed as follows:

Table III.

	Number of faults	Percentage of 3046 calls	Percentage of number of faults (29)
Contact faults in registers and relays appurtenant thereto.....	23	0.76	79.31
1st group selectors	1	0.03	3.45
Sequence switches and relays appurtenant thereto ...	1	0.03	3.45
Lines within the automatic exchange.....	1	0.03	3.45
Calling dials on subscribers' instruments.....	3	0.10	10.34
Total 29		0.95	110.00

For traffic over call indicator junction positions, 196 of the 274 calls whose faults were attributed to the automatic system and which constituted 0.96 % of the

total number of supervised calls, were locked in time. The localized faults are distributed as follows:

Table IV.

	Number of faults	Percentage of 28,461 calls	Percentage of number of faults(196)
Contact faults in registers and relays appurtenant thereto.....	109	0.38	55.61
Mechanical faults in selectors	7	0.02	3.57
1st Group Selectors	33	0.12	16.84
Sequence switches and relays appurtenant thereto	5	0.02	2.55
Line within autom.exchange	3	0.01	1.53
Buzzer.....	1	0.00	0.51
Call indicator junction positions and devices appurtenant thereto	16	0.06	8.16
Calling dials on subscribers' instruments.....	22	0.08	11.23
Total 196		0.69	100.00

A comparison between these figures and corresponding figures for the manual system in Stockholm with about 70 % junction calls may be of special interest.

The supervisory control periods in May and November 1926 for the manual traffic show the following results:

Table V.

	May	Nov.
Number of supervised calls.....	8650	7862
of which faultless ...	8361 or 96.66 %	7571 or 96.30 %
faulty	289 » 3.34 %	291 » 3.70 %
Total 8650 or 100.00 %		7862 » 100.00 %

In the faulty calls, the faults were assigned to the following categories:

a. Action on part of subscriber	107 or 1.24 %	98 or 1.25 %
b. Action on part of operator	114 » 1.32 %	143 » 1.82 %
c. Joint action on part of subscriber and operator	48 » 0.55 %	34 » 0.43 %
d. Technical arrangements	20 » 0.23 %	16 » 0.20 %
Total 289 or 3.34 %		291 or 3.70 %

A comparison with the full automatic service (Table I) shows the faulty calls with manual service to be from 3.34 to 3.70 % against the 8.99 % with automatic service. However, if we deduct the faults caused by the subscribers themselves, in both cases, we obtain a remainder of 1.31 % for the automatic service against 2.10 to 2.45 % for the manual service.

An increased familiarity with the automatic system on the part of the public will doubtlessly considerably reduce the mean total percentage of faults occurring in automatic traffic. Also, when judging the advantages of automatic service in a large telephone net with considerable junction traffic, one must not neglect to take

into consideration the important gain as regards the disconnecting times which an automatic system offers.

Test calls.

During the time between April 19th and May 31st 1927, 6817 full automatic test calls were made by a chief operator at Norra Vasa. This testing was so arranged that from each five-hundred group about five hundred calls were made, distributed among the five-hundred groups occupied by subscribers' lines (14 groups).

The results of this testing are given in the following.

Table VI.

Number of calls	6817	
of which	6758	or 99.13 % faultless
and	59	» 0.87 % faulty
	Total 6817 or 100.00 %	

Specification of faults.

Faulty connection.....	27	or 0.40 %
Incomplete »	13	» 0.19 %
No register tone	1	» 0.02 %
The register tone does not cease.....	1	» 0.02 %
No calling signal tone.....	4	» 0.06 %
False busy signal	11	» 0.16 %
Signal not heard by subscriber	1	» 0.01 %
Contact with other subscriber's line.....	1	» 0.01 %
	Total 59 or 0.87 %	

Of these 59 faults, 57 were localized and distributed among the following categories:

Automatic system:		
localized	51	or 0.75 %
not localized	2	» 0.03 %
	} 0.78 %	
Causes not attributed to autom. system,		
localized to outside line of calling		
subscriber	4	» 0.06 %
Faults of a more temporary nature ...	2	» 0.03 %
	Total 59 or 0.87 %	

Distribution of the 51 faults localized to the automatic system:

	Number of faults	Percentage of 6817 calls	Percentage of number of faults (51)
Contact faults in registers and relays appurtenant thereto.....	32	0.47	62.75
Mechanical faults in regis- ters	3	0.05	5.88
2nd Group Selectors	1	0.01	1.96
Sequence switches and re- lays appurtenant thereto	14	0.21	27.45
Lines within automatic ex- change.....	1	0.01	1.96
	Total 51		100.00

From the above we find that the percentage of faults which can be attributed to the automatic system does not amount to more than 0.78, truly a very good result.

In Stockholm, the week day traffic at present amounts to about 850,000 calls.

Monthly reports of complaints lodged by subscribers, specified as to the various causes of these complaints, are made out, the complaints against each separate local exchange being given in the number per thousand subscribers during the month and also per 10,000 calls.

Thus, it was found that the average figures for the time March 1926 to February 1927 were as follows:

Complaints per thousand subscribers during one month:

At the manual exchanges	5.90
At the automatic exchange	2.00
Complaints per ten thousand calls:	
At the manual exchanges	0.18
At the automatic exchange	0.11

Maintenance.

The Norra Vasa exchange, with 6 000 subscribers' lines in service, does not require a maintenance force of more than seven men, this number having been found more than sufficient. The following men are employed:

- 1 foreman,
- 2 head repairmen,
- 3 assistant repairmen,
- 1 handy man, for sweeping, dusting, etc.

The total maintenance force for a 10,000-line exchange with an intensity of traffic equal to that of Norra Vasa with seven calls per line and day should not amount to more than eight men. For exchanges with still larger capacities, certain cost items, such as maintenance of the power plant, night watchman's salary and — with the Ericsson system — also for keeping the premises clean, are considerably lower. The new Stockholm exchanges now under construction — Central and Kungsholmen — which will be completed during 1928 will have initial capacities of 20,000 and 15,000 lines respectively, the four remaining automatic exchanges being projected for an initial capacity of 20,000 to 30,000 lines each. A force of nine men for 10,000 lines will undoubtedly be ample.

With 2 400 working hours per man and year, this will mean

L. M. Ericsson

$$\frac{9 \times 2400 \times 1000}{365 \times 9000} = 6.58 \text{ maintenance}$$

hours per 1 000 subscribers and day, or 2.40 hours per subscriber and year, assuming that only 9 000 lines are connected up for service, which is the case in actual practice.

At the present time, the capacity of the Norra Vasa exchange is 10,000 lines, switching devices for 8 000 subscribers being installed. Their number is as follows:

Line finders	496
First group selectors	496
Second » »	140 (for full autom. traffic)
» » »	60 (for incoming semi-autom. traffic.
	A part of the incoming traffic is directed over B-positions)
Connectors	412
Total number of selectors	1604
Registers	114

The total number of calls during January	
1927 amounted to	1,073,891
Number of calls during busy hour	4,225
» » » per busy hour and subscriber	0.7

The traffic is exceptionally evenly distributed throughout the day. The faults occurring during January were as follows:

in the selectors	25.0
in the registers	11.0
per 100 subscribers and month	0.6
» 100 selectors » »	1.6

Unwarranted disconnecting of calls has not occurred during the entire control period, neither has there been any trouble in the contacts between the contact arms of the selectors and the multiple wires during the entire three years of operation. The continuous control of the efficiency of the traffic has given satisfactory evidence of the efficiency of the maintenance.

The February 1926 number of 'Zeitschrift für Fernmeldetechnik, Werk- und Gerätebau' contains an article in which the author, Dr. Lubberger of Berlin, makes a purely theoretical comparison between step-by-step selectors and machine driven selectors.

After some argumentation which, however, is not supported by any adduced proofs founded on actual experience, the author arrives at the conclusion that a step-by-step selector is superior to a machine driven selector. Mr. G. Deakin of Antwerp has profited by this occasion to take up the defense of the machine-driven systems, for which purpose he has produced some interesting figures bearing on the efficiency of traffic and on the maintenance of automatic telephone ex-

changes. Mr. Deakin makes the statement that "reliable statistics gathered from systems in actual operation are the only decisive factor when judging the advantages of one system as compared with those of another system, and no such proofs have been produced by Dr. Lubberger". Further, Mr. Deakin states that "efficiency in operation is the watchword of automatic telephony. No other arguments are of any value if this important requirement is not filled. If no reliable figures are obtainable as to operation it is impossible to know how a system will function in actual practice and where faults are liable to occur".

Mr. Deakin must be seconded in his above cited views. When comparing various systems, it is quite natural that cost of maintenance and efficiency in operation should be considered as decisive factors, and all the more so with the ever increasing demand for service with the highest possible degree of efficiency. During the present year, Siemens and Halske have published an excerpt from 'Zeitschrift für Fernmelde-technik, Werk- und Gerätebau' Nos. 5 & 6, 1926, entitled 'Betriebserfahrungen bei der Instandhaltung der Automatischen Fernsprechämter in Amsterdam' by engineer-in-chief Dr. Ir. K. C. E. Maitland and containing quite a bit of statistical information as to the operation of the Strowger plant in Amsterdam installed by the above-mentioned company.

It is of decided interest to compare Deakin's and Maitland's figures with our own experiences from the Ericsson automatic system, a comparison — both as to maintenance and efficiency of operation — which we are sure will prove of equal value to all those who are interested in automatic telephony. Figures on the supervisory control of the subscribers' calls, in similarity with those here given for Norra Vasa in tables I to IV, are regrettably missing in Maitland's report, but even though the available figures be studied with all possible circumspection it will be impossible to make a decision in favour of the step-by-step type of selector.

The above statements give sufficient evidence that the Ericsson system has met very high expectations both as to efficiency and low cost of maintenance. As far as I know, the results obtained in Stockholm are the best official ones hitherto published with regard to any automatic system.

Stockholm den 28 juni 1927

C. Signell

R. 735

The Skövde and Herrljunga Interlocking Plants.

By Captain T. H:son Almqvist, signal engineer district II of the Swedish Gov't Ry. service.

When planning the interlocking plants for Herrljunga and Skövde in District No. II of the Swedish Gov't Railways, the fundamental idea was to have an interlocking machine which need be manoeuvred only for the movements of trains and only by the train dispatcher himself.

Both of these interlocking plants have been delivered and erected by Signalbolaget, Stockholm, sales company for railway signal and safety devices manufactured by L. M. Ericsson and by the Avos company of Örebro. The greater part of the electric devices in these plants are of Ericsson manufacture.

The Skövde plant.

The Skövde station serves its purpose mainly as a through station, as all the trains on the main line Stockholm—Gothenburg pass through it. The trains from Karlsborg, however, do not run further than Skövde.

The area covered by this plant is shown on the track plan in fig. 1. Special mention should be made of the fact that the starting signals for the side tracks can be used for all the sidings in the station yard, so that — when the traffic is heavy — a certain train (freight train) may leave the station on a given signal no matter whether it is standing on a locked track or not.

As already mentioned, the interlocking machine is not manned except during the passage of a train. For shunting purposes, the points provided with central control are set locally: consequently, there is no necessity to manoeuvre the interlocking machine on such occasions.

The plant is provided with an electric interlocking machine of standard type (see fig. 2), placed in the

signal cabin (fig. 3) on the north side of the station building. The interlocking machine is provided with nine point and skotch block levers, five point locking levers, two levers for manoeuvring the crossing gates, and thirteen signal levers. A switchboard for power distribution, an illuminated track plan and the necessary relays are also mounted in the signal cabin. The track plan is placed at eye-level on the wall in back of the interlocking machine, and is a true reproduction of the entire track system. The various track sections (track circuits) are shown on this plan. A small electric lamp — one for each

section — denotes whether a section is clear or not, a glowing lamp indicating a clear section. By observing this track plan, the train dispatcher can follow the various train movements and switching operations out in the station yard. The relays are mounted in a special cabinet with glass doors, under the track plan.

Cabinets with signal indicators, whose lamps are on the same circuits as the regular signal lamps, are also placed under the track plan. These signal indicators show the positions of the signals.

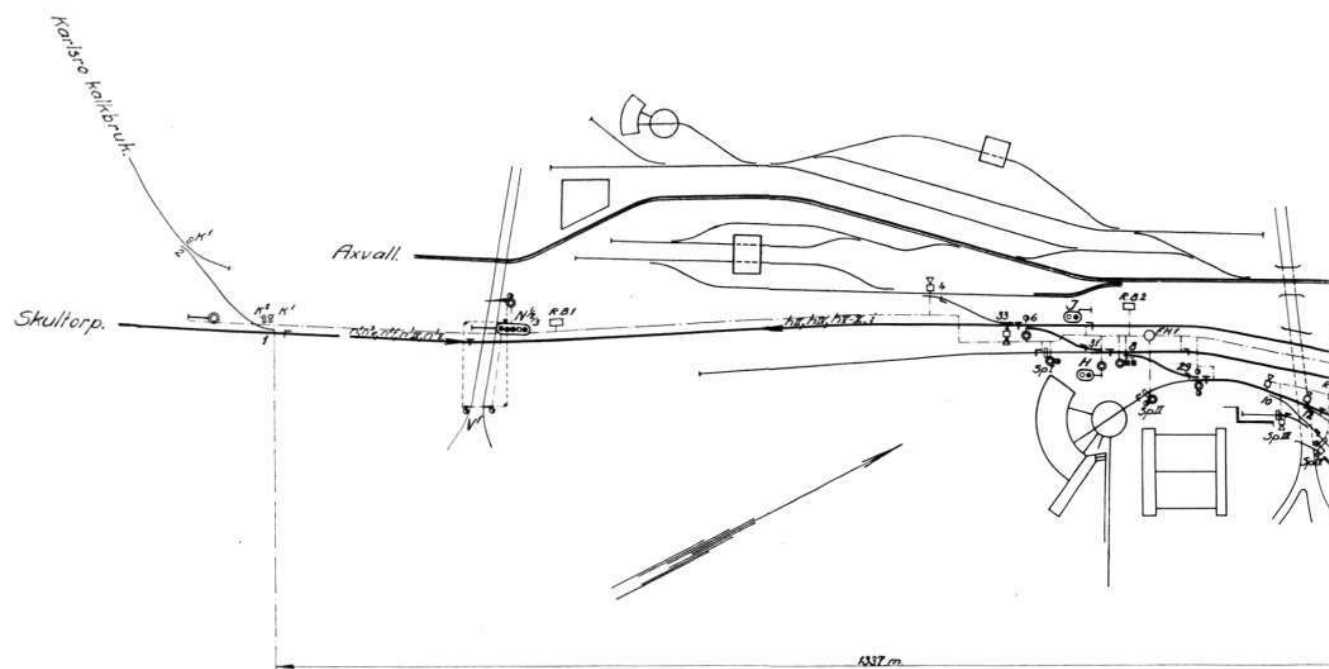
All the signals are electric day signals. Since the main line through Skövde is electrified, the light signals have — as far as possible — been mounted on the posts and gantries which support the wires for the traction current (see figs. 4 & 5). Where this was not feasible, concrete posts have been erected for this purpose.

The signals are controlled by means of signal relays (D. C. relays) mounted in the signal cabin, these relays, in turn, being actuated by the aid of the signal



R 776

Fig. 2. The Interlocking Machine at Skövde.



Skövde.

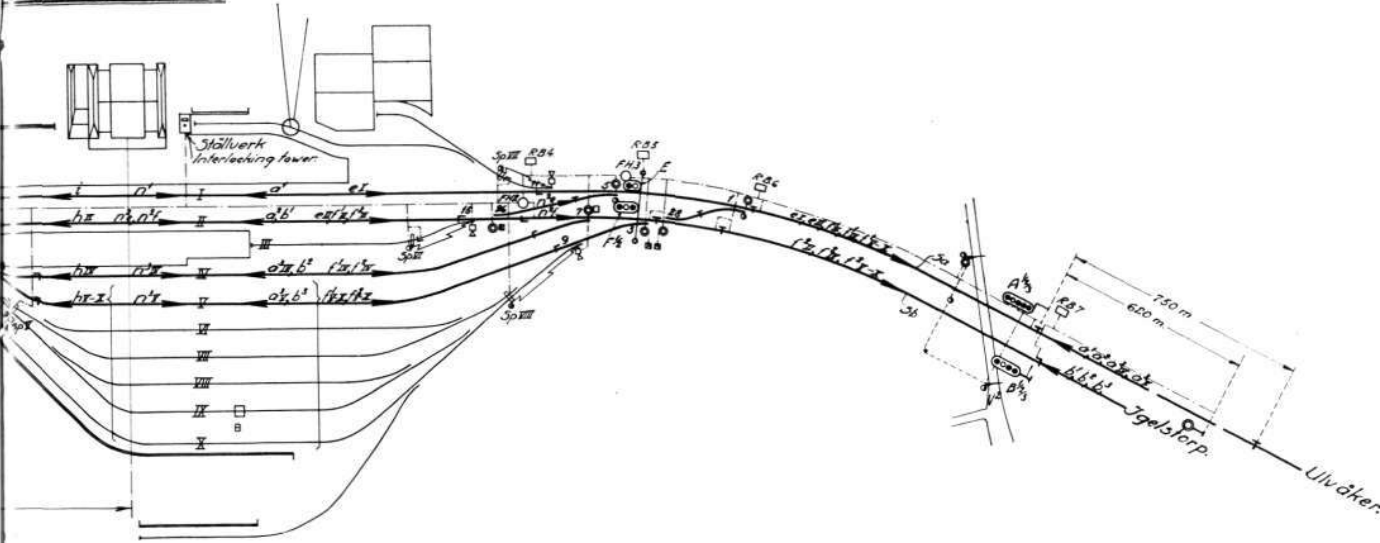
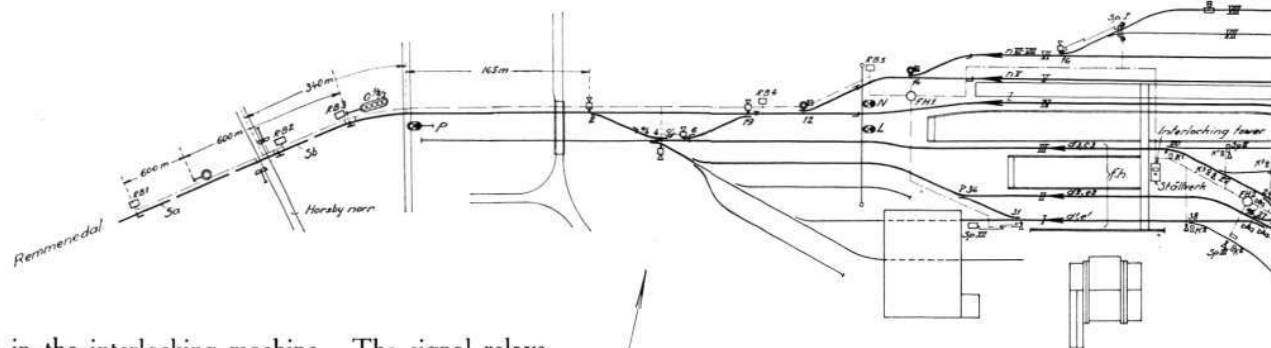


Fig. 1.



Herrljunga.

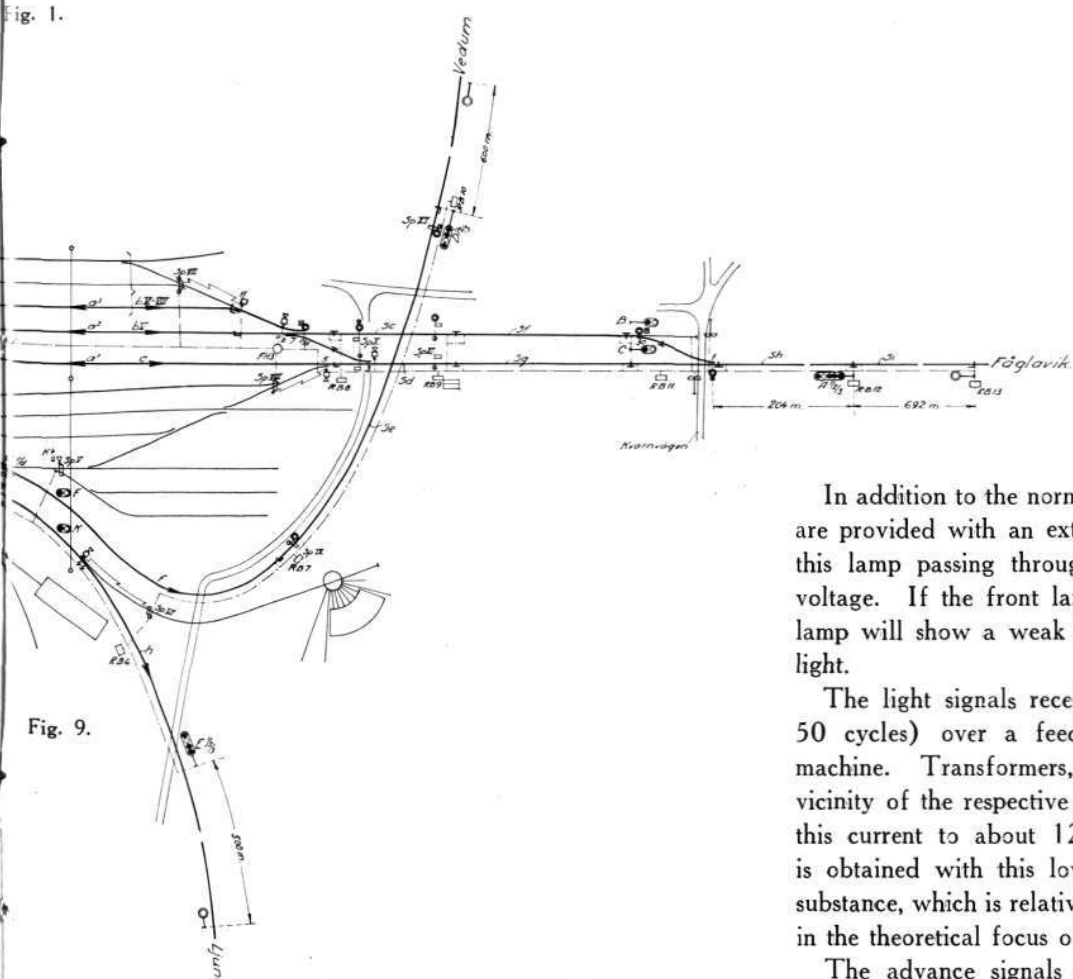


Fig. 9.

levers in the interlocking machine. The signal relays are also influenced by one or more of the above-mentioned track circuits, so that a signal cannot be set to "clear" as long as a track section forming a part of the track in question is occupied by any form of rolling stock.

The lights of the signals conform to the formation of the night signal of a semaphore, i. e. a red light means "stop", and one, two or three steady green lights means a clear incoming main or side track respectively.

When a signal consists of two or three green lights, it is possible that one of the lights does not burn,

thus giving the train a false signal. This is prevented by placing a balancing resistance or balancing impedans in circuit before the lamp transformers. As soon as one lamp ceases to glow, these resistances prevent the current from reaching the other lamps and all the green lights are extinguished.

In addition to the normal, front lamp, all red signals are provided with an extra rear lamp, the current for this lamp passing through a resistance to reduce its voltage. If the front lamp should not burn, the rear lamp will show a weak but still quite discernible red light.

The light signals receive their current (110 volts, 50 cycles) over a feed line from the interlocking machine. Transformers, mounted in cabinets in the vicinity of the respective signals, reduce the tension of this current to about 12 volts. A good luminosity is obtained with this low voltage, since the glowing substance, which is relatively small, can be concentrated in the theoretical focus of the lens system.

The advance signals used by the Swedish Gov't Railways have both green and white intermittent

flash-lights. Green indicates that the co-operating main signal is set to "stop"; the white one, that it is set to clear. Since certain trains pass through Skövde over the main track without stopping, it was found desirable to provide the main starting signals with advance signals, so as to advise the locomotive engineer as soon as possible of the position of the starting signal. This has been arranged by using one of the green lights of the home signal — the third one — for a green flash-light, and by placing a white flash-light in the unoccupied space between the second and third green lights (the right hand signal in fig. 4). These two flash-lights serve as advance signals for the starting signals of the main tracks so that at the same time as a steady green light at the head of the signal mast indicates a clear incoming track, a green flash-light at the foot of the mast indicates that the corresponding starting signal in the direction of the incoming train



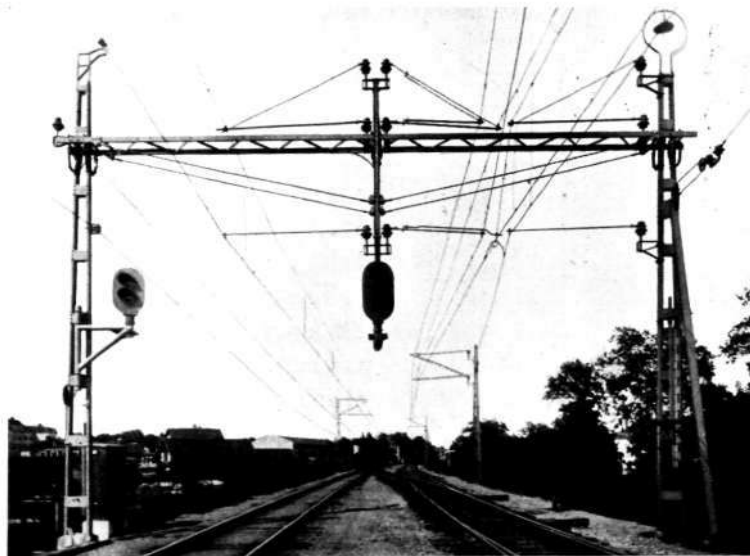
R 777

Fig. 3. The Skövde Signal Cabin.



R 778

Fig. 4. Home Signals at Skövde for Trains from Stockholm (Ulvåker) and Karlsborg (Igelstorp).



R 779

Fig. 5. Starting Signals at Skövde for Trains to Stockholm (Ulvåker) and Karlsborg (Igelstorp).

is set to stop. If this starting signal should be set to clear, this is indicated by means of a white flash-light instead of the green. Should the incoming or home signal be set to stop, or — by means of one or two green lights — indicate that the incoming train is being directed to a side-track, the position of the starting signal is not indicated on the home signal.

The current for the advance signal of the starting signal is obtained over the signal relays of the starting signals and home signals in question.

All the local point setting arrangements are constructed according to the principle adopted by the Swedish Gov't Railways, comprising an electric switch located near the point and which energizes a relay mounted in the signal cabin. When the relay energizes, the control circuit for the corresponding point lever in the interlocking machine is broken, a circuit which furnishes current to the switch motor being

simultaneously closed. If the control magnet contacts do not break the circuit when the point is set locally, a special relay is provided which then energizes and closes an alarm circuit, simultaneously cutting the supply of control current for the entire interlocking machine and causing all the signals to be set to stop.

Those points and skotch blocks which are not controlled by the interlocking machine but nevertheless must be included in the installation, are provided with a locking device (see fig. 6). Contacts actuated by the point itself close a current over a locking magnet on the locking lever, naturally on condition that the point is in a position permitting of its being locked. If this is not the case, the locking lever cannot be set.

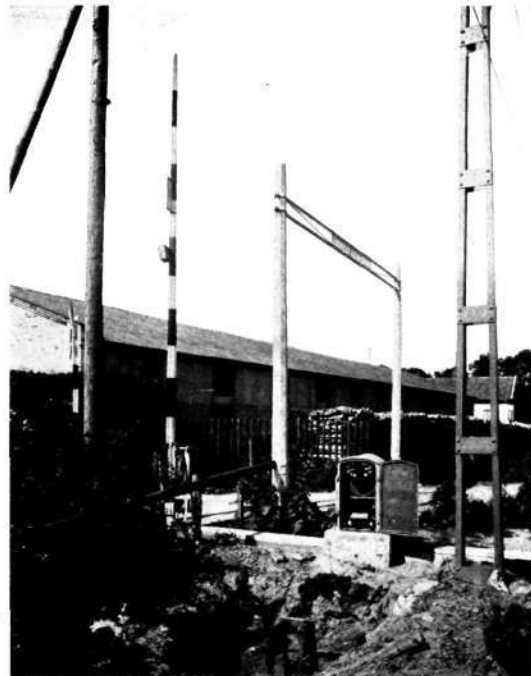
The *crossing gates* at both ends of the station yard are also power driven and controlled by means of levers in the interlocking machine. The signal relay

is placed in a wooden cabinet beside its respective section. The track relay for each section is placed in a wooden cabinet beside its respective section. The positions of the track relays are repeated by special d. c. relays mounted in the signal cabin, which close circuits to the different lamps mounted behind the track plan. Further, the circuits providing current for the various signals are closed over these relays in various contact combinations, and the relays



R 780

Fig. 6. Locking device.



R 781

Fig. 7. Crossing Gates at the North Grade Crossing, Skövde.

current is influenced by the position of these gates. When a train for which the gates have been lowered enters a certain track section, the crossing gate lever in the interlocking machine can be restored to normal, but the gates will not be raised until the train has passed the crossing. The motors which raise and lower the gates, as well as the switch machines, are for d. c. One of the bars of the crossing gates at the north end of the station yard is shown in fig. 7. The electric driving mechanism is free-standing and connected to the mechanical actuating devices between the gates.

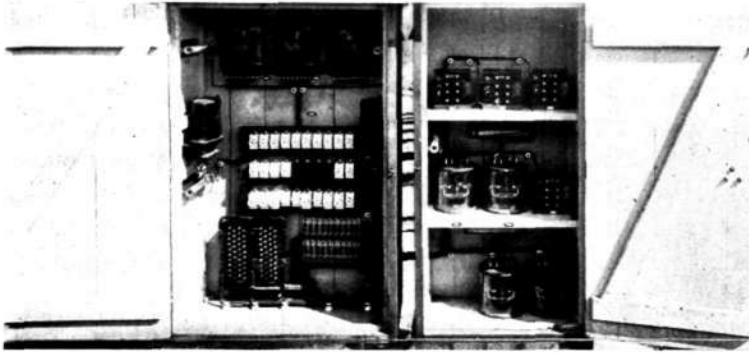
As already mentioned, the illuminated track plan in the signal cabin (see fig. 2) shows the tracks and points at both ends of the station yard. Since the middle portion is under the direct supervision of the train dispatcher, a saving has been effected by excluding it from the track plan.

The various tracks are divided up into fifteen in-

are used for various other purposes, such as track releasing, point locking etcetera.

The track circuits are fed by a 220-volt 50-cycle alternating current with the exception of the one farthest to the South, which is fed by battery current. The alternating current is transformed down to a suitable voltage by the track transformers.

The electric traction prevents the use of more than one rail as a conductor for the signal current. The other rail must continue uninterruptedly so as to serve as a return conductor for the $16\frac{2}{3}$ -cycle traction current. This return current is responsible for a certain drop in tension in the return rail, this drop, in turn, creating a current over the track relay and the track transformer. In order to prevent the energizing of the track relays by means of this current, frequency relays are used. The track relays used in Skövde are so-called double vane relays, built so that if the strength of the $16\frac{2}{3}$ -cycle current should surpass that



R 782

Fig. 8. Cabinet No. 2 at Skövde.

of the 50-cycle current by a certain margin, the relay is de-energized and the front contacts are broken. A resistance of about 0.7 ohms is connected in series with the relays for the purpose of limiting the traction current to a certain value in the relays.

The a. c. relays are energized by a normal pole tension of two to three volts, the current in the track circuits having a tension of about six to eleven volts. The current over the relay maintains a strength of about 8.5 amperes.

The d. c. track circuit is fed with current from a battery of Edison soda cells. In order to provide protection against the detrimental influence of the traction current, a suitably proportioned choke coil and a resistance are connected — the first in series and the latter in parallel — with the relay.

The a. c. relays are de-energized when a shunt of about 0.75 ohms is established between the rails, the d. c. relay doing likewise for a shunt of about 0.5 ohms. During the passage of a train, this shunt is not more than $\frac{1}{1000}$ of an ohm.

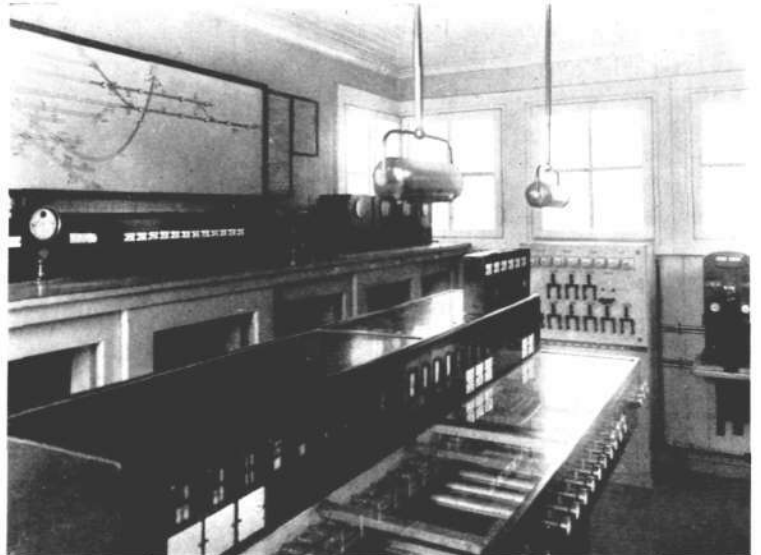
The road is almost entirely ballasted with gravel, macadam or crushed stone being used at the points only.

As previously mentioned, the transformers for the light signals as well as the track relays and track transformers are mounted in small wooden cabinets placed beside the track sections out in the station yard. The cabinets are placed so that the fall in tension in the lines on the secondary side shall be as small as possible. They accommodate transformers and resistances, as well as the cable terminal boxes, which are mounted furthest down in the cabinets. In fig. 8 (cabinet RB/2 in Skövde), the cabinet to the left contains six track transformers, fuses, resistances,

porcelain terminal blocks and two cable terminal boxes, while in the right hand cabinet are mounted four signal transformers, four track relays and transformers.

All the cables are made according to the specifications of the Royal Swedish Railway Administration, each conductor having a cross section of 2 sq.mm.

The necessary current for the interlocking plant is furnished by two storage batteries, the one — a 130 volt Tudor



R 783

Fig. 10. The Interlocking Machine at Herrljunga.

battery — for the switch machines and locking devices, the other — a smaller 30 volt battery — being for the control current, signal lights and repeating relays. These storage batteries are mounted in a special addition to the signal cabin, shown in



R 784

Fig. 11. The Herrljunga Signal Cabin.

fig. 11 (signal cabin in Herrljunga). The necessary feed current is obtained from the railway's own power line, which furnishes a single phase, 10,000-volt 50-cycle current. This is transformed down to 2×110 volts at which tension it enters the previously mentioned distribution board. The current for charging the storage batteries is rectified by means of a mercury vapour rectifier, which is visible to the right above the relay cabinet in fig. 2.

The Skövde plant was put in operation on June 30th, 1927.

The Herrljunga plant.

The interlocking plant at Herrljunga is built in accordance with the plan shown in fig. 9 and on the same principle as the Skövde plant.

The interlocking machine (fig. 10) is mounted in the signal cabin (fig. 11) and is equipped with six point and skotch block levers, six locking levers and eight signal levers.

This plant differs from the one in Skövde in the following respects:

For economical reasons, the points and skotch blocks in the tracks leading to and from Vedum and Ljung are not provided with locking devices, but are only under control. The control current passes over point contacts and control magnets, these latter being mounted in a separate cabinet above the interlocking machine. The control magnets indicate which track has been cleared and this can be observed through the small indicator windows, the signal combination for the cleared track being formed when the signal lever is set. The switching current for the signals controls the position of the points so that the laying over of a switch in a track that has already been cleared will cause the clear signal to be reset to stop.

These points and skotch blocks which are under control only are so near the interlocking machine as to be under the direct supervision of the train dispatcher.

A special distance signal has been placed at the west end of the station yard, as it often happens — on account of the form of the station yard — that the locomotive of an extra long freight train stands beyond its own starting signal, in which case the train is given a starting signal by means of the above-mentioned distance signal.

Skotch blocks on all the main tracks have been provided at the grade crossing at the east end of the station yard. A clear signal cannot be given for a train until the skotch blocks have been placed over all the tracks which cross the main tracks in question.

The plant is also equipped with two alarm bell aggregates for road crossings, one at each end of the station yard. These alarm systems work automatically, a continuous signal being given by the alarm bell while a train is passing over a certain track section, depending on which signal has been set to clear. The alarm system at the west crossing, on the other hand, always rings for incoming trains, no matter whether the home signal is set to clear or not.

Lastly, we will find that at Herrljunga 2-phase relays of the latest Westinghouse type have been used for certain track sections — "two element, two position, frequency selective vane relay, style 'L'." These are the first relays of this type delivered by the company. They are frequency selective even though a $16\frac{2}{3}$ -cycle current should enter both the local and track phase at the same time. The local phase has a tension of 110 volts, the track phase having a normal tension of 2 to 2.6 volts. The pole tension of the relay is then about 1.9 to 2.4 volts. The normal strength of the current through the relay is 1.03 to 1.21 amperes.

The Herrljunga plant was put in operation on June 22nd 1927.





R 769

Borås Weaving Mills, Kungsfors Works.

Time Control and Efficiency.

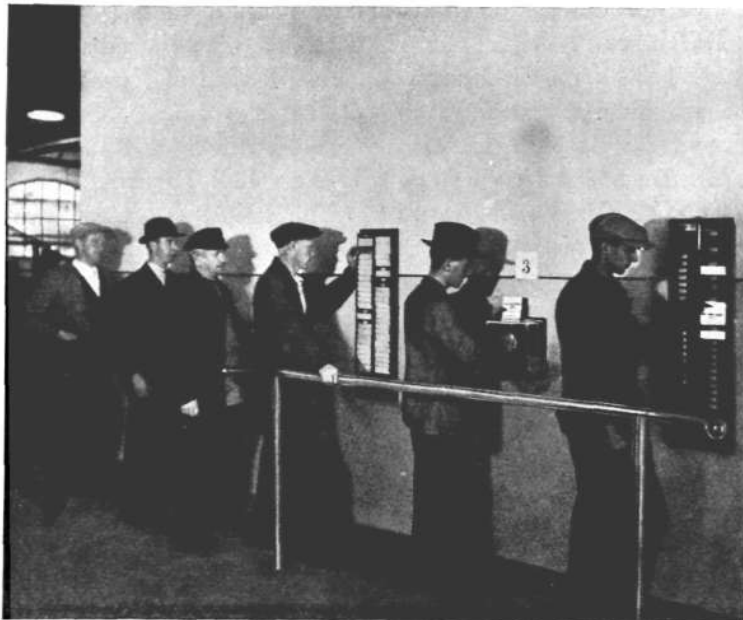
By Alexander Engblom, chief engineer, Borås Weaving Mills, Sweden.

Increasing competition in all branches of industry make it imperative that the working hours be used to the best possible advantage. Constantly recurring losses of time, even though they do not amount to more than but a few minutes per man and day will, by the end of the year, add up to a surprisingly large figure. For instance, if each man in a force of one thousand men wastes three minutes every day, the total time loss by the end of one year will amount to 15,000 hours.

The serious disadvantages which accompany such losses cannot be but evident, even in cases where the

timework system is not applied. Also with piecework the decrease in production occasioned by the time loss means a corresponding increase in overhead and poorer results for the company from a financial point of view.

For these reasons, attempts have been made to devise some form of time control or time keeping system that will eliminate the above-mentioned disadvantages. One well known system which has been extensively used is the one with brass checks in which the worker, on entering the premises, receives a check on which his number is stamped and hands it in again when leav-



R 768

ing. In some cases, the closing of the gates at a certain time is practiced in connection with this system. The checks are counted and the gates closed and opened by a timekeeper, who thus is in a position to keep track of the presence or absence of the workers.

This system, however, has quite a number of disadvantages, one of the greatest being that the worker is dependent on the sympathy or antipathy of the

This system has the advantage of registering all times impartially, thus, in a way, making every worker his own timekeeper. Also, the timekeeping is placed more under the direct supervision of a superintendent instead of in the hands of some subordinate employee. The importance of this fact from a disciplinary point of view need hardly be accentuated.

The various points of view which have here been

N:r

BORÅS WÄFVERI AKTIEBOLAG
Avd. Wiskaholm

Veckans N:r

Permission beviljad					
Dag	Tid	Sign.	Dag	Tid	Sign.

	Söndag	Måndag	Tisdag	Onsdag	Torsdag	Fredag	Lördag	S:a
Kom								
Gick								
Kom								
Gick								
Kom								
Gick								
Kom								
Gick								
Ord. tid								
Över. tid								
Över. tid								

Kortet skall stämpas egenhändigt

R 785 a

timekeeper. Also, it does not — generally speaking — make it possible to check up the actual working time, but merely indicates whether the worker is present or absent.

For this reason the use of time clocks, which — in some way or other, either by means of cards or paper bands — register the actual time of arrival and of departure for each worker, have come into general use.

Avlöning den 192 ..

N:r	Ant. tim.	Kronor
		Tidlön
		Övertid 25 % .
		„ 50 % .
		Ackord
		% .
		Dyrtidstillägg
		Förtjänst s:ma

Avgår:

	Kronor
Sjukasseavgift	
Hyra	
Elektrisk belysning	
Ved	
Intressekontoret	
Plikt	
Kost	
Skatt	
Barnkrubban	
Sparkassan	

Kontant

Ovanstående avlöning kvitteras:

(Namn).

R 786 a

set forth should make it apparent that a rational time control system is of invaluable aid to every manufacturer in his efforts to get the best possible results with the means at his disposal. It is necessary, however, to arrange the time control in the manner most suited to the existing conditions.

Aside from purely local points of view, the time clocks should be placed with due consideration for the desirability of letting the workers attend to their

L. M. Ericsson

various preparations for work — such as change of clothing etc. — before punching the time clock. If possible they should be set up in the immediate neighbourhood of the place of work, thereby affording the advantage — from a psychological point of view — of making the time punching operation an integral part of the work itself. Also, in this manner, the registered time will correspond more accurately with the net working time.

The number of time clocks should be determined so as to provide one time clock for every fifty (max. seventy-five) workers; also, a bar of some kind should be erected in front of the time clock so as to provide “one-way traffic” and avoid crowding. By providing suitable arrangements of this kind the time required by each man for punching his card can be reduced to two or three seconds.

As regards the most suitable type of time clock, we have — generally speaking — the choice of two systems. The one consists of clocks which function altogether independently of each other, while the other is the so-called central system, in which the various

time clocks are connected to and regulated by a main clock.

Of these two, the central system possesses unquestionable advantages. Exactly the same time is indicated by all the clocks, thus eliminating many controversies. Various auxiliary apparatus, such as signal devices, secondary clocks to show the time, etc. can be made to function simultaneously at the same time as they are simply and accurately controlled by means of a program clock which can be set as desired.

At the works with which the author is connected — The Borås Weaving Mills — time control plants according to the central system have been installed and in operation since 1923. These plants comprise a total of thirty-one time clocks and have given excellent service and perfect satisfaction in every respect.

These plants are delivered and erected by the Ericsson telephone company of Stockholm and are consequently of Swedish make. In the capacity of technical manager of a large industrial concern it is gratifying to be able to authenticate that also in this branch Swedish products are fully equal, if not superior, to those of foreign make.



R 793

Borås Weaving Mills, Borås.



*Inquiries may be addressed to
Telefonaktiebolaget L. M. Ericsson
Stockholm—Sweden*

or

their corresponding agencies

(See Ericsson News N. 4/1927 p. 2)

Field Telephone Switchboard for Buzzer and Magneto Signals.

A field telephone switchboard should fill certain special requirements, the following being among the more important:

- lightness of weight, to facilitate transportation,
- readiness for immediate use,
- reliability,
- easy and simple replacement of parts and units,
- simplicity of operation.

A cordless switchboard for buzzer and magneto signals and with removable line units is shown in fig. 1, while fig. 2 gives a view of the same board open. This switchboard is for four double lines, the terminals,

Besides the above-mentioned terminals, there are two more for connecting a standard telephone instrument for exchange service purposes. There is also an alarm device for incoming calling signals.

Since the switchboard is intended for use with both buzzer and magneto instruments, it is evident that the indicator must be suited for both kinds of current. A sufficiently sensitive and reliable indicator has been obtained by providing the electromagnet with a



R 745

Fig. 1.

carbon protectors, fuses, indicators and keys for the different lines being mounted on separate black lacquered metal strips (line units) which are easily removed by loosening the two screws in the ends of the strips.

The capacity of the switchboard is easily increased by connecting another similar board to the first one by means of the terminal screws located on the top cover, no changes whatever in the wiring of the boards being necessary. Naturally, the capacity is restricted by the three switching possibilities of the boards.



R 743

Fig. 2.

laminated core and two coils, the armature being of a very light construction and attached to a spring. This spring is formed so that one end serves as a locking device for the shutter, the other end being bent out near its point of support. A set-screw presses against the bent portion of the spring and permits the regulating of the air gap between the armature and

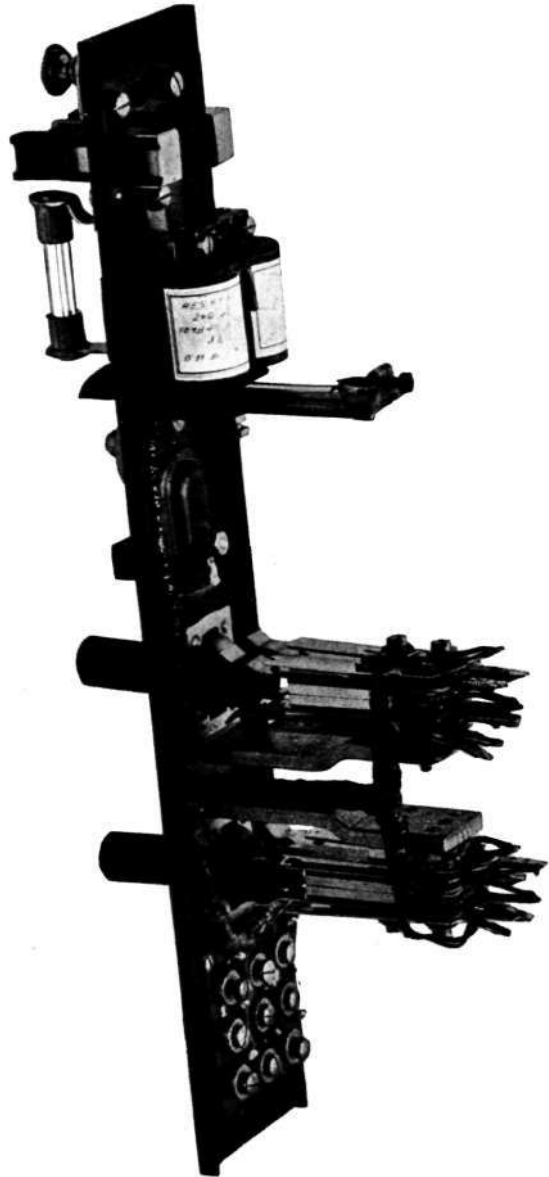
the core of the electro-magnet. Thus, a correct adjustment will make the indicator sufficiently sensitive to the buzzer current as well as to the generator current.

The locking device of the shutter is protected from harm by means of a projection. During transportation the tension of the locking device is released, this latter being held in place by means of a spring lever.

The above-described switchboard has three switching possibilities, i. e. three simultaneous calls are possible. The bus-bars are connected in parallel by means of terminals or — in order to avoid all screw contacts — by means of a device resembling a knife-switch.

P. Otto Walter.

The previous issue (Nos. 4 to 6) of this journal contained an article entitled "Field Telephone Switches and Switchboards" by Captain W. Gyllencreutz of the Royal Swedish Signal Corps, in which also this type of switchboard was described. This description was accompanied by a circuit diagram. The above short article completes this description by setting forth the principles of design which enable the indicator to be actuated by both generator and buzzer currents. Interested readers who wish to obtain information as to the functioning of this switchboard are referred to the above-mentioned article, more detailed information being gladly furnished by this company or by any of our subsidiaries or agencies (see pages 1 and 2 of the Ericsson News, No. 4 of the current year). We wish to draw our readers' attention to the statement of such an eminent expert as Captain Gyllencreutz, in which he says that this type of switchboard — on account of the indicator design — fills a gap in the collection of existing military switching devices, that it has the advantage — from a military point of view — of functioning with weak generator currents and transformed currents with strong damping of the signal current and that these advantages have been obtained without in any way lessening its other good qualities.



R 744

Fig. 3.

In addition, this present article describes those features which make possible a simple and quick replacement, repairing and adjustment of parts.

The Editor.

Ericsson
COMPLETE
EQUIPMENT
FOR
FIELD TELEPHONE
INSTALLATIONS
TELEFONAKTIEBOLAGET L. M. ERICSSON
STOCKHOLM - SWEDEN

R 808 e

Local Telephone Installations with Push Button Inter-communication Telephone Instruments and Series-Connected Exchange Instruments.

Intercommunication telephone instruments of the type here described are intended for use in private installations, with or without central exchange connections. In the former case the telephones are connected in series to one or more city lines besides being connected in parallel to the local lines. Also, the city lines may be extended to only a certain number of the telephone instruments, in which case the remainder are restricted to intercommunication service only.

In both cases the switching devices consist of push buttons which are released mutually as well as by depressing the cradle rest for the handmicrotelephone or by replacing this latter, thus breaking an existing connection. Contrary to certain earlier types of intercommunication instruments with a selective arm or with plugs, the type in question precludes the possibility of a connection remaining unbroken even after the handset has been replaced, or because the selective arm has not been restored to its normal position or the plug removed.

The connecting in series of the telephones to the central lines offers the advantage of preventing all listening-in from another telephone instrument in the system, since the attempt of a third party — either wilful or otherwise — to connect himself up to a busy central line results in the breaking of the existing connection or in a failure on his part to obtain the desired connection. Consequently, in a local plant with central exchange lines connected in this manner, it is of advantage that they are led first to those instruments which are primarily intended for city calls.

This method of connecting the central exchange lines, means that an incoming call from the city net is received by the last instrument to which this line is connected. Polarized bells, drop indicators, visual indicators or lamps (eventually combined with galvanic extension bells) may be used to indicate an incoming call. These devices are mounted in a separate wall box together with the special arrangements for the central line connection.

In case of several city lines with bells for incoming signals, these should have different tones or be provided with some other device to distinguish them one from the other.

In the circuit diagram, shown in fig. 2, the exchange line *EL* is led through the telephone instruments *R1* to *R4*

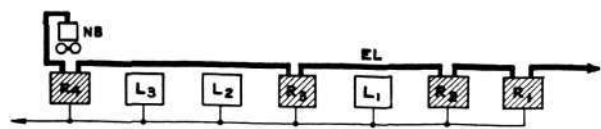
but passes by the instruments *L1*, *L2* and *L3*. The internal lines *IL* pass through all the telephone instruments in the system.

An incoming exchange call rings the bell of the last telephone *R4* connected in series to this exchange line. (In the following description this instrument is called the *service telephone*, all other series connected instruments in the installation being called



R 741

Fig. 1.



R 762

IL
Fig. 2.

exchange line telephones, while those instruments which are not provided with central exchange possibilities are termed *local telephones*.) The person answering

the call removes the handset from the cradle rest and depresses the exchange line key, thus connecting his telephone instrument to the calling exchange line. All the visual indicators connected to this line are simultaneously energized and indicate that it is busy. If the incoming call is to be directed to *R2*, this latter is called from *R4* by the depression of the corresponding local key without, however, breaking the central connection, in the manner described further on. The subscriber at *R2* removes his handset and receives the information that he is wanted on line number so-and-so, after which he depresses the corresponding exchange line key on his instrument. The subscriber at *R4* then replaces his microtelephone on the cradle rest.

If, during a conversation over an exchange line, the speaking subscriber desires information of some sort from the subscriber at *L2* or *R3*, for instance, he makes the local connection by depressing the local key which corresponds to the desired instrument. The exchange line key then automatically returns to its normal position, thus preventing listening-in on the local conversation by the city subscriber without, however, breaking the exchange line connection. When this local conversation is finished the exchange line key is again depressed, thus breaking the local connection and permitting a resumption of the conversation over the exchange line.

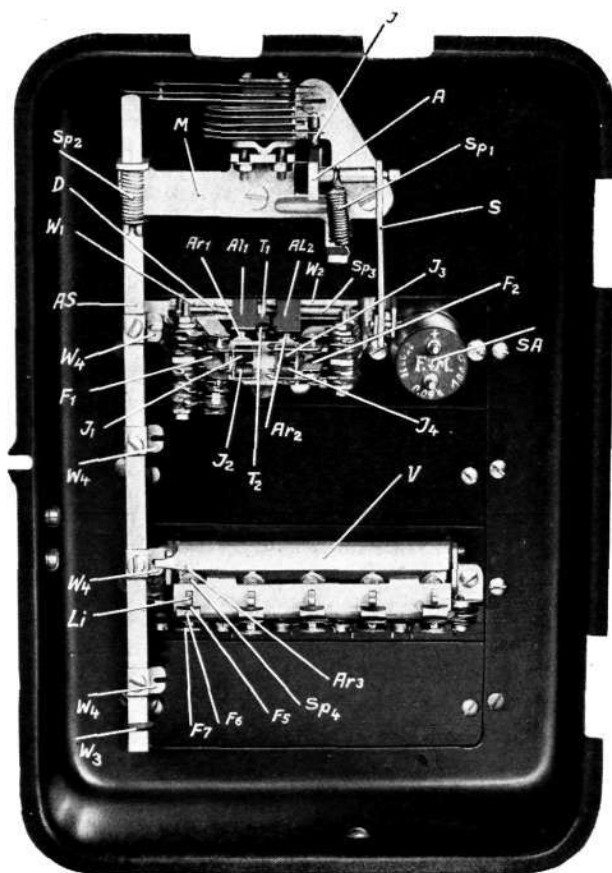
When the conversation is finished, the handset is replaced on the cradle rest, thus releasing the exchange line key and breaking the connection over the central exchange. All the visual indicators are simultaneously restored to normal after which they indicate that the exchange line is disengaged.

The central exchange may be called from any of the exchange telephones by merely depressing the exchange line key after having lifted the handset off the cradle. If the central exchange is built on the *CB* system, no additional manipulations are necessary, but if it is an *LB* exchange, an additional ringing key is provided for closing an alternating current ringing circuit over a transformer or a pole changer. If the central exchange is automatic, the ringing key is replaced by a calling dial.

A local telephone instrument is called by depressing as far as possible the key for the desired line, thus closing a d. c. ringing circuit over the telephone instrument in question. The local line keys have two positions, and when the depressed key is released it automatically takes the middle or speaking position. The called subscriber need only remove the handset from the cradle rest to complete the connection. At

the end of the conversation both parties replace their handsets and the depressed line key of the calling party automatically returns to its normal position, thereby breaking the connection.

The switching mechanism of an exchange telephone instrument is shown in fig. 3; above is the cradle switch, in the centre the exchange line key set with the visual indicator, while the lower part of the illustration shows a set of intercommunication keys for five lines.



R 743

Fig. 3.

A is the cradle lever arm which gives the two insulations *J* and the attached springs an upward movement when the handset is placed on the cradle rest. The lever arm *A* is provided with a pin, on the free end of which the releasing arm *S* for the exchange line key is pivoted. The function of the spiral spring *Sp1* is to pull down the end of the lever arm *A* when the handset is removed from the cradle rest.

The exchange line switching device consists of two spring groups *F1* and *F2* and a push button key — not visible in the illustration. The depressing of this key forces the two plungers down between the insula-

tions *J1*, *J2* and *J3*, *J4* respectively, thus influencing the two spring groups *F1* and *F2*.

Further, the switching device consists of two angles *W1* and *W2*, movable around the common axle *D*. A tooth on the angle *W1* engages a notch on the angles *W4* which are attached to the releasing bar *AS*. This angle is provided with a locking projection *AL1* on which is a tooth *T1*. The other end of the releasing arm *S* is pivoted on the angle *W2*. Also this angle has a locking projection *AL2*, on which is a tooth *T2*, lying under the tooth *T1* of the projection *AL1*. The angle *W1* with its projection *AL1* is pressed against the locking pawl *Ar1* by means of the spiral *Sp2* on the releasing bar *AS*, and the projection *AL2* of the angle *W2* is pressed against the locking pawl *Ar2* by means of the spiral spring *Sp3*. The depressing of the push button causes the locking projections to be pressed under *Ar1* and *Ar2*, thus preventing the return of the key to normal when the button is released.

The top of the releasing bar *AS* is pivoted on the angle *M* which supports the cradle lever arm, and the bottom is pivoted on an angle *W3* fixed to the casing of the instrument.

The locking bar *V* for the local keys engages a notch on one of the angles *W4* on the releasing bar *AS*. The pressure of the spiral spring *Sp2* forces the locking bar *V* against the locking pawl *Ar3* on the five local line keys *Li*.

When one of these local keys *Li* is depressed, the locking bar *V* is slowly pushed back, raising the releasing bar *AS* and acting on the three springs of the upper spring group. This causes negative to be connected to the case of the instrument and to the contact springs *F5*, *F6* and *F7* respectively, and a ringing signal is sent out to the desired instrument. In this case, the push button is depressed as far as it will go, thus pushing the locking bar *V* as far over as possible. When the push button is released, it is raised by means of its own spiral spring *Sp4*. The locking bar simultaneously moves back again under the shoulder of the push button, thus locking the latter in speaking position.

When — at the end of the conversation — the cradle rest is actuated by the replacing of the hand-microtelephone the releasing arm *S* is raised and the angle *W2* with the locking projection *AL2* is turned upwards. By the aid of the tooth *T2* the locking projection *AL2* is able to lift the angle *W1* as well as the projection *AL1*. As previously mentioned, the angle *W1* engages a notch in the angle *W4* on the releasing bar *AS*. This bar is also raised, causing the

locking bar *V* to release the push button, the pressure of its own spiral spring causing this latter to return to normal.

If, after having established an exchange call and the exchange key, therefore, is in its depressed position, it is desired for some reason or other to get in touch with a local telephone instrument without breaking the exchange connection and without permitting the central exchange subscriber to listen in on the local conversation, the key of the desired local line is depressed. This manipulation causes the raising of the releasing bar *AS* and, consequently, the angle *W1* is turned upwards. The locking projection *AL1* is released from the locking pawl *Ar1* and the key is restored to normal. The right hand locking projection *AL2* remains under the locking pawl *Ar2*. This is explained by the fact that the spring group *F2* is actuated — on the depression of the exchange key — by means of a plunger which is not rigidly attached to the button, the other plunger — which actuates spring group *F1* —, on the other hand, being withdrawn from this group when the key returns to normal, resulting in the release of *F1* while *F2* remains in its working position. When the local conversation is ended, the exchange key is again depressed, causing the renewed moving of the locking projection *AL1* under the pawl *Ar1*. The angle *W1* raises the releasing bar, causing the locking bar *V* to resume its position under the pawl *Ar3* of the local line key.

When the conversation over the exchange line is terminated, the handset is replaced on the cradle rest, causing the angle *W2* to turn upwards. The locking projection *AL2* with its tooth *T2* takes with it the projection *AL1* on the angle *W1*, so that this latter is also turned upwards. This results in the withdrawal of the projections *AL2* and *AL1* from the pawls *Ar2* and *Ar1*, its own spring pressure causing the exchange line key to return to normal.

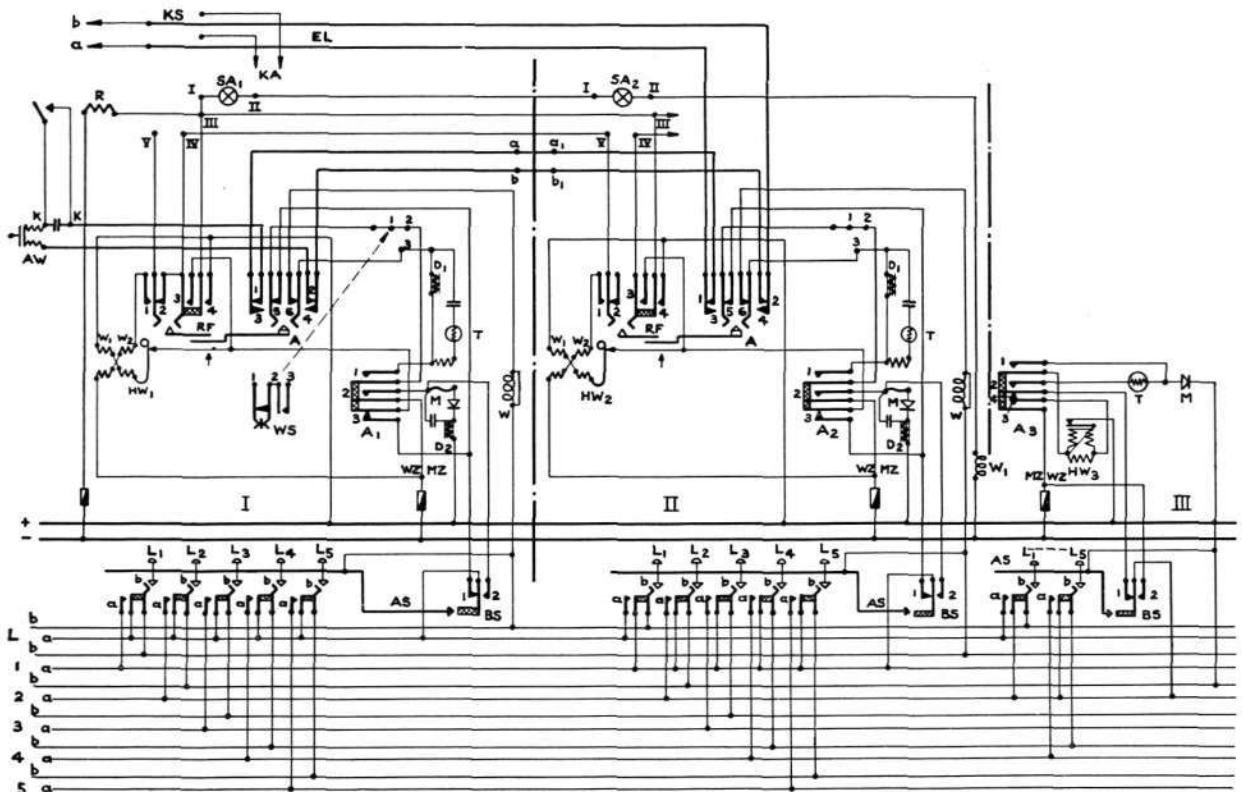
The exchange line key is provided with a small, red indicator, which becomes visible in a celluloid covered opening beside the key as soon as the key is depressed. This indicator has its own, special purpose to fill when several exchange lines enter the same telephone instrument, since it is possible that all of these are marked "busy". When a local conversation takes place during the course of an exchange call from the same telephone instrument, the exchange line that is connected up is marked "busy", besides which the corresponding exchange line key — as already described — has returned to its rest position. When the subscriber wants to resume the conversation

over the exchange line, it is very probable that he has forgotten which one it was. The red indicator — which is still visible in spite of the fact that the exchange line key has returned to normal — then indicates the line used. This indicator does not return to its rest position and disappear from view until the handset is replaced on the cradle rest.

Taking into consideration the number of lines to its rest position and disappear from view until the following types can be furnished:

being provided for the connections between the telephone instrument and the wall terminal box as well as from this last to the outside lines, this same method being applied to the connecting cabinets for the exchange lines. These cabinets as well as the wall terminal boxes are made of black lacquered pressed sheet steel, due consideration having been given the importance of leading exchange lines and local lines through separate cables.

The accompanying diagram (fig. 4) shows the inside



R 763

Fig. 4.

Intercommunication telephones for 5, 10, 15 or 20 double or single lines,

Exchange telephones for 5 local and 1 to 3 exchange lines,

Exchange telephones for 10 local and 1 to 2 exchange lines,

Exchange telephones for 15 local and 1 exchange line. (See further Ericsson News No. 6, 1927, page 4.)

It would be uneconomical — on account of the high cost of the lines — as well as unpractical from the point of view of design (depending on the lightness in weight of the handset, which would cause uncertainty in the functioning of the releasing mechanism) to increase the above-mentioned capacities.

All inside connections are soldered, terminal screws

and outside circuits for two exchange telephones and one intercommunication telephone. The local lines are double and the central exchange is assumed to be on the *CB* principle.

The two branches *a* and *b* of the exchange line first pass over a testing key *KS*, by means of which this line can be switched over from the local net to a testing device *KA*. From the testing key the line is carried over all the exchange telephones and to the service telephone instrument I and its connecting cabinet.

Call from central exchange.

A call from the central exchange causes the bell *AW* — in the connecting cabinet of the service tele-

phone — to ring. The answering party removes the handmicrotelephone from the cradle rest, closing contacts 1 and 2 and breaking contact 3 in the cradle spring group *AI*. The exchange line key *RF-A* is then depressed, the bell being disconnected from the main circuit over the contacts *AI* and 2, the inductive resistance *DI* and the handmicrotelephone of the service telephone being brought in circuit over contacts 3 and 4 of the key *A* and contact 1 in the cradle switch *AI*. The transmitter circuit is closed over contact 2 in *AI* and the visual indicators *SA1* and *SA2* and the relay *R* are simultaneously energized over contact *RF4* in the spring group of the exchange line key. The relay closes a contact which short-circuits the condenser *KK* of the exchange line. The visual indicators are connected in series mutually as well as with a resistance *W1*, permitting the use of a common battery for the local d. c. signal, the transmitter circuit and the visual indicators. The resistance *W1* is adjusted to suit the voltage of the main *CB* (24 volts) and the number of visual indicators in series, and is thus dependent on the number of exchange telephone instruments.

Calling an exchange telephone instrument.

After having received information as to the desired exchange instrument, the party answering the service telephone depresses the corresponding local line key, for instance *LI*. This moves the releasing bar out of its rest position and releases the key *A*, its contacts 1, 2, 5 and 6 being closed while 3 and 4 are broken. The connection of the handset to the exchange line is broken over contacts 3 and 4, while instead of inductive resistance *DI* the signal bell *AW* is connected up over contacts 1 and 2 so as to form a bridge between the two branches of the exchange line, thus preventing a clearing signal at the central exchange. In order to prevent a momentary break in the exchange line connection, contacts 3 and 4 are not broken until contacts 1 and 2 are closed. The *RF* side of the exchange line key is not actuated by the return of the key to normal, whereby the visual indicators remain energized and the condenser *KK* in the exchange circuit remains short circuited.

By depressing the key *LI* as far as possible contacts *a* and *b* are closed and the releasing bar *AS* is pushed over far enough to influence contacts 1 and 2 of the battery switch *BS* on the service telephone. Contact 2 closes the signal circuit to exchange telephone II while contact 1 breaks the receiver circuit so as to eliminate the unpleasant noises in the receiver

while giving the signal. The signal circuit is then as follows: negative, contact 2 of cradle switch *AI*, contact 2 of battery switch *BS*, line *La*, contact *a* in *LI*, line *1a*, contact 1 of the battery switch *BS* in exchange telephone II, contact 3 of *A2*, winding *w1* of the bell *HW2*, to positive. The signal bell of the exchange telephone II rings, the handset is removed from the cradle rest and the ringing circuit is broken at contact 3 of *A2*.

When the party at the service telephone releases the key *LI*, it returns — as already mentioned — to an intermediate speaking position, its contacts *a* and *b* remaining closed. Simultaneously with the releasing of the key *LI*, the releasing bar *AS* is brought back to normal by its spiral spring, so that contact 1 in *BS* is closed and contact 2 broken. This connects the handmicrotelephone to the local circuit and disconnects negative of the calling circuit from the service telephone, forming the following circuit:

contact 1 in *AI*, secondary winding of induction coil, receiver *T*, condenser, terminal 3, contact *A6*, the short-circuited resistance *W*, releasing bar *AS*, contact *b* in *LI*, line *1b*, the short-circuited resistance *W* in the exchange telephone II, contact 6 in exchange key *A* of the same telephone instrument, terminal 3, condenser, receiver *T*, secondary winding of induction coil, contact 1 in *A2*, contact 5 in key *A*, contact 1 in key *BS* of exchange telephone II, line *1a*, contact *a* in key *LI* of service telephone, line *La*, contact 1 in key *BS* of service telephone, contact 5 in key *A*, and back to contact 1 in cradle switch *AI*.

The called exchange telephone instrument is connected to central exchange line.

The person at the service telephone now requests the called local subscriber to connect his telephone to the exchange line. This last subscriber depresses the key *RF-A*.

As previously described, the depressing of this key connects the handset of the exchange telephone to the exchange line, the service telephone being simultaneously disconnected from the same. At the same time, both the visual indicator and the relay *R* remain energized over contact *RF4* in the exchange telephone I. The following signal circuit to the service telephone is simultaneously closed, indicating that the subscriber at the exchange telephone I has completed the connection:

negative, fuse, winding *w2* of *HW2*, contact *RF1* in exchange telephone, terminal *V*, terminal *IV*, con-

tact *RF3* in service telephone, winding *w1* of *HW1* to positive.

The signal bells *HW1* and *HW2* ring. The person at the service telephone replaces his handmicrotelephone, causing the exchange and local keys in his telephone instrument to return to normal. Contacts *RF3* and *RF4* in the service telephone are broken and the bells *HW1* and *HW2* cease to ring. The subscriber at the exchange telephone I is thus informed of the fact that the handmicrotelephone of the service telephone has been replaced. The visual indicator and the relay *R* are now energized only over contact *RF4* in the exchange telephone I. The speaking circuit from the exchange telephone is now the same as previously for the service telephone.

In case the subscriber at the exchange telephone I — which is now connected to the central exchange — should desire information of some sort from a subscriber at a local telephone instrument with intercommunication possibilities only, the local key *L2*, for instance, is depressed, causing the contact springs of the exchange and local line keys to be actuated in the same manner as previously during a call from the service telephone to an exchange telephone instrument. The exchange line circuit is closed over contacts *A1* and *A2*, the microtelephone being disconnected from the same at contacts *A3* and *A4*. In this way there is no possibility of listening-in on the local conversation from the exchange line. The signal circuit to the local telephone instrument III is as follows:

positive, over bell *HW3*, contact *A3—5*, contact *1* in key *BS* of local telephone, line *2a*, contact *a* of local line key *L2* in exchange telephone II, line *La*, contact *2* of key *BS*, contact *2* in *A2* to negative.

The bell of the local telephone instrument III rings, and the subscriber removes the microtelephone, thereby breaking the signal current at contact *A3—4* while

the speaking circuit is closed over contact *A3—2*. The following transmitter circuit is closed:

positive, transmitter, contact *A3—1*, in parallel through both windings of *HW3*, contact *A3—3* and negative. The speaking circuit is as follows:

contact *A2—1*, secondary winding of induction coil, receiver *T*, condenser, contact *A6* in exchange instrument II, the short-circuited resistance *W*, releasing bar *AS*, contact *b* of local line key *L2* in exchange instrument, line *2b*, transmitter and receiver of local instrument, contact *A3—2*, contact *BS1*, line *2a*, contact *a* of key *L2* in exchange telephone instrument II, line *1a*, contact *BS1*, and contact *A5* back to contact *1* in *A2*. This speaking connection is shown in principle on the diagram in fig. 5.

An answer is received from the local telephone instrument.

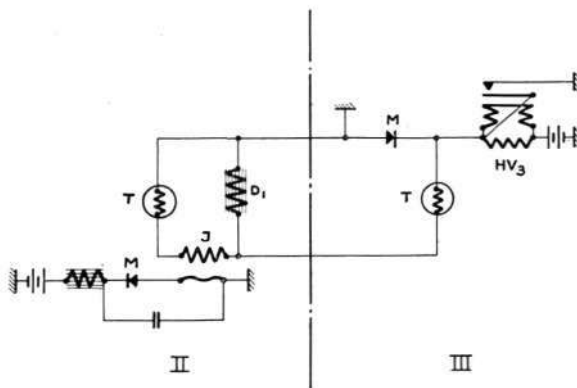
When the handmicrotelephone of the local telephone is removed from the cradle rest, the armature of the bell *HW3* is attracted and held by the transmitter current. This breaks the armature contacts, making it impossible for the transmitter to be short-circuited over the same.

Termination of local conversation.

As soon as the subscriber at the exchange telephone instrument II has finished the local conversation, the exchange line key is depressed, causing the spring group at *A* to be again actuated and the local line key *L2* returns to normal. Contacts *A5* and *A6* are broken while contacts *A3* and *A4* are closed. The handmicrotelephone is switched over from the local line to the exchange line, the inductive resistance *DI* being connected so as to form a bridge over the two branches of the exchange line. Contacts *A1* and *A2* are broken and disconnect the bell *AW* from the exchange line only after the closing of contacts *A3* and *A4*, this bell having been connected between the branches of the local line during the local call instead of *DI*. This arrangement permits the renewed depressing of the exchange line key without giving the central exchange a clearing signal.

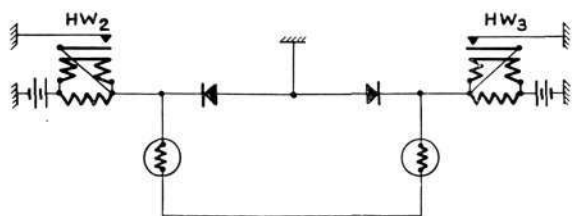
Termination of central exchange call.

When the conversation over the exchange line is terminated, the handmicrotelephone of the exchange telephone instrument is replaced, causing the exchange line key to return to normal and the exchange line is again connected straight through to the bell *AW*. The breaking of contact *RF4* then causes the visual



764

Fig. 5.



R 765

Fig. 6.

indicator *SA* and the relay *R* to de-energize and the condenser *RR* of the exchange line is again connected up in series in one of the line branches.

Calling the central exchange.

Central is called by merely depressing the exchange line key, thereby energizing relay *R*, short-circuiting the condenser *KK* and connecting the resistance *DI* across the two branches of the exchange line. The calling lamp at the central exchange glows.

In telephone instruments of the above described type, the switching devices for exchange connections are designed so as to be adapted — easily and at small cost — to different telephone systems. For co-operation with an automatic system the terminals 1, 2 and 3 are used, the calling dial *WS* being connected to the same after having broken the connection between 1

and 2. For magneto exchanges with or without automatic clearing signal, — the connection to the telephone is broken at 1 and 3, and in its stead is connected a calling key which — during the giving of a calling signal — disconnects the receiver and closes an a. c. circuit over a transformer or a pole changer. For plants with automatic clearing signal at central, the resistance *DI* is eliminated and the relay *R* is re-connected as may be found necessary in the various cases.

Signalling and conversations between local inter-communication telephone instruments takes place in exactly the same way as between exchange and local telephones. The only difference is in the speaking circuit, a diagram of which is shown in fig. 6, and from which it is evident that there is no induction coil in this circuit. The transmitters receive current over the bell coils.

If these telephone instruments are to be made for single lines, all the terminals of the local *b*-lines are connected to a common return. In this case the resistances *W* are not short-circuited, their function being to damp the speech current in order that the cross-talk which is inevitable with single lines be reduced to a minimum.

K. P.

Projecting City Telephone Nets.

According to the Ericsson System of Cable Distribution.



R 239

Ericsson Cable Works at Älvsjö, near Stockholm, Sweden.

When preparing the project for a city telephone net, the only basis from which to work consists of information as to the number of inhabitants and the yearly increase in population based on the statistics of the previous year. Furthermore, the assumed number of inhabitants to each telephone instrument is based on local conditions and on statistical data from other

cities. In small or average sized cities, where the telephone net is operating satisfactorily and the rates are normal, this figure can be taken at about twenty. Instances with both higher and lower figures are not lacking, but for a normal project the figure mentioned should be very close to the actual one, or at least close enough for preparing the first rough draft. If there

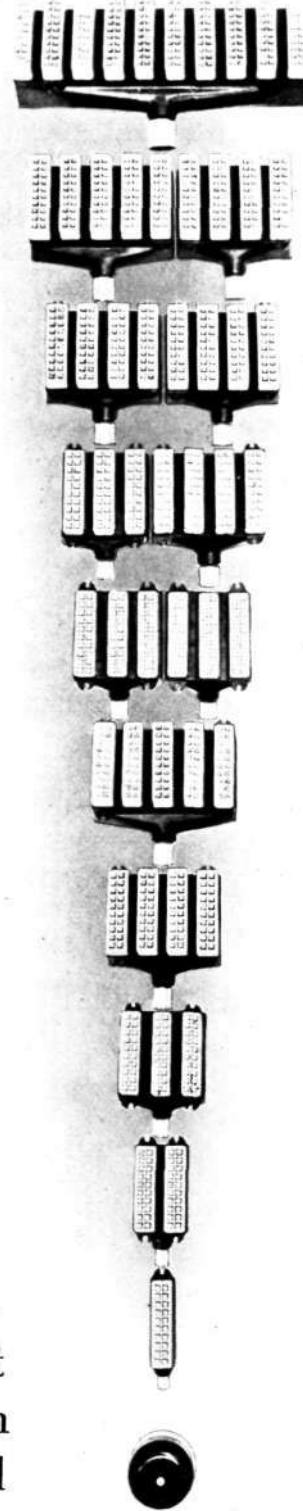


Ericsson

Line Material

Thanks to more than 40 years experience in the building and operating of telephone nets we are able to offer to our customers first class modern line material which covers all the details and tools necessary for a telephone installation.

Our construction department executes on contract all kinds of work connected with telephone lines as well as complete installations. — Complete plans, estimates and catalogues supplied on request to be addressed direct to us or to our agencies in various parts of the world



TELEFONAKTIEBOLAGET L. M. ERICSSON
STOCKHOLM, SWEDEN

is an old net in the city, too much importance must not be attached to the existing number of subscribers, as the service most likely has been poor and the capacity of the plant insufficient, thus restricting its natural growth and development.

Since the project, as already mentioned, is based chiefly on the increase in population, it is clear that a certain period of time must be established during which the initial capacity of the net shall suffice for the current needs of the city. This holds good for the distributing cables and open wire distribution, the main cable lines, on the other hand, being successively added to as the necessity arises. Such a time period is usually fixed at from five to ten years, eventually to a still longer time period, for the underground canalisation and naturally depends upon the available capital as well as on a number of local conditions which may influence the normal expansion of the plant. However, it is well to keep in mind that an initial capacity designed to meet the requirements for a comparatively long period generally means a lower first cost.

After having assumed the maximum number of inhabitants — including a certain increase — during a certain period of time, which number we will designate by the letter a , and the number of inhabitants b per telephone instrument has also been assumed, the following necessary data for preparing the project are obtained by the aid of these figures.

1. Number of subscribers $c = \frac{a}{b}$
2. Number of lines d in outgoing main cables.

This figure is generally taken 30 % higher than the calculated number of subscribers, as a result of the wide experience gained from the operation of underground telephone nets. Thus we have

$$d = 1.3 c = 1.3 \frac{a}{b}$$

3. Number of distribution lines e .

Based on the same experience, the rational operation of a telephone net requires that this figure be $\frac{1}{3}$ times the calculated number of main lines. This gives us

$$e = \frac{1}{3} d = \frac{1}{3} \cdot 1.3 \frac{a}{b} = 1.75 \frac{a}{b}$$

4. Number of distribution cabinets f and their capacity h .

With due consideration for local conditions, a distribution cabinet with a suitable capacity h is chosen from among the standard catalogue types. In these cabinets the necessary number of line terminals are reserved for the main lines and the distribution lines in the above-mentioned ratio of 3 to 4. Thus, the necessary number of distribution cabinets

$$f = \frac{e + d}{h} = 3 \frac{c}{h} = 3 \frac{a}{bh}$$

5. Number of ducts g in the outgoing conduit lines from the central exchange.

This number depends on the chosen capacity h of the main cables, from which we obtain

$$g = \frac{e}{h} = 1.75 \frac{c}{h} = 1.75 \frac{a}{bh}$$

Thus, the resulting number of ducts is sufficient for the required distribution cables as well.

In order to illustrate this method by means of a concrete example, we will assume $a = 100,000$ inhabitants within 10 years and $b = 20$ inhabitants per telephone instrument, the following figures within 10 years then being obtained according to the above formulas:

number of subscribers

$$c = \frac{a}{b} = \frac{100,000}{20} = 5000$$

» » main lines

$$d = 1.3 c = 1.3 \times 5000 = 6500$$

» » distribution lines

$$e = 1.75 c = 1.75 \times 5000 = 8750$$

» » distribution cabinets

$$f = 3.00 \frac{c}{K} = 3.00 \times \frac{5000}{700} = 22$$

on condition that the capacity of the cabinets has been taken at 700 lines, i. e. in the ratio of 3 to 4 — 300 main lines and 400 distribution lines.

» » ducts in the outgoing conduits from the central exchange, on condition that the capacity of the main cables has been fixed at 300

$$g = 1.75 \frac{c}{K} = 1.75 \times \frac{5000}{300} = 30$$

1. Cabinet areas.

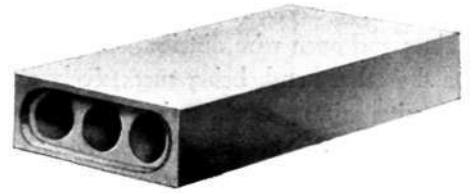
When the foregoing data for the net have been calculated, the city is divided up into *cabinet areas*



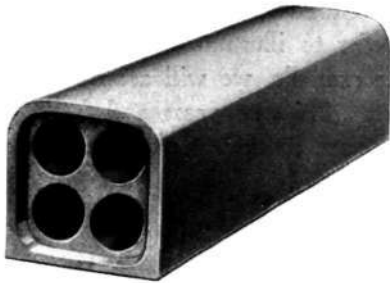
NJ 1/1



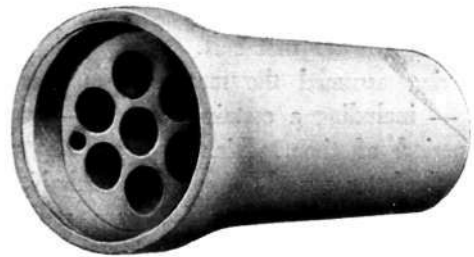
NJ 1/2



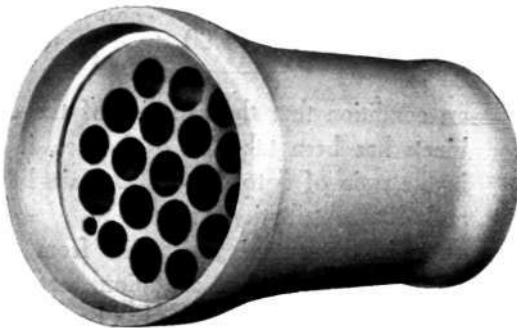
NJ 1/3



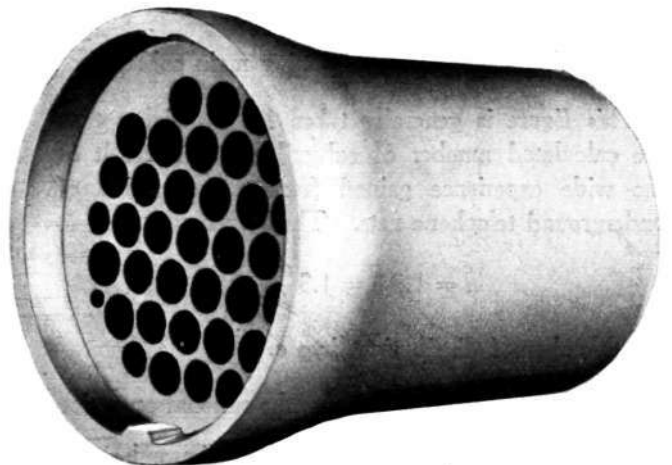
NJ 1/4



NJ 1/7



NJ 1/19.



NJ 1/37.

Cement Conduits

according to the number of distribution cabinets. The number of subscribers c_s in each cabinet area will then be

$$c_s = \frac{c}{f} = \frac{k}{3}$$

or about 200 to 250 subscribers, if the capacity of the cabinet has been set at 700 lines, which is usually the case.

The distribution cabinets are the fixed points about which the whole net is built. For this reason their number should be sufficient to insure efficient distribution without future sub-dividing or replanning of the areas, this last expedient being both difficult and costly. The above method of calculation insures the filling of this requirement on condition that the sizes of the areas are determined with due consideration for the increase in population during the period for which the net has been projected. Consequently, the making of the project should be preceded by a thorough investigation of the existing local conditions.

In order to determine the size of the cabinet area with due consideration for future subscribers, it is customary to make a so-called block estimate, i. e. the requirements for each house in a city block are estimated, this estimate being based on the present number of apartments, stores, offices etc. as well as on the assumed future development. A number of suitably located buildings which, according to the estimate, will have $\frac{k}{3}$ subscribers during the predetermined period, are then grouped together so as to form a cabinet area.

2. Telephone exchange.

The choice of location for the telephone exchange is intimately connected with the grouping of the subscribers — especially since most large, modern nets are planned for automatic switching —, economical as well as efficient service being decisive points of view in this case. Consequently, the discussion of this question does not lie within the scope of the present article. The author only wishes to state that, if only one or several exchanges are being considered, the system with cabinet areas gives reliable guidance in determining their location, other factors which may influence the decision, however, being the possibility of acquiring a suitable site for the exchange building and the direction in which the city is expected to expand.

3. The underground net.

The conduit lines are now planned in accordance

with the projected division of the city into cabinet areas.

The calculated number of ducts in the outgoing conduit lines is distributed among these latter as conditions may require, conduits with suitable numbers of ducts being chosen from among the standard types. The number of ducts in the respective conduit lines are successively diminished while passing through the cabinet areas, due consideration being given the probable future development of the net as well as the standard sizes of conduits.

The underground lines follow the shortest possible route through the most thickly populated parts of the city in order to make the cable lines as short as possible. Streets already occupied by tramways should be avoided in order to minimize the serious effects of electrolysis.

Wherever possible, the distribution cabinets should be placed along the main conduit lines, either against a building or in a niche cut into the wall, or in an open place. Pits, for admitting the cables to the cabinets, are built under the cabinets, communication with the conduits being obtained by means of suitable pipe lines.

4. Main cables.

A general rule which should be kept in mind when planning cable nets is that the main cables should be laid with a capacity per cabinet area approximately corresponding to the actual number of main lines calculated to fill the demand for one or two years in advance and to the standard cable types. This system gives the main cables a capacity which exceeds that of the cables which lead to the corresponding cabinets, although always with a surplus equal to a cable of standard size with respect to the number of pairs. These surplus lines terminate at suitable points, so as to be easily accessible when needed for the increase of the number of main lines in the cabinets. The main cables are increased from year to year in proportion to the actual yearly increase in the number of subscribers so that d always will be equal to 1.3 c .

5. Distribution cables.

These cables should always be laid with a capacity fully equal to what has been calculated for the future needs of the plant during the entire time period for which it is projected. These cables are laid to the greatest possible extent in the main conduit lines, although it may be found necessary to branch off conduit lines of small capacity (with one or two ducts) or even to use aerial cables, in order to make the

cable lines as short as possible. The distribution cables for a cabinet area are carried to a point of distribution centrally located with respect to the homes of the subscribers. These distribution points should not be for more than ten or twenty lines, so that the lines from here to the subscribers' stations shall be as short as possible.

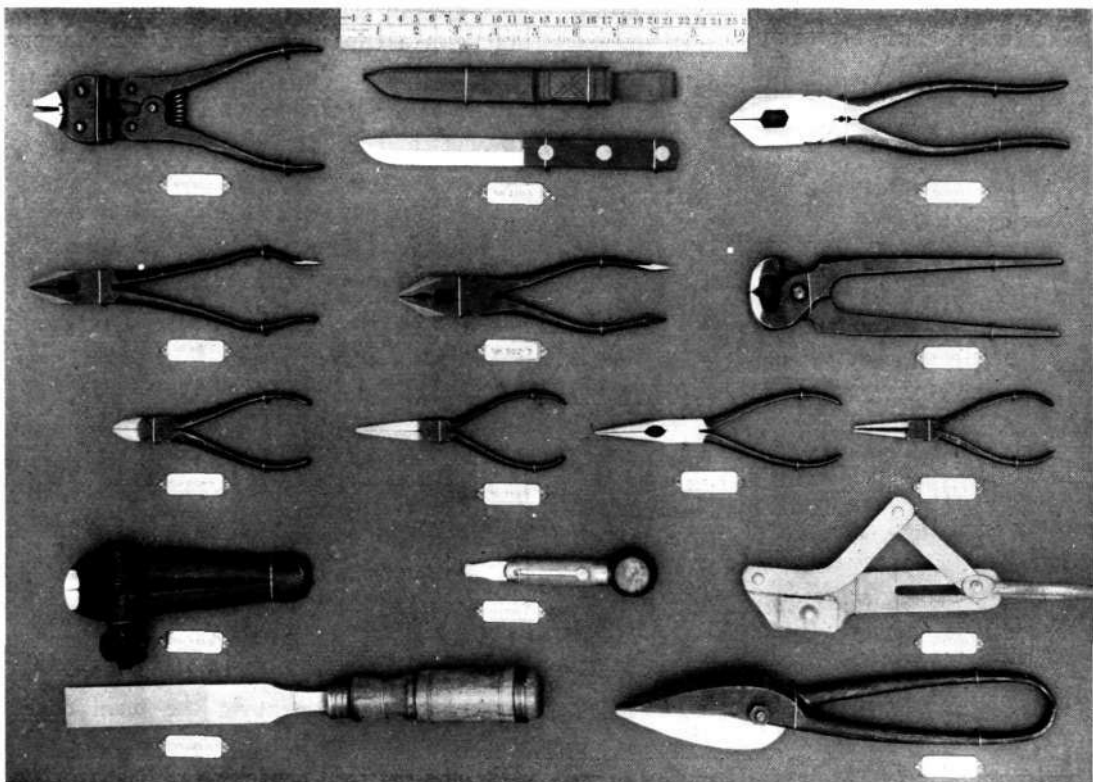
If lack of capital should prevent the completion of the net along the above lines, certain restrictions will naturally have to be made. These restrictions must on no condition influence the number of distribution cabinets, however, but these shall be erected to the full number estimated. It should be kept in mind that the erection of the full number of cabinets will give shorter distribution cables, thus affording considerable reductions in the first cost. On the other hand, the capacity of the projected conduit lines can be diminished, in which case the conduits should be laid deep enough to permit the laying of future lines above them. No reduction of the estimated capacity of the main cables (see point 4) can be effectuated and a reduction in the distribution cables should be resorted to only in case of absolute necessity, as the saving effected is only apparent, the cost for laying additional cables at a future date being much higher.

6. *Subscribers' lines from point of distribution to subscribers' stations.*

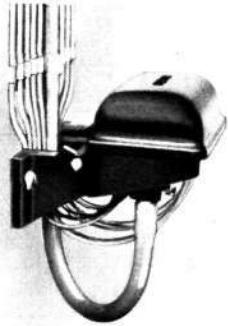
These lines can be carried in direct aerial cables or by means of combined cable and open wire lines, depending on the concentration of the subscribers' stations. In the more central parts of a city and with large buildings, the firstnamed method is generally used; the latter system — on the other hand — is more suitable towards the outskirts or where subscribers are more sparsely located. From the point of view of operation, the first-mentioned system is preferable. Subscribers' lines are mounted only as the necessity for the same arises, i. e. only in accordance with an actual increase in subscribers.

Such, in short, are the basic principles which must receive first consideration when preparing an estimate for an outdoor telephone plant. A considerable saving can be effected by preparing the project with the utmost care from the very beginning. The plant can then develop smoothly without the necessity for expensive re-construction work, and there will be no difficulty in maintaining the high standard of the net, a condition which is of the utmost importance for the operating company as well as for the subscribers.

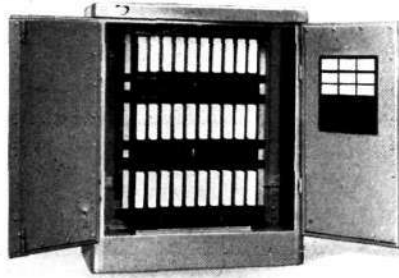
E. A. E.



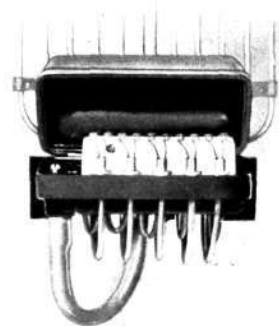
R 754



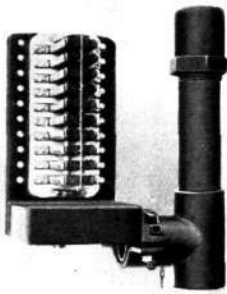
NC 5



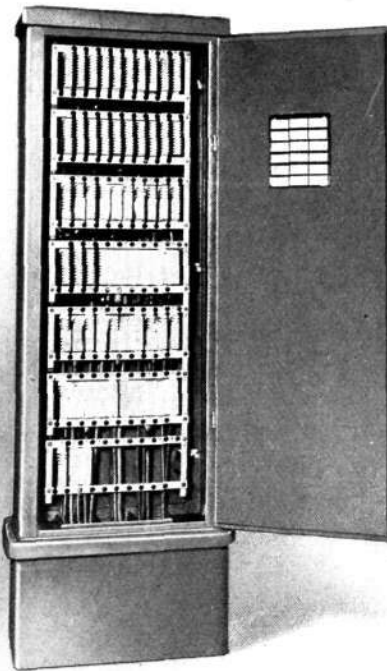
NA 25



NC 5



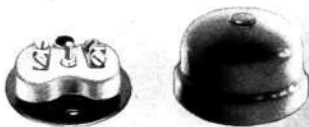
NC 115/10



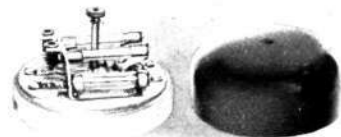
NA 15



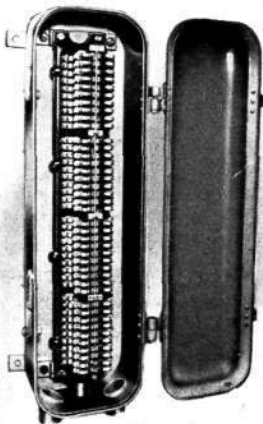
NC 115/10



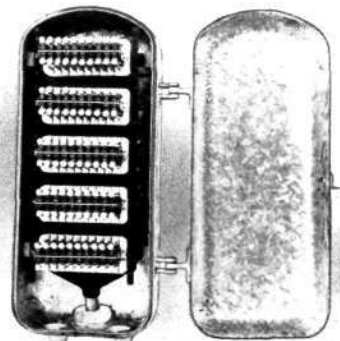
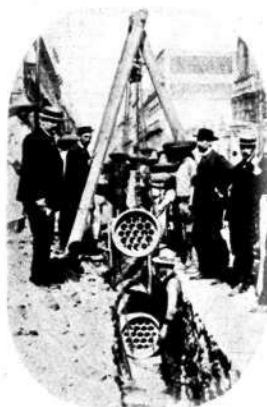
ND 1000/1



ND 370



NA 100



NA 115



L. M. Ericsson

The *Ericsson*
Automatic Fire-Alarm System

gives
increased safety
and
reduces insurance premiums.

Information and offers on application.

Ericsson

R 797

CONTENTS OF THIS NUMBER: In memoriam: Carl Johan Andersson. — In memoriam: Erik O. Sandberg. — The Burial of Erik O. Sandberg. — The L. M. Ericsson Automatic Telephone System. Experiences from the Stockholm telephone net concerning the efficiency and maintenance of the system. — The Skövde and Herrljunga Interlocking Plants. — Time control and efficiency. — Field Telephone Switchboard for Buzzer and Magneto Signals. — Local Telephone Installations with Push Button Intercommunication Telephone Instruments. — Projecting City Telephone Nets.

The L. M. Ericsson Review



VOL. IV

OCTOBER-DECEMBER 1927

Nos. 10 to 12



H. R. H. THE CROWN PRINCE OF ITALY,
UMBERTO OF SAVOY.

ENGLISH EDITION

L. M. Ericsson

graph Administration, he expressed his unfeigned admiration for the efficient organization of the Swedish telephone service, for the excellence of Swedish telephone material and for the manner in which Swedish enterprise has contributed to the development of this important means of communication. At the L. M. Ericsson stand he devoted his whole interest to a detailed explanation of the switching process of the Ericsson automatic system. Before leaving he autographed a portrait of himself which had been placed in the exhibition room.

The Italian Minister of Communications, his excellency Costanzo Ciano, visited the exhibition and Ericsson's had the pleasure of seeing him devote himself exclusively to a study of their exhibits. He evinced a very special interest in the Ericsson automatic system.

Among the many visitors at the Ericsson stand may be mentioned

On. Bisi, secretary of the Public Welfare Department,

On. Augusto Turati, secretary in chief of the Fascist party,

Comm. Arnaldo Mussolini, a brother of the Dictator,

General of the Fortifications, Caviglio,

Prof. Dr. Hebel, director of the Post Office in Munich,

Engineer Muri, director of the Swiss telephone and telegraph department.

The International Telegraph, Telephone and Radio Convention, which was attended by prominent scientists and technical experts from over the whole world, was held in Como from the 10th to the 15th of September under the presidency of the Italian Minister of Communications, his excellency Costanzo Ciano.

Professor Giovanni di Pirro served as chairman for the program committee. Thirty-five discourses were delivered by the foremost scientists in these subjects during the course of the convention. The Swedish contribution consisted of a discourse on the subject »General Theory on Homogeneous Parallel Lines«, delivered on September 15th by Mr. H. Pleijel, professor at the Royal Institute of Technology in Stockholm and vice president of the board of directors of Telefonaktiebolaget L. M. Ericsson. This discourse will be found on page 123 of this number.

In Memoriam.

Leo Spørhase died on October 14th 1927 in Leningrad at the age of 53, after a prolonged illness. His death means the loss of one of the oldest in years of service of L. M. Ericsson's foreign staff. After having graduated in 1898 from the St. Petersburg Electrotechnical College and spent some time in practicing elsewhere, he entered the service of Telefonaktiebolaget L. M. Ericsson & Co. — as it was then called — in the capacity of first assistant to Mr. E. O. Sandberg, director of the Ericsson subsidiary established three years previously in the Russian capital. In Leo Spørhase, Mr. Sandberg found both a strong and devoted ally in the overcoming of those obstacles which beset the company, obstacles which arose out of the peculiar conditions existing in Russia. The seriousness of these obstacles even caused the advisability of shutting down the factory to be considered and it was largely due to Spør-



R 812

Leo Spørhase.

hase that the necessity for such an action was warded off. The many valuable services which he rendered the Ericsson company in Russia during the period 1901 to 1905, at which latter date the branch was reconstructed into a Russian stock company, led to his being appointed vice president of the board of directors as well as technical manager of the company. These positions he retained as long as the company was in active operation in Russia. As a result of the renown he had gained in his native country through his many achievements in the field of telephony, he was appointed professor of tele-

phony at the Electrotechnical College of St. Petersburg, a post which he retained until the outbreak of the war. Spørhase's benevolent and kindly nature made him popular among his superiors, comrades and subordinates alike and he will not soon be forgotten by the many friends he acquired during his lifetime.

Obituary.



R 811 Stanislaw Grodzki.

Stanislaw Grodzki died on October 23rd 1927 in Warsaw at the age of 61 years. He was still quite young when, after his father's death, he took charge of his business, a well known Polish firm for the sale of agricultural machines and implements. Notwithstanding his youth and lack of experience, he was able — through energy and intelligence, inherited from his father — to build up the business, his success giving him one of the foremost positions in Poland in this branch.

Grodzki was of a considerate and unassuming nature and preferred to keep out of public life and politics although possessing all the necessary attributes therefore. On the other hand, he rendered his native country and city many important services in a quiet way. His open character and varied cultural interests gave him a wide circle of personal relations both within and outside of his native country. These relations were associated also with Sweden and were a contributing cause to his being offered a position on the board of directors when Telefonaktiebolaget L. M. Ericsson decided to establish a sales company in Poland. This offer he accepted and the company had the pleasure of profiting by his experience and good advice during a number of years.



R 827 Anselm Van Minden.

Anselm Van Minden, president of the board of directors of Société des Téléphones Ericsson, died in Paris on November 5th 1927, 77 years old.

Ever since the above-mentioned company was formed sixteen years ago, Van Minden has been president of its board of directors, to which work he devoted a large part of his energies. He took an active interest in questions concerning the business and his wide experience made his advice valued and sought for, while his engaging personality made it a pleasure for any one to work together with him. His death is a serious loss to the Ericsson company and it will be a difficult task to fill the ensuing vacancy.

Mr. Van Minden was chairman of a number of other boards of directors as well, his personal connections in France as well as in other countries being very widespread. As a very warm friend of both Sweden and Norway, he took an active part in strengthening the commercial relations between France and these countries. The distinctions conferred upon him by the governments of these countries give ample proof of how highly these efforts were valued.



Person to Person Long Distance Calls.

By A. Lignell, superintendent of telephones, Stockholm.

The one great advantage which the telephone possesses over other means of communication is its faculty of quickly placing one in apparent personal contact with the party with whom one desires to communicate. The mails, as we are aware, require an ample length of time, while a telegram — in addition to the actual time required for sending the message over the wires — takes a certain length of time to be delivered to the addressee. Besides, neither of these two means of communication offer the same possibilities as the telephone for the immediate discussion of a question or for arriving at an immediate decision if the character of the subject is such as to permit this. In these bustling times it consequently is quite natural that the telephone should be the most popular means of communication. The extent to which the telephone is able to fill its mission, however, depends largely upon whether the traffic regulations are formulated so as to give the public all the advantages which may tend to increase the efficiency and rational use of the telephone.

As long as orders for toll calls were received for calls to a certain number only, one always ran the risk — after the completion of the connection — of not finding the individual with whom one desired to communicate, probably the only person who could give the desired information or make a decision in the matter under discussion. It was very desirable, therefore, to be able to get in touch with the right person and it soon became necessary to find a solution to this question, a necessity which made itself felt in direct proportion to the distance involved and — consequently — to the tariff rates. A lost fee as well as the wasted time must be avoided as far as possible.

It was for this reason that the advance ordering of calls was introduced in Sweden more than twenty years ago, making it possible for a subscriber to get in touch with the very person with whom he wanted to communicate, naturally on condition that this person could be reached, a small extra charge for this advance order service being made. There was no toll charge unless the conversation had actually taken place, but

the advance order charge was always collected, this being but fair since the toll line was necessarily engaged during the forwarding of the order, and also since a certain amount of service was required. As time has advanced, these advance orders (for calls to a certain person or to a certain telephone instrument) have gained in importance through the adoption of various rules and regulations intended to increase the efficiency with which these calls were established. It did not take long for the Swedish Telegraph Administration to realize how important it was, from their own point of view as well as from that of the public, to adopt practical regulations for the handling of this traffic.

The regulations now in force in Sweden for the handling of personal calls are in short as follows:

Orders are received for personal calls of the following categories:

a. *The desired person is reached by telephone only:* a call to one certain person or either of two simultaneously designated persons at a certain telephone instrument; also to a certain person at either of two simultaneously designated telephone instruments within the same rate zone.

b. *The desired person is reached by messenger:* a call to one certain person or either of two simultaneously designated persons to be sought at a given address. An order in which more than the above stipulated number of persons or telephone instruments are designated is also accepted but the charges are then figured as for two — or eventually several — orders.

The following rules apply for the handling of advance orders:

If, on delivery of the order to the given subscriber's number, information is received that the addressee is not there, the receiving exchange shall inquire whether the addressee can be reached at some other number within the same rate zone and shall — in the affirmative — attempt to reach him there or make inquiries as to when and where he may be reached. The

information received shall be given as soon as possible to the sending exchange which then imparts it to the ordering number. An ordering party who is not a subscriber has the right to demand that this information be delivered to him by messenger on payment of a messenger fee.

If the ordering party request that the order shall remain in effect during the day until the addressee has announced himself, this request is granted. If the addressee is not heard from during the day, the order is cancelled. Should word be received from the addressee, however, information to this effect shall be forwarded to the ordering party on the shortest possible notice. It then depends on the directions received from the ordering party whether the call shall be effectuated in regular order or at a certain time, or if the order shall be cancelled.

Should the connection be desired after a certain hour, or if a new telephone number or addressee is desired, a new order shall be placed.

If, on the forwarding of an advance order for a personal or number call, no answer be received from the called telephone instrument after the giving of two double ringing signals at an interval of a few minutes, this fact shall be imparted to the calling party after which the call is dealt with according to the above regulations.

In order to eliminate all unnecessary delay in the notification of the calling party when an order remains standing and no special time has been given when the addressee may be reached, the receiving exchange shall make inquiries at the desired number at least once an hour to see if the addressee cannot be reached; also, if no answer is received from the desired telephone instrument, the ringing signal to this instrument shall be repeated with the same frequency.

A connection for a personal call to a subscriber's instrument (*préavis*) or a call where a certain person is called to a public telephone (*avis d'appel*) is never established until *the exchange is certain that both the ordering and the desired subscriber are at their telephone instruments and ready to begin the conversation.* If the conversation does not take place, no toll charge is ever collected; an advance order charge is always collected, however.

The tariff rate for forwarding call orders is unusually modest and is as follows for personal calls to a subscriber's station:

.20 crowns where the toll rate
does not exceed 50 crowns per period

.30 crowns where the toll
rate does not exceed . . 1.10 crowns per period
.50 crowns where the toll
rate exceeds 1.10 » » »
(note: 1 period = 3 minutes)

When the desired party is to be called by messenger to a public station, an additional charge of .30 crowns is made for messages within the telegram distribution area of this station (In Sweden the public telephone stations are combined with a telegraph station, both means of communication being handled by the same administration). For messages outside of this area a charge of .50 crowns per km. is made, although the total is never less than 1.00 crown.

Messenger service is provided at every central exchange and at certain sub-exchanges specially designated in the telephone directory.

It is evident from what has been said that all possible measures have been taken to make the advance ordering of personal toll calls as valuable and efficient as possible for the public.

In this connection, it may be of interest to see to what extent this type of calls is made use of.

In September 1924 an investigation was made at the Stockholm exchange to ascertain the number of orders placed for personal calls as well as their percentage distribution among the different call distances, showing that twenty-nine percent of all calls ordered were of the person to person type.

For distances not exceeding 180 km. the personal call percentage was	20.7
For distances between 180 and 540 km.	42.5
» » exceeding 540 km.	55.0

In January 1927 the increase in these figures was such that the total percentage of personal calls had gone up from 29 to 43.9.

The increase for each of the above distances was as follows:

Less than 180 km.	from 20.7 to 33.4 %
Between 180 and 540 km. »	42.5 » 54.7 %
Over 540 km.	55.0 » 81.7 %

truly a very satisfying result in not much more than two years.

These figures clearly show that the number of personal call orders increases with the distance and the toll rate; a perfectly natural condition, as has already been pointed out. On the other hand, advance ordering of personal calls combined with messenger service, i. e. the calling of the desired party to a

public telephone station (avis d'appel), is not extensively used on account of the widespread use of the telephone in Sweden.

Thus, at the present time, about 5500 outgoing toll calls from the Stockholm exchange are accompanied by personal call orders, while not more than about twenty are accompanied by 'avis d'appel'.

In January 1927 an investigation was made to ascertain the result of the personal call orders. Out of 21,210 personal call orders, 17,189 or 81 % resulted in conversations while 4,021 or 19 % of the ordered calls did not materialize.

An investigation as to the various causes gave the following result:

of all personal call orders.

In	1926	instances	or	9.1	%	the addressee has not been within immediate reach and the calling party has cancelled the call.
»	886	»	»	4.2	%	the addressee has not been within immediate reach. After waiting a short time, the calling party has cancelled the call before the addressee could be reached.
»	24	»	»	.1	%	the ordering party has no longer wished to communicate with the addressee when informed later on that this latter has been reached and the call was cancelled before the connection was established.
»	628	»	»	3.0	%	the addressee has been out of town. The calling party has been informed as to his whereabouts.
»	133	»	»	.6	%	the addressee has been unknown at the stated telephone number (generally hotels).
»	283	»	»	1.3	%	the given number has not answered.

In	126	instances	or	.6	%	the addressee has been prevented by sickness from receiving the call.
»	15	»	»	.1	%	the addressee has for unknown reasons refused to receive the call.

Total	4021			19	%
-------	------	--	--	----	---

Of the 17,189 calls which took place in connection with advance ordering, 13,763 were dispatched in regular turn, in 330 instances the ordering party wished to speak even though the desired individual was not at hand and in 3096 instances the call took place later when the addressee had been located.

There is no doubt but that this manner of handling advance orders is of inestimable value to the public as well as to the telephone administration.

The ordering party has the assurance of getting in touch with exactly the person with whom he desires to speak, insofar as this is at all possible. If this person cannot be reached immediately, he is sought for — if so desired — during the course of the day and if he is found the ordering subscriber is immediately apprised of this fact, after which he may accept the call or cancel it as he sees fit. If the addressee is out of town, the calling party is informed of his whereabouts and can reach him there by telephone.

Thus, the ordering subscriber need not run the risk of paying the fee for a call which may prove to be of no value to him whatever.

The steady increase in the frequency of advance orders gives ample proof of the popularity of personal calls in Sweden, in spite of the very low toll rates existing in that country.

On the other hand, the telephone administration derives benefit from a steady increase in traffic based on the adaptation of the telephone service to the requirements of the public; also, the advance order fees are an important source of income which covers a considerable portion of the salaries of the force required for the dispatching of the calls.

In the international telephone traffic, personal calls have long since been introduced in the service between Sweden on the one hand and Denmark, Norway and Germany on the other, although the traffic with Germany does not provide the same degree of convenience for the public as the traffic with Denmark and Norway.

At the present time personal calls ('préavis' and 'avis d'appel') are introduced in the traffic between Sweden

and all other European countries except England and Finland.

The instructions of 'The International Telephone Regulations' and 'The International Consultative Committee' for advance order toll service are as follows:

The purpose of 'avis d'appel' is to call *one* person to a public telephone station for a conversation.

The purpose of 'préavis' is to inform *one* subscriber's station that the ordering party desires to speak with *one* certain person or with *one* certain *extension* telephone instrument.

The fee for 'avis d'appel' and 'préavis' is one third of the regular rate unit — with a minimum fee of fifty centimes — to be divided in the same proportions as the toll rates among the administrations participating in the establishing of the call.

Advance orders are forwarded from exchange to exchange with the utmost haste during the intervals between the toll service and are announced by the words 'avis d'appel' or 'préavis'.

Messenger service for 'avis d'appel' is provided on the same basis as the regular telegraph messenger service and it is up to the ordering party to give so clear information as to address etc. that the messenger will have no difficulty in reaching the addressee.

Conversations resulting from 'avis d'appel' or 'préavis' are subject to the customary regulations for international telephone traffic.

Advance order calls are dispatched in turn, although not until the forwarding exchange has been informed that the addressee is ready to receive the call.

The following must be observed when effectuating advance order calls to *one* certain person or to *one* extension instrument (*préavis*):

a. As soon as the receiving exchange has received the advance order, this exchange shall make inquiries at the given subscriber's station as to whether the desired person or extension instrument are prepared to receive the call;

b. if the answer is in the affirmative, the receiving exchange shall immediately notify the directing exchange, which effectuates the call when its turn arrives;

c. if the receiving station is informed that the desired person or extension instrument are not prepared or refuse to receive the call, both the directing and forwarding exchanges shall be notified to this effect; the last mentioned exchange then notifies the ordering party after which the advance order is officially cancelled;

d. if, on the other hand, the receiving exchange is informed that the desired person cannot receive the

call until later, the given subscriber's instrument is requested to give information as soon as possible as to the exact time after which the call may be effectuated;

if the call is not yet in turn at the hour after which the addressee is prepared to receive it, it is effectuated when its turn comes,

if its turn has already passed, the call is dispatched among calls with the same right of dispatch and immediately following those calls which are then under preparation,

if, after two or three hours, the receiving exchange has received no communication from the given subscriber's instrument, this exchange shall renew its request when the call is to a hotel or a boarding house, for instance. If possible, the forwarding exchange shall not insist on information from the distributing exchange as to the exact hour after which the call can be effectuated. If the ordering party finds the waiting time too long, he may cancel the advance order, in which case the receiving exchange shall be notified to this effect,

e. when an advance order call is in turn to be effectuated the receiving exchange — both when preparing the call and effectuating the connection — shall inform the given subscriber's instrument of the person or extension with whom communication is desired. If the receiving subscriber's instrument — during the preparation of the call or the effectuation of the connection — declares that it cannot receive the call because of the absence of the desired person or because the extension instrument does not answer, *the tariff rate for one period shall be charged for the type of call that has been ordered.*

The following must be observed when effectuating calls combined with messenger service (*avis d'appel*):

a. As soon as the addressee, after having been notified by messenger, has presented himself at a public telephone or communicated that he is prepared to receive the call at a certain subscriber's station designated by him, the receiving exchange shall immediately notify the distributing exchange, after which the call is effectuated in turn;

b. if the messenger receives the information that the desired person cannot or does not wish to receive the call, the distributing and forwarding exchanges shall be notified to his effect. This last exchange shall notify the calling party, after which the advance order is cancelled;

c. if the messenger is informed that the desired person cannot receive the call until later, the receiving

station shall make a note of this but shall not notify the distributing exchange until the addressee is ready to receive the call;

d. if, at the hour after which the addressee is prepared to receive the call, its turn has not yet come, the order retains its normal turn,

if its turn has already passed, the call is dispatched among other calls with the same right of dispatch and immediately following those calls which are then under preparation.

If the ordering party should cancel an advance call order (préavis or avis d'appel) after the forwarding of the order has already begun, the order charge is not annulled. The receiving exchange shall be notified of this cancellation.

Should the ordering party — when it is a question of a call with messenger service — desire the sending of another message to the addressee, an additional order fee shall be charged.

If, previous to the effectuation or — when the call must be prepared — the preparation of the call, the desired number (for préavis) or the person called by messenger (for avis d'appel) give notice that they cannot wait until the turn of the call arrives, the ordering party shall be notified to this fact and can then cancel his order, if it concerns a call with 'préavis'. If it is a question of 'avis d'appel', the order is officially cancelled.

Advance order fees and messenger fees are restituted in the following cases only:

a. When the order or message has not been for-

warded depending on a mistake on the part of the telephone administrations;

b. when, after the forwarding of the order or the message, the call cannot be effectuated on account of trouble either on the lines or in the subscribers' instruments.

From the above, it is evident that the international regulations do not offer the same advantages as those governing this type of service in Sweden, Norway and Denmark, especially in regard to the finding of the addressee and the manner of applying the toll rates. Also, the advance order charge, which is equal to the call charge for one minute, may seem rather high.

The figures in the following table give the extent of the advance order traffic during September last between Stockholm and the countries mentioned:

Traffic between Stockholm and	Calls from Stockholm			Calls to Stockholm		
	Number	With advance ordering		Number	With advance ordering	
		Number	Percentage		Number	Percentage
Denmark	2511	1604	63.9	2376	1440	60.6
Norway.....	2289	1560	68.2	2322	1470	63.3
Germany	2511	1539	61.3	2765	492	17.8

With other countries, this type of traffic is newly opened and of rather small proportions, but there is no doubt that personal calls over these traffic routes will be appreciated by the general public in the same degree as in the above cited cases.

C. Signell



R. 704.

L. M. Ericsson

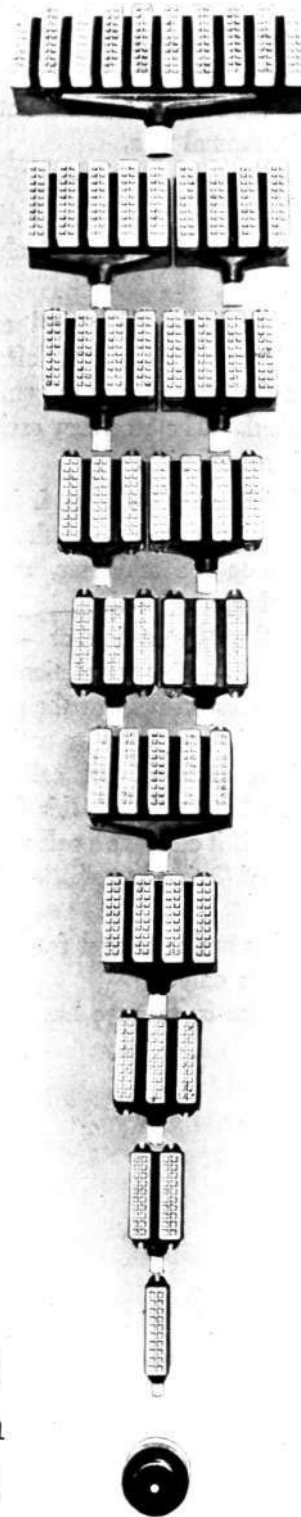


Ericsson

Line Material

Thanks to more than 40 years experience in the building and operating of telephone nets we are able to offer to our customers first class modern line material which covers all the details and tools necessary for a telephone installation.

Our construction department executes on contract all kinds of work connected with telephone lines as well as complete installations. — Complete plans, estimates and catalogues supplied on request to be addressed direct to us or to our agencies in various parts of the world



TELEFONAKTIEBOLAGET L. M. ERICSSON
STOCKHOLM, SWEDEN

General theory on homogeneous Parallel lines.

By *H. Pleijel.*

In the study of the mutual influence between telephone lines or in treating problems relative to the induction caused by superior harmonics of current of a »strong«-current line, it is necessary to consider the formation of waves. This is particularly necessary if it refers to lines of any great length, inasmuch as in this case there are generally several wave-lengths on the stretch of line.

For weightier reasons this holds good in respect of high-frequency telephony and the effects of induction of progressive waves.

It is also within the scope of the theory of progressive waves that the effects of induction have first been studied in a system of parallel lines without any particular condition of the current or tension on the lines.

In an article in the "Elektrotechnische Zeitschrift" of 1914, K. W. Wagner has established a system of equations relative to a system of parallel lines by assuming the resistance of the conductors as negligible and the coefficients of induction of the lines as proportional to the coefficients of electro static potential. As Wagner has demonstrated, we obtain in this instance a single common wave which is propagated towards increasing x for all the lines and even a common reflected wave.

In order to investigate more closely into the question concerning the mutual influence of parallel lines I have busied myself in a work, published in 1926 in the Journal of the Academy of Engineering Science in Stockholm, with the problem relating to the influence of a "strong"-current system upon the cable systems when the cable is placed in one or several cylindrical metallic sheaths. In this work the following theorem has been demonstrated:

If two systems of conductors A and B influence each other it is always possible when calculating the tensions and currents of system B , to substitute the influence of system A by electro-motive forces operating in the conductors of system B , these electro-motive forces being equal at each point to the force of the

electric field which produces the system A , if the conductivity of the conductors of system B were zero.

In the same work it has been demonstrated that in the case of parallel lines these fictitious electro-motive forces can be decomposed in a longitudinal electro-motive force equal to the electro-magnetic induction, another, also longitudinal, depending upon the drop in the tensions on the lines of system A , and a third longitudinal electro-motive force localised at the points where the lines of system B continue outside the lines of system A , these electro-motive forces being equal to the tension existing between the point in question and the earth resultant from system A . In transverse connections between the lines and the earth there are also electro-motive forces which equal the tension due to system A between the two extremities of the connection.

Assuming that all the currents are sinusoidal, we find moreover that it is possible to reduce the problem of a cable with several sheaths to a problem concerning a system of parallel wire conductors. In order to complete the theory it is necessary then to study a trifle more thoroughly how the tensions and currents act in a system of parallel lines united at their ends by net-works composed of resistances, inductances and capacities, if in these net-works there exist any electro-motive forces.

For a single line we obtain a system of equations of the form:

$$\begin{cases} v_o = Hi_o - Ai_s \\ v_s = Ai_o - Ki_s \end{cases}$$

where v_o and i_o are the tension and the current respectively at one of the ends of the line, and v_s and i_s the corresponding magnitudes at the other end. The coefficients H , A and K are independent of each other. If the line is symmetrical in respect of its central point we have:

$$H = K.$$

The fact that we have the same coefficient A in both equations is the reason why the reciprocal theorem is applicable to such a line, connected at the

ends by networks, allowing for resistances, inductances and capacities.

If the line is homogeneous and if we have introduced its characteristic impedance Z and its constant of propagation γ , we get, as we know:

$$\left\{ \begin{array}{l} H = Z \operatorname{ctgh} \gamma s \\ A = \frac{Z}{\sinh \gamma s} \end{array} \right\}$$

s being the length of the line.

In an article in the publications issued on the occasion of the inauguration of the new premises of the Royal University of Technology, in Stockholm, in the year 1917, the author presented a general study of the form which obtains the systems of equations between the tensions and currents at the ends of a system of parallel lines. The resistance, inductance, capacity and loss are assumed as being variable arbitrarily all along the line. The writer has found that the system of equations between the tensions and currents at the extremities of the lines may always be given under the formulae:

$$\left\{ \begin{array}{l} v_{mo} = \sum_{r=1}^n [H_{mr} i_{ro} - A_{mr} i_{rs}] \\ v_{ms} = \sum_{r=1}^n [A_{mr} i_{ro} - K_{mr} i_{rs}] \end{array} \right\}$$

Moreover we have here:

$$\begin{aligned} H_{mr} &= H_{rm} \\ K_{mr} &= K_{rm} \\ A_{mr} &= A_{rm} \end{aligned}$$

The similarity of structure between this system of equations and that of a single line is evident. In the aforesaid article the proprieties of the system of solutions were deduced immediately from the original system of equations without any knowledge of the functions H , A and K . It is in the nature of things that in these general cases it is impossible to determine these functions. The most important case, however, in practice is where the parallel lines are homogeneous. Being given the conformity of structure between the general system of solutions and that of a single line, it is probable that we are able in the case of homogeneous lines to express the constants H , A and K by characteristics and constants of propagation, in analogy with the case of a single line.

Thus our first task is to specify further the form of solutions in a system of homogeneous parallel lines.

General Theory.

In order to simplify the problem we select three lines. The resistances per length-unit are designated with r , the inductance with l , the mutual inductance with l_{mn} . The three lines, their constants, their currents and their tensions will be supplied by the indices 1, 2 and 3.

Let us furthermore designate the differential coefficient $\frac{d}{dt}$ by p and introduce:

$$\begin{aligned} z_{11} &= r_1 + pl_1 \\ z_{12} &= pl_{12} \\ &\dots \dots \dots \end{aligned}$$

and call x the distance from one of the terminals of the line.

We shall then have the system of equations:

$$\left\{ \begin{array}{l} -\frac{dv_1}{dx} = z_{11}i_1 + z_{12}i_2 + z_{13}i_3 \\ -\frac{dv_2}{dx} = z_{21}i_1 + z_{22}i_2 + z_{23}i_3 \\ -\frac{dv_3}{dx} = z_{31}i_1 + z_{32}i_2 + z_{33}i_3 \end{array} \right\} \dots \dots (1)$$

Here

$$z_{mn} = z_{nm}$$

In the following we shall call q the electric charge per length-unit of a line and a_{mn} the loss-coefficients of the line. The condition of continuity will therefore give the system of equations:

$$\left\{ \begin{array}{l} -\frac{di_1}{dx} = pq_1 + a_{11}v_1 + a_{12}v_2 + a_{13}v_3 \\ -\frac{di_2}{dx} = pq_2 + a_{21}v_1 + a_{22}v_2 + a_{23}v_3 \\ -\frac{di_3}{dx} = pq_3 + a_{31}v_1 + a_{32}v_2 + a_{33}v_3 \end{array} \right\} \dots \dots (2)$$

Note. The coefficients a_{mn} are not loss-coefficients in the ordinary sense of the word. Thus the loss-coefficient between line 1 and the earth is $a_{11} + a_{12} + a_{13}$, and the loss-coefficient between lines 1 2 is $-a_{13}$ etc. We are, however, able generally to write:

$$a_{mn} = a_{nm}$$

Since the distance between the lines is assumed slight in comparison with the wave-length, we are able to use Maxwell's formulae in the relation between the charges and tensions. We shall denominate the coefficients of capacity per length-unit of lines c_{mn} .

Assuming that the earth-potential is zero, we obtain the following system of equations:

$$\begin{cases} q_1 = c_{11}v_1 + c_{12}v_2 + c_{13}v_3 \\ q_2 = c_{21}v_1 + c_{22}v_2 + c_{23}v_3 \\ q_3 = c_{31}v_1 + c_{32}v_2 + c_{33}v_3 \end{cases}$$

If we introduce these expressions of the charges q into the system of equations (2) we get:

$$\begin{cases} -\frac{di_1}{dx} = (a_{11} + \rho c_{11})v_1 + (a_{12} + \rho c_{12})v_2 + (a_{13} + \rho c_{13})v_3 \\ -\frac{di_2}{dx} = (a_{21} + \rho c_{21})v_1 + (a_{22} + \rho c_{22})v_2 + (a_{23} + \rho c_{23})v_3 \\ -\frac{di_3}{dx} = (a_{31} + \rho c_{31})v_1 + (a_{32} + \rho c_{32})v_2 + (a_{33} + \rho c_{33})v_3 \end{cases}$$

From this system of equations we assume the tensions v resolved as functions of the differential coefficients $\frac{di_n}{dx}$

Consequently we get a system of equations thus:

$$\begin{cases} -v_1 = y_{11}\frac{di_1}{dx} + y_{12}\frac{di_2}{dx} + y_{13}\frac{di_3}{dx} \\ -v_2 = y_{21}\frac{di_1}{dx} + y_{22}\frac{di_2}{dx} + y_{23}\frac{di_3}{dx} \\ -v_3 = y_{31}\frac{di_1}{dx} + y_{32}\frac{di_2}{dx} + y_{33}\frac{di_3}{dx} \end{cases} \dots (3)$$

If the loss is negligible the coefficients are there converted into coefficients of potential of the lines divided by the operator ρ .

For determining the tensions and currents we have now the two systems of equations (1) and (2). In eliminating the tensions between these equations we shall, for determining the intensities, have the following system of equations where we are making use of the designation $D = \frac{d}{dx}$

$$\begin{cases} (y_{11}D^2 - z_{11})i_1 + (y_{12}D^2 - z_{12})i_2 + (y_{13}D^2 - z_{13})i_3 = 0 \\ (y_{21}D^2 - z_{21})i_1 + (y_{22}D^2 - z_{22})i_2 + (y_{23}D^2 - z_{23})i_3 = 0 \\ (y_{31}D^2 - z_{31})i_1 + (y_{32}D^2 - z_{32})i_2 + (y_{33}D^2 - z_{33})i_3 = 0 \end{cases} \dots (4)$$

Let us assume that the determinant equals zero and we shall have a system of equations which has three roots for D^2 . We call these roots

$$\gamma'^2, \gamma''^2 \text{ and } \gamma'''^2$$

To start with we assume that these roots are unequal. The solutions of the system of equations present themselves therefore under the forms:

$$Ae^{-\gamma'x}, Ae^{-\gamma''x}, Ae^{-\gamma'''x}, Ae^{\gamma'x}, Ae^{\gamma''x} \text{ and } Ae^{\gamma'''x}$$

Instead of selecting this forms we can introduce as independent solutions:

$$\begin{aligned} &A' \frac{\sinh \gamma'(s-x)}{\sinh \gamma's}, B' \frac{\sinh \gamma'x}{\sinh \gamma's}, A'' \frac{\sinh \gamma''(s-x)}{\sinh \gamma''s}, \\ &B'' \frac{\sinh \gamma''x}{\sinh \gamma''s}, A''' \frac{\sinh \gamma'''(s-x)}{\sinh \gamma'''s}, B''' \frac{\sinh \gamma'''x}{\sinh \gamma'''s} \end{aligned}$$

We can write the solutions under the formula:

$$i_n' = \xi_n' \left[i_o' \frac{\sinh \gamma'(s-x)}{\sinh \gamma's} + i_o' \frac{\sinh \gamma'x}{\sinh \gamma's} \right]$$

where the total embraces the three terms corresponding to the roots

$$\gamma', \gamma'' \text{ and } \gamma'''$$

The constants ξ_n' are not independent of each other. If we insert in the equations (4) the values obtained from i_n we get:

$$(y_{n2}\gamma'^2 - z_{n2})\xi_1' + (y_{n2}\gamma'^2 - z_{n2})\xi_2' + (y_{n3}\gamma'^2 - z_{n3})\xi_3' = 0 \dots (5)$$

We obtain the same system of equations for ξ_n'' and ξ_n''' ; it suffices to change γ' into γ'' and γ''' .

One of the equations being dependent on the others, another condition is necessary for determining completely the ξ_n' .

We assume:

$$\xi_1' + \xi_2' + \xi_3' = 1 \dots (6)$$

and likewise:

$$\begin{cases} \xi_1'' + \xi_2'' + \xi_3'' = 1 \\ \xi_1''' + \xi_2''' + \xi_3''' = 1 \end{cases} \dots (6')$$

It must be observed that the coefficients ξ_n are only dependent on the constants of the lines.

We are further introducing the following designations:

$$\begin{cases} U_n' = \gamma' [y_{n1}\xi_1' + y_{n2}\xi_2' + y_{n3}\xi_3'] \\ U_n'' = \gamma'' [y_{n1}\xi_1'' + y_{n2}\xi_2'' + y_{n3}\xi_3''] \\ U_n''' = \gamma''' [y_{n1}\xi_1''' + y_{n2}\xi_2''' + y_{n3}\xi_3'''] \end{cases} \dots (7)$$

In support of the system of equations (5) we are also able to write the equations which define the characteristics U_n as follows:

$$\begin{cases} \gamma' U_n' = z_{n1}\xi_1' + z_{n2}\xi_2' + z_{n3}\xi_3' \\ \gamma'' U_n'' = z_{n1}\xi_1'' + z_{n2}\xi_2'' + z_{n3}\xi_3'' \\ \gamma''' U_n''' = z_{n1}\xi_1''' + z_{n2}\xi_2''' + z_{n3}\xi_3''' \end{cases} \dots (8)$$

After having obtained the currents i_n we have immediately from the equations (3) the tensions v_n .

For v_n we obtain thus the following formula:

$$v_n = \sum \left\{ U_n' \left[i_o' \frac{\cosh \gamma'(s-x)}{\sinh \gamma's} - i_s' \frac{\cosh \gamma'x}{\sinh \gamma's} \right] \right\}$$

the total embraces the partial solutions belonging to γ' , γ'' and γ''' .

In the following we call *partial systems* the independent solutions corresponding to each of these three roots.

For γ' we thus obtain the following partial system:

$$\begin{cases} i_n' = \xi_n' \left[i_o' \frac{\sinh \gamma'(s-x)}{\sinh \gamma's} + i_s' \frac{\sinh \gamma'x}{\sinh \gamma's} \right] \\ v_n' = U_n' \left[i_o' \frac{\cosh \gamma'(s-x)}{\sinh \gamma's} - i_s' \frac{\cosh \gamma'x}{\sinh \gamma's} \right] \end{cases} \dots (10)$$

This system of equations is the one obtained for a single line, γ' being the constant of propagation and U_n the characteristic.

Thus we obtain as a rule as many constants of propagation γ as there are lines, and on each line we have consequently a current and a tension corresponding to each one of these constants of propagation.

Let us make the total of the currents i_n' and assume:

$$i' = i_1' + i_2' + i_3'$$

We obtain

$$i' = i_o' \frac{\sinh \gamma'(s-x)}{\sinh \gamma's} + i_s' \frac{\sinh \gamma'x}{\sinh \gamma's}$$

This equation shows that i_o' is the total of the partial currents belonging to γ' , at the end $x=0$ and i_s' the total of the currents at the extremity $x=s$.

We introduce further:

$$\begin{aligned} U' &= U_1' + U_2' + U_3' \\ v' &= v_1' + v_2' + v_3' \end{aligned}$$

Then v' is the total of the tensions appertaining to the partial system γ' .

We obtain:

$$v' = U' \left[i_o' \frac{\cosh \gamma'(s-x)}{\sinh \gamma's} - i_s' \frac{\cosh \gamma'x}{\sinh \gamma's} \right]$$

Consequently we introduce the significations:

$$\begin{aligned} \eta_n' &= \frac{U_n'}{U'} \\ \eta_n'' &= \frac{U_n''}{U''} \\ \eta_n''' &= \frac{U_n'''}{U'''} \end{aligned}$$

A mere glance at the formulae obtained shows that we have:

$$\begin{cases} i_n' = \xi_n' i' \\ v_n' = \eta_n' v' \end{cases} \dots \dots \dots (11)$$

and the corresponding formulae for the currents and tensions appertaining to the partial systems γ'' and γ''' .

These equivalents prove that:

in each partial system the relation between the intensities of the currents of the lines is constant and dependent only on the constants of the lines, and consequently independent of the length of the lines or dispositions which connect the ends of the lines. It is just the same as regards the tensions in the partial systems.

For the total current i' and the total tension v' we have obtained the system of equations:

$$\begin{cases} i' = i_o' \frac{\sinh \gamma'(s-x)}{\sinh \gamma's} + i_s' \frac{\sinh \gamma'x}{\sinh \gamma's} \\ v' = U' \left[i_o' \frac{\cosh \gamma'(s-x)}{\sinh \gamma's} - i_s' \frac{\cosh \gamma'x}{\sinh \gamma's} \right] \end{cases} \dots \dots (12)$$

The corresponding equations are to be obtained for the partial systems appertaining to γ'' and γ''' .

The above equalities are identical with those which are obtained in the case of a single line, if we assume that the characteristics of the line are U' and the constant of propagation γ' .

In this manner we find that:

in each partial system it is possible to look at the total of the currents i' and the total of the tensions v' as appertaining to a single line.

Consequently we may put the equations under all the forms employed in the case of a single line. Therefore we are able to write:

$$\begin{cases} v' = v_o' \frac{\sinh \gamma'(s-x)}{\sinh \gamma's} + v_s' \frac{\sinh \gamma'x}{\sinh \gamma's} \\ U' i' = v_o' \frac{\cosh \gamma'(s-x)}{\sinh \gamma's} - v_s' \frac{\cosh \gamma'x}{\sinh \gamma's} \end{cases}$$

and

$$\begin{cases} v_o' = v' \cosh \gamma'x + U' i' \sinh \gamma'x \\ U' i_o' = v' \sinh \gamma'x + U' i' \cosh \gamma'x \end{cases}$$

Here v_o' is the total of the tensions at the extremity $x=0$ and v_s' the corresponding tension at $x=s$.

The formulae (10) give us the individual currents and tensions of the lines expressed in the totals of currents at the extremities. Nevertheless for exceptional cases which we shall treat later on, it will be more suitable to introduce instead of the totals of

the currents at the extremities the corresponding individual currents.

We call the currents at the extremities of the line n , i_{no} and i_{ns} , and the corresponding tensions v_{no} and v_{ns} .

We introduce further the designations:

$$\begin{aligned} Z'_{mn} &= \gamma' y_{mn} \\ Z''_{mn} &= \gamma'' y_{mn} \\ Z'''_{mn} &= \gamma''' y_{mn} \end{aligned}$$

If we multiply the first of the equations (12) with ξ_n' and the last with η_n' we obtain:

$$\left\{ \begin{aligned} i_n' &= i'_{no} \frac{\sinh \gamma'(s-x)}{\sinh \gamma's} + i'_{ns} \frac{\sinh \gamma'x}{\sinh \gamma's} \\ v_n' &= U_n' \left[i'_{o'} \frac{\cosh \gamma'(s-x)}{\sinh \gamma's} - i'_{s'} \frac{\cosh \gamma'x}{\sinh \gamma's} \right] \end{aligned} \right\} \dots (13)$$

But we are able to write:

$$\begin{aligned} U_n' i_o' &= \gamma' [y_{n1} i_{1o}' + y_{n2} i_{2o}' + y_{n3} i_{3o}'] \\ U_n' i_s' &= \gamma' [y_{n1} i_{1s}' + y_{n2} i_{2s}' + y_{n3} i_{3s}'] \end{aligned}$$

or

$$\begin{aligned} U_n' i_o' &= Z'_{n1} i_{1o}' + Z'_{n2} i_{2o}' + Z'_{n3} i_{3o}' \\ U_n' i_s' &= Z'_{n1} i_{1s}' + Z'_{n2} i_{2s}' + Z'_{n3} i_{3s}' \end{aligned}$$

For one line we thus obtain the system of equations:

$$\begin{aligned} i_n' &= i'_{no} \frac{\sinh \gamma'(s-x)}{\sinh \gamma's} + i'_{ns} \frac{\sinh \gamma'x}{\sinh \gamma's} \\ v_n' &= [Z'_{n1} i_{1o}' + Z'_{n2} i_{2o}' + Z'_{n3} i_{3o}'] \frac{\cosh \gamma'(s-x)}{\sinh \gamma's} - \\ &\quad - [Z'_{n1} i_{1s}' + Z'_{n2} i_{2s}' + Z'_{n3} i_{3s}'] \frac{\cosh \gamma'x}{\sinh \gamma's} \end{aligned}$$

Conditions at the Ends of the Lines.

We have resolved to express the currents and tensions by the intensities of current at the ends of the lines. In order to have the solution complete it is further necessary to determine these currents by the conditions adhering by reason of the dispositions by which the lines are united between them and the earth at the points $x=0$ and $x=s$. We assume that consisting of resistances, inductances and capacities (or other lines) and also that there exist in these networks certain electro-motive forces.

To specify further we shall, however, assume that

there are electro-motive forces in the net-work at $x=0$ but not at $x=s$.

If we first consider the net-work at the end $x=0$, the currents and electro-motive forces in this net-work are connected with the tensions at the points where the net-work is connected with the lines, by homogeneous and linear equations obtained by means of Kirchhoff's Laws. By eliminating all the currents in the net-work, except those which circulate in the conductors connecting the net-work to our system of parallel lines, we get a system of equations thus:

$$E_n = b_{n1} i_{10} + b_{n2} i_{20} + b_{n3} i_{30} + v_{no}$$

E_n are linear homogeneous functions of the electro-motive forces of our net-work. It might be mentioned en passant that these E_n 's equal the tensions that would be obtained in our net-work at points of junction with the parallel lines, if these junctions were broken off.

A corresponding system of equations is obtained for the net-work connecting the lines at $x=s$. Having assumed that there are no electro-motive forces in this net-work, we are able to write:

$$v_{ns} = d_{n1} i_{1s} + d_{n2} i_{2s} + d_{n3} i_{3s}$$

We introduce into the equations which stand for the net-work at point $x=0$ the following expressions:

$$\left\{ \begin{aligned} i_{no} &= \xi_n' i_o' + \xi_n'' i_o'' + \xi_n''' i_o''' \\ v_{no} &= \eta_n' v_o' + \eta_n'' v_o'' + \eta_n''' v_o''' \end{aligned} \right\}$$

We thus obtain three linear and homogeneous equations of the electro-motive forces, total currents and total tensions at the ends of the lines in $x=0$. From these three equations we are generally able to determine the tensions v_o' , v_o'' and v_o''' as functions of the electromotive forces and currents.

We are therefore able to write:

$$\left\{ \begin{aligned} E' &= g_a' i_o' + g_a'' i_o'' + g_a''' i_o''' + v_o' \\ E'' &= g_b' i_o' + g_b'' i_o'' + g_b''' i_o''' + v_o'' \\ E''' &= g_c' i_o' + g_c'' i_o'' + g_c''' i_o''' + v_o''' \end{aligned} \right\}$$

Here the index a coincides with the partial system γ' , b with the partial system γ'' and c with the partial system γ''' .

The electro-motive forces E' , E'' and E''' are homogeneous and linear functions of the electro-motive forces assumed in the net-work, at the end $x=0$.

On the other hand if we assume that $x = o$ in the equations (12), we get:

$$v_o' = U' \left[i_o' \operatorname{ctgh} \gamma' s - i_s' \frac{1}{\sinh \gamma' s} \right]$$

and corresponding equalities for v_o'' and v_o''' .

If we then substitute these tension values in the equations above, we get finally:

$$\begin{cases} E' = [g_a' + U' \operatorname{ctgh} \gamma' s] i_o' + g_a'' i_o'' + g_a''' i_o''' - i_s' \frac{U'}{\sinh \gamma' s} \\ E'' = g_b' i_o' + [g_b'' + U'' \operatorname{ctgh} \gamma'' s] i_o'' + g_b''' i_o''' - i_s'' \frac{U''}{\sinh \gamma'' s} \\ E''' = g_c' i_o' + g_c'' i_o'' + [g_c''' + U''' \operatorname{ctgh} \gamma''' s] i_o''' - i_s''' \frac{U'''}{\sinh \gamma''' s} \end{cases}$$

At the end $x = s$ we are able to write:

$$\begin{cases} v_s' = h_a' i_s' + h_a'' i_s'' + h_a''' i_s''' \\ v_s'' = h_b' i_s' + h_b'' i_s'' + h_b''' i_s''' \\ v_s''' = h_c' i_s' + h_c'' i_s'' + h_c''' i_s''' \end{cases}$$

where the coefficients h have been formed in the same manner as previously the coefficients g .

By inserting $x = s$ in the equations (12) we obtain:

$$v_s' = U' \left[\frac{i_o'}{\sinh \gamma' s} - i_s' \operatorname{ctgh} \gamma' s \right]$$

and corresponding equivalents for v_o'' and v_o''' .

By eliminating the tensions between the two systems of equation thus obtained we get at the end $x = s$ the following conditions:

$$\begin{cases} \frac{U'}{\sinh \gamma' s} i_o' = [h_a' + U' \operatorname{ctgh} \gamma' s] i_s' + h_a'' i_s'' + h_a''' i_s''' \\ \frac{U''}{\sinh \gamma'' s} i_o'' = h_b' i_s' + [h_b'' + U'' \operatorname{ctgh} \gamma'' s] i_s'' + h_b''' i_s''' \\ \frac{U'''}{\sinh \gamma''' s} i_o''' = h_c' i_s' + h_c'' i_s'' + [h_c''' + U''' \operatorname{ctgh} \gamma''' s] i_s''' \end{cases}$$

As the result of existing conditions at $x = o$ and $x = s$ we have therefore obtained six equations which connect the six currents at the ends of the lines and the electro-motive forces in the net-work. From the six equations thus obtained we are able to determine the intensities $i_o', i_o'', i_o''', i_s', i_s''$ and i_s''' , which then present themselves as linear and homogeneous functions of the electro-motive forces. The currents and tensions at the arbitrary points of the system of lines can therefore be determined from the systems of equations (11) and (12).

A glance at the solutions obtained will show us:

our general problem is reduced to a problem concerning three homogeneous lines which do not affect each other. The constants of propagation of these lines are γ', γ'' and γ''' and their characteristics U', U'' and U''' . The currents and tensions on these three fictitious lines are the totals of the individual currents and tensions in the partial system. The fictitious lines are joined at the ends by net-works containing electro-motive forces, and in which the impedances g_a, g_b, g_c, h_a, h_b and h_c are obtained by knowing the coefficients ξ and η .

For practical calculations it is, however, convenient to place the equations at the ends under another form.

In the equation:

$$E_n = b_{n1} i_{10} + b_{n2} i_{20} + b_{n3} i_{30} + v_{no}$$

we introduce:

$$i_{no} = \xi_n' i_o' + \xi_n'' i_o'' + \xi_n''' i_o'''.$$

We find:

$$E_n = g_n' i_o' + g_n'' i_o'' + g_n''' i_o''' + v_{no}$$

where

$$\begin{cases} g_n' = b_{n1} \xi_1' + b_{n2} \xi_2' + b_{n3} \xi_3' \\ g_n'' = b_{n1} \xi_1'' + b_{n2} \xi_2'' + b_{n3} \xi_3'' \\ g_n''' = b_{n1} \xi_1''' + b_{n2} \xi_2''' + b_{n3} \xi_3''' \end{cases} \dots (15)$$

On the other hand if we assume $x = o$ in the equation (13) we get:

$$v_{no} = \sum \left\{ U_n' \left[i_o' \operatorname{ctgh} \gamma' s - i_s' \frac{1}{\sinh \gamma' s} \right] \right\}$$

the total being extended to all the partial systems.

Substituting therefore the values v_{no} in the above equation we get finally:

$$E_n = \sum [U_n' \operatorname{ctgh} \gamma' s + g_n'] i_o' - \sum \left[U_n' i_s' \frac{1}{\sinh \gamma' s} \right] (16)$$

For the extremity $x = s$ we obtain corresponding equivalents. If h_n', h_n'' and h_n''' are the coefficients corresponding to g_n', g_n'' and g_n''' respectively, we get for the net-work at $x = s'$:

$$\sum U_n' i_o' \frac{1}{\sinh \gamma' s} = \sum [U_n' \operatorname{ctgh} \gamma' s + h_n'] i_s' \dots (17)$$

The solution of our problem is therefore presented by the following formulae:

$$\left\{ \begin{aligned} i_n &= \sum \left\{ \xi_n' \left[i_o' \frac{\sinh \gamma' (s-x)}{\sinh \gamma' s} + i_s' \frac{\sinh \gamma' x}{\sinh \gamma' s} \right] \right\} \\ v_n &= \sum \left\{ U_n' \left[i_o' \frac{\cosh \gamma' (s-x)}{\sinh \gamma' s} - i_s' \frac{\cosh \gamma' x}{\sinh \gamma' s} \right] \right\} \\ E_n &= \sum [U_n' \operatorname{ctgh} \gamma' s + g_n'] i_o' - \sum U_n' i_s' \frac{1}{\sinh \gamma' s} \\ \sum U_n' i_o' \frac{1}{\sinh \gamma' s} &= \sum [U_n' \operatorname{ctgh} \gamma' s + h_n'] i_s' \end{aligned} \right. \quad (18)$$

The totals are extended upon all the partial systems.

The constants ξ_n and U_n appertaining to the partial system are determined by the equations:

$$\left\{ \begin{aligned} \xi_1' + \xi_2' + \xi_3' &= 1 \\ (y_{n1} \gamma'^2 - z_{n1}) \xi_1' + (y_{n2} \gamma'^2 - z_{n2}) \xi_2' + \dots & \\ (y_{n3} \gamma'^2 - z_{n3}) \xi_3' &= 0 \dots \dots \dots \end{aligned} \right. \quad (19)$$

$$U_n' = \gamma' [y_{n1} \xi_1' + y_{n2} \xi_2' + z_{n3} \xi_3'] \dots \quad (20)$$

The coefficients g_n and h_n are given by the following formulae:

$$\left\{ \begin{aligned} g_n' &= b_{n1} \xi_1' + b_{n2} \xi_2' + b_{n3} \xi_3' \\ h_n' &= d_{n1} \xi_1' + d_{n2} \xi_2' + d_{n3} \xi_3' \end{aligned} \right. \dots \quad (21)$$

The conditions at the ends are supposed to be of the form:

$$\left\{ \begin{aligned} E_n &= b_{n1} i_{10} + b_{n2} i_{20} + b_{n3} i_{30} + v_{n0} \\ v_{n3} &= d_{n1} i_{10} + d_{n2} i_{20} + d_{n3} i_{30} \end{aligned} \right\}$$

In the preceding we have assumed that the three roots γ' , γ'' and γ''' are unequal.

If the direct coupling between the lines is weak the three roots become almost equal at $\frac{z_{11}}{y_{11}}$, $\frac{z_{22}}{y_{22}}$ and $\frac{z_{33}}{y_{33}}$. Then ξ_1' , ξ_2'' and ξ_3''' approximate unity and the other coefficients ξ become very small. Each line therefore gets its own partial system.

If the coupling between the lines by the network is weak, even an electro-motive force directly applied to one of our lines does not produce in all the lines any currents but those appertaining to the partial system of the line with the electromotive force.

Exceptional Cases. *

The general theory is not directly applicable if we are able to extract from the system of equations between the coefficients ξ_n the relation:

$$\xi_1 + \xi_2 + \xi_3 = 0$$

or if two or more of our roots are equal.

In the first instance we shall study the case in which we have for one of the constants of propagation, e. g. γ' , the relation:

$$\xi_1' + \xi_2' + \xi_3' = 0$$

Consequently we can no more assume:

$$\xi_1' + \xi_2' + \xi_3' = 1$$

and there remain only two equations between the ξ_1' , ξ_2' and ξ_3' . The equations which exist are two of the equations containing ξ_n' (5). One of these equations may be substituted by the equation:

$$\xi_1' + \xi_2' + \xi_3' = 0$$

By multiplying the equations (5) by i' and putting

$$i_n' = \xi_n' i'$$

we get two homogeneous and linear equations between the currents, i_1' , i_2' and i_3' . We obtain these equations directly by replacing the ξ_n' with the i_n . Therefore we are able to make all the calculations with the equations at the ξ_n' and from the calculations made we can substitute the ξ_n' by the currents i_n' . We thus get two homogeneous and linear equations between the currents i_1' , i_2' and i_3' . One of these equations may be substituted by the equation:

$$i_1' + i_2' + i_3' = 0.$$

The total of the currents being zero it naturally follows that we cannot make use of the system of equations (12). Instead of these equations we take the equations (14) which give the individual currents and tensions of the lines. At each end we shall thus have to determine three currents instead of one, and consequently we must have two more relations between our currents. These relations are obtained, as we have stated hereabove, by the system of equations connect-

*) In a work to follow we shall prove that all exceptional cases can be avoided by introducing in the general theory instead of the relations (6) and (6') $\xi_1 = 1$, $\xi_2 = 1$ and $\xi_3 = 1$. If we have a multiple root of the order m we find that m of the ξ become independent. It is convenient to put all these ξ equal to nought except one which we put equal to one. When putting different independent ξ equal to one we obtain m fictive lines with the same constant of propagation.

ing the coefficients ξ_n' or the currents i_n' . These equations gives us two homogeneous and linear relations between the currents. As we have stated previously, one of these equations can be substituted by the equivalent:

$$i_1' + i_2' + i_3' = 0$$

In support of these relations we can always express two of the currents by the third.

Hence the system of equations (14) can be written under the following form:

$$i_n' = i_{n_0}' \frac{\sinh \gamma'(s-x)}{\sinh \gamma's} + i_{n_3}' \frac{\sinh \gamma'x}{\sinh \gamma's}$$

$$v_n' = Z_n' \left[i_{n_0}' \frac{\cosh \gamma'(s-x)}{\sinh \gamma's} - i_{n_3}' \frac{\cosh \gamma'x}{\sinh \gamma's} \right]$$

For each line we obtain another system of equations of the same form as for a single line.

If there is any symetry between our lines it may happen that the Z_n' become all equal, and we then get a system of equations common to the lines.

Another case in which the general theory is not directly applicable is when our determinant has two or more equal roots.

If, for example, we have a multiple root of the order m , m of our equations between the coefficients ξ_n' become dependent on the others and it is no longer possible to determine the ξ_n' corresponding to this root. Hence, as in the preceding instance, the solutions must be employed under the form (14) where there enter the individual currents of the lines instead of the total current.

Nevertheless, on account of the supposition that m roots are equal, the Z_{mn} corresponding to the equal roots become also equal. The result therefore is that all the appurtenant solutions (14) to the equal roots are identical and consequently we are able to look upon all the partial systems corresponding to the equal roots as a partial system.

If we have p lines we get thus p individual currents appurtenant to this partial system.

The unequal roots give us at each end $p-m$ unknown currents; that is the reason why we have to determine $2p-m$ currents at each end. Between the currents corresponding to the multiple root there exist, however, as we have found here-above, $p-m$ relations which are homogeneous and linear. Therefore there remain to us unknown p currents.

It follows that at each end of the lines the number of unknown currents always becomes the same as in

the general case. These currents become completely determined by the p equations which supply at each end the net-works which connect the lines.

To be precise we shall assume that γ' is a multiple root of the order m , and that the other roots $\gamma'', \gamma''', \dots$ are simple ones.

We then introduce into the partial system γ' the individual currents and tensions of the lines.

In the system of equations (13) we substitute therefore $U_n' i_o'$ and $U_n' i_s'$ by the following expressions:

$$\begin{cases} U_n' i_o' = Z_{n_1}' i_{1_0}' + Z_{n_2}' i_{2_0}' + Z_{n_3}' i_{3_0}' + \dots \\ U_n' i_s' = Z_{n_1}' i_{1_s}' + Z_{n_2}' i_{2_s}' + Z_{n_3}' i_{3_s}' + \dots \end{cases}$$

We effect the same substitution in the equation (16) and we insert furthermore:

$$\begin{cases} g_n' i_o' = b_{n_1} i_{1_0}' + b_{n_2} i_{2_0}' + \dots \\ g_n' i_s' = b_{n_1} i_{1_s}' + b_{n_2} i_{2_s}' + \dots \end{cases}$$

Hence the equation (16) can be written in the following manner:

$$E_n = [Z_{n_1}' \text{ctgh } \gamma's + b_{n_1}] i_{1_0}' + [Z_{n_2}' \text{ctgh } \gamma's + b_{n_2}] i_{2_0}' + \dots + [U_n'' \text{ctgh } \gamma''s + g_n''] i_o'' + [U_n''' \text{ctgh } \gamma'''s + g_n'''] i_o''' + \dots - \frac{Z_{n_1}'}{\sinh \gamma's} i_{1_s}' - \frac{Z_{n_2}'}{\sinh \gamma's} i_{2_s}' - \dots - \frac{U_n''}{\sinh \gamma''s} i_s'' - \frac{U_n'''}{\sinh \gamma'''s} i_s''' - \dots$$

Between the currents i_1', i_2', \dots we shall get $p-m$ homogeneous and linear relations, if p is the number of lines. These relations are rendered by the system of equations (5) where we substitute the i_n' for the ξ_n' . Then we are able to eliminate $p-m$ of these currents. The result of this is that the number of independant currents considered at each end and appertaining to the partial system γ' is the same as the degree of multiplicity of the root γ'^2 .

After having thus selected the independent m currents of the partial system γ' the other currents of the lines in this system are generally obtained as homogeneous and linear functions of these m currents. In the same way we find that the tensions of the individual lines become homogeneous and linear functions of the independent currents at the ends.

We obtain m independent tensions, and the other tensions are obtained as homogeneous and linear functions of these m tensions.

Consequently we find that:
when there are any multiple roots it is impossible

as a rule to obtain the equations of the currents and tensions of the partial system corresponding to that root under the same form as that which holds good for a single line.

If the parallel lines are situated symmetrically in agreement with one another, it may happen that the total of the coefficients forming a column in our system of equations containing ξ' become all equal. This is for example the case when all the lines are equal and are in the same position to each other, or when the parallel lines form a cable of double lines or a cable of quadruple lines, both being perfectly balanced.

If in such a case we total up the equations we get an expression of the following form:

$$(a\gamma^2 - b)[\xi_1 + \xi_2 + \dots] = 0$$

This equation shows us that there is a simple root which is rendered by the relation:

$$\gamma'^2 = \frac{b}{a}$$

The determinant being symmetrical, the total of the coefficients in each equation gives us also:

$$a\gamma^2 - b$$

Hence the result is that in this partial system appertaining to γ'' all the ξ_n'' are equal.

The total of these ξ_n'' should, however, be equal to the unit. Then we get:

$$\xi_1'' = \xi_2'' = \xi_3'' = \dots = \frac{1}{p}$$

where p is the number of lines.

For the other constants of propagation γ' we get:

$$a\gamma^2 - b \geq 0$$

Consequently for all the partial systems we have with the exception of γ'' :

$$\xi_1 + \xi_2 + \xi_3 + \dots = 0$$

or

$$i_1' + i_2' + i_3' + \dots = 0$$

$$i_1'' + i_2'' + i_3'' + \dots = 0$$

We find therefore:

If all the columns in the system of equations for the coefficients ξ_n render the same total, we find that there is a partial system in which the currents in all the lines are equal, and that in the other partial systems the total of the currents of the lines is equal to zero.

After these preliminary observations we shall apply to certain special cases what we have found.

A Properly Balanced Cable of Quadruple Conductors.

Let us assume that there are $\frac{p}{4}$ quarter or p conductors in the cable.

All the conductors being equal we shall designate with y and z respectively the coefficients y_{mm} and z_{mm} . We call y' and z' the corresponding coefficients between two conductors which are closest to each other in one and the same quarter, and y'' and z'' the mutual coefficients of two diagonal conductors. We shall designate by y''' and z''' respectively the mutual coefficients between two conductors belonging to different quarters.

For abbreviating the formulae we shall use for the moment the following designations:

$$\begin{aligned} y\gamma^2 - z &= h \\ y'\gamma^2 - z' &= h' \\ y''\gamma^2 - z'' &= h'' \\ y'''\gamma^2 - z''' &= h''' \end{aligned}$$

Hence we are able to write the equations between our ξ_n in the following manner:

$$\left\{ \begin{aligned} h\xi_1 + h'\xi_2 + h''\xi_3 + h'''\xi_4 + h''[\xi_5 + \xi_6 + \dots] &= 0 \\ h'\xi_1 + h\xi_2 + h''\xi_3 + h'''\xi_4 + h''[\xi_5 + \xi_6 + \dots] &= 0 \\ h''\xi_1 + h'\xi_2 + h\xi_3 + h'''\xi_4 + h''[\xi_5 + \xi_6 + \dots] &= 0 \\ h'''\xi_1 + h''\xi_2 + h'\xi_3 + h\xi_4 + h''[\xi_5 + \xi_6 + \dots] &= 0 \\ h''[\xi_1 + \xi_2 + \xi_3 + \xi_4 + \xi_5 + \dots] + h\xi_5 + h'\xi_6 + & \\ \quad + h''\xi_7 + h'''\xi_8 + \dots &= 0 \\ \dots & \dots \end{aligned} \right.$$

These p equations can be substituted by the following:

$$\left\{ \begin{aligned} (h - h'')[\xi_1 - \xi_3] &= 0 \\ (h - h'')[\xi_2 - \xi_4] &= 0 \\ (h - h'')[\xi_5 - \xi_7] &= 0 \\ (h - h'')[\xi_6 - \xi_8] &= 0 \end{aligned} \right\} \frac{p}{2} \text{ equations}$$

$$\left\{ \begin{aligned} (h - h' + h'' - h''')[\xi_1 - \xi_2 + \xi_3 - \xi_4] &= 0 \\ (h - h' + h'' - h''')[\xi_5 - \xi_6 + \xi_7 - \xi_8] &= 0 \end{aligned} \right\} 4 \text{ equations}$$

$$\left\{ \begin{aligned} (h + h' + h'' + h''' - 4h''')[\xi_1 + \xi_2 + \xi_3 + \xi_4 - (\xi_5 + \xi_6 + \xi_7 + \xi_8)] &= 0 \\ (h + h' + h'' + h''' - 4h''')[\xi_5 + \xi_6 + \xi_7 + \xi_8 - (\xi_9 + \xi_{10} + \xi_{11} + \xi_{12})] &= 0 \end{aligned} \right\} \frac{p-1}{4} \text{ equations}$$

$$(h + h' + h'' + h''' + (p-4)h''')[\xi_1 + \xi_2 + \dots + \xi_p] = 0$$

one equation.

These equations show that we have four different roots γ' , γ'' , γ''' and γ'''' γ' rendered by the equation:

$$h - h'' = 0$$

is a multiple root of order $\frac{p}{2}$.

We find γ'' by the equation:

$$h - h' + h'' - h' = 0$$

This root has the degree of multiplicity $\frac{p}{4}$.

γ''' is rendered by the following equivalent:

$$h + h' + h'' + h' - 4 h''' = 0$$

The degree of multiplicity of this root is $\frac{p}{4} - 1$.

Then we find the root γ'''' , which is rendered by the relation:

$$h + h' + h'' + h' + (p - 4)h'''' = 0.$$

This is a simple root.

Thus we have four constants of propagation.

Now we have to determine the relations existing between the ξ_n or between the currents in the four partial systems.

Partial System γ' .

The root being of the order $\frac{p}{2}$, there are $\frac{p}{2}$ relations between the ξ_n' .

We find

$$\begin{aligned} \xi_1' + \xi_3' &= 0 \\ \xi_2' + \xi_4' &= 0 \\ \xi_5' + \xi_7' &= 0 \\ \xi_6' + \xi_8' &= 0 \\ &\dots \end{aligned}$$

or

$$\begin{aligned} i_1' &= -i_3' \\ i_2' &= -i_4' \\ i_5' &= -i_7' \\ &\dots \end{aligned}$$

In this partial system the diagonal currents of each quarter are equal, but the signs contrary.

Partial System γ'' .

The multiple of the root being of the order $\frac{p}{4}$, there are $\frac{3p}{4}$ independent relations between the ξ_n''

We find directly:

$$\begin{aligned} \xi_1'' &= -\xi_2'' = \xi_3'' = -\xi_4'' \\ \xi_5'' &= -\xi_6'' = \xi_7'' = -\xi_8'' \\ &\dots \end{aligned}$$

In the partial system appertaining to the constant of propagation γ'' the total of the currents in each quarter is therefore zero, and the currents on the diagonal conductors are equal and of the same sign

Partial System γ''' .

There exist $p - \left(\frac{p}{4} - 1\right)$ relations between the coefficients ξ_n''' . These relations give us:

$$\begin{aligned} \xi_1''' &= \xi_2''' = \xi_3''' = \xi_4''' \\ \xi_5''' &= \xi_6''' = \xi_7''' = \xi_8''' \end{aligned}$$

and furthermore:

$$\sum \xi_n''' = 0$$

All the currents are equal in each quarter and directed in the same sense. The total of all the currents in the cable is zero.

Partial System γ'''' .

We have $p - 1$ equivalents between the coefficients ξ_n'''' . These equivalents render:

$$\xi_1'''' = \xi_2'''' = \xi_3'''' = \dots = \xi_p''''$$

As in this partial system the total of the currents is not zero we are able to introduce the relation:

$$\xi_1'''' + \xi_2'''' + \dots + \xi_p'''' = 1$$

whence we obtain:

$$\xi_1'''' = \xi_2'''' = \dots = \xi_p'''' = \frac{1}{p}$$

In this partial system all the currents are equal and of the same direction.

Now we shall determine the characteristics in the different partial systems.

By reason of the symetry it is sufficient to make the calculations for one of the lines, and we are choosing the line designated by the index 1.

We introduce the following designations:

$$\begin{aligned} \gamma' y &= Z_1' = Z_{11}' = Z_{22}' = \dots \\ \gamma' y' &= Z_2' = Z_{12}' = Z_{23}' = \dots \\ \gamma' y'' &= Z_3' = Z_{13}' = Z_{24}' = \dots \\ \gamma' y''' &= Z_5' = Z_{15}' = Z_{16}' = \dots \\ \gamma'' y &= Z_1'' = Z_{11}'' = Z_{22}'' = \dots \\ \gamma'' y' &= Z_2'' = Z_{12}'' = Z_{23}'' = \dots \end{aligned}$$

In the formula which gives us the partial tension of line 1 we have two homogeneous and linear expressions in the currents at the ends of the lines. As we have found, one of these expressions has the form:

$$Z_{11}i_{10} + Z_{12}i_{20} + \dots + Z_{1p}i_{p0}$$

and we obtain the other by substituting for the currents i_{no} the currents i_{ns} .

We put for the moment:

$$Hi_{10} = Z_{11}i_{10} + Z_{12}i_{20} + \dots + Z_{1p}i_{p0}$$

In the partial system γ' we obtain:

$$H'i_{10}' = Z_1'i_{10}' + Z_2'i_{20}' + Z_3'i_{30}' + Z_2'i_{40}' + Z_5'(i_{50}' + \dots)$$

In consequence of the equalities we have found between the currents in this partial system the result is:

$$H' = Z_1' - Z_3'$$

In the same way we obtain in the partial system γ'' :

$$H'' = Z_1'' - 2Z_2'' + Z_3''$$

and in the partial system γ''' :

$$H''' = Z_1''' + 2Z_2''' + Z_3''' - 4Z_5'''$$

Finally the total of the currents in the system γ''' not being zero, we must in this partial system determine U_1 .

We find:

$$U_1''' = \frac{1}{p} [Z_1''' + 2Z_2''' + Z_3 + (p-4)Z_5''']$$

For H_1''' we get:

$$H_1''' = Z_1''' + 2Z_2''' + Z_3''' + (p-4)Z_5'''$$

Now that the H have been determined we can write the solutions directly. We find:

$$\left\{ \begin{aligned} i_n' &= i_{no}' \frac{\sinh \gamma'(s-x)}{\sinh \gamma's} + i_{ns}' \frac{\sinh \gamma'x}{\sinh \gamma's} \\ v_n' &= H' \left[i_{no}' \frac{\cosh \gamma'(s-x)}{\sinh \gamma's} - i_{ns}' \frac{\cosh \gamma'x}{\sinh \gamma's} \right] \end{aligned} \right\}$$

$$\left\{ \begin{aligned} i_n'' &= i_{no}'' \frac{\sinh \gamma''(s-x)}{\sinh \gamma''s} + i_{ns}'' \frac{\sinh \gamma''x}{\sinh \gamma''s} \\ v_n'' &= H'' \left[i_{no}'' \frac{\cosh \gamma''(s-x)}{\sinh \gamma''s} - i_{ns}'' \frac{\cosh \gamma''x}{\sinh \gamma''s} \right] \end{aligned} \right\}$$

and thus in succession.

We have found above that the currents on the lines in a partial system are not independent of each other. As independent currents we can select the following:

In the partial system γ' :

$$i_1', i_2', i_5', i_6', \dots$$

In the partial system γ'' :

$$i_1'', i_5'', i_9'', \dots$$

In the partial system γ''' :

$$i_1''', i_5''', i_9''', \dots$$

Nevertheless one of these currents is dependent on the others in virtue of the relation:

$$i_1''' + i_5''' + i_9''' + \dots = 0$$

In the partial system γ'''' :

$$i_1''''$$

Now the conditions at the end $y=0$ can be written:

$$\begin{aligned} E_n &= i_{10}'(b_{n1} - b_{n3}) + i_{20}'(b_{n2} - b_{n4}) + i_{50}'(b_{n5} - \\ &\quad - b_{n7}) + \dots + \\ &+ i_{10}''(b_{n1} - b_{n2} + b_{n3} - b_{n4}) + i_{50}''(b_{n5} - b_{n6} + \\ &\quad + b_{n7} - b_{n8}) + \dots + \\ &+ i_{10}'''(b_{n1} + b_{n2} + b_{n3} + b_{n4}) + i_{50}'''(b_{n5} + b_{n6} + \\ &\quad + b_{n7} + b_{n8}) + \dots + \\ &+ i_{10}''''(b_{n1} + b_{n2} + \dots + b_{np}) + \\ &+ H' \operatorname{ctgh} \gamma's \cdot i_{no}' - H' \frac{1}{\sinh \gamma's} \cdot i_{ns} + \dots \end{aligned}$$

At the end $x=s$ we obtain a similar system of equations.

If the currents i_{no}', i_{no}'' are not of those we have chosen as independent currents we must substitute them by currents of this latter category.

The Currents of Certain Lines in the System fulfil the Condition:

$$\frac{z_{mn}}{y_{mn}} = u^2$$

The fact that certain lines fulfil the relations:

$$\frac{z_{mn}}{y_{mn}} = u^2$$

indicates that we have assumed that these lines are perfect conductors and that the same is the case with the earth.

We assume here that the number of parallel lines is three, and that two of them fulfil the above conditions.

In that case we have:

$$\frac{z_{21}}{y_{21}} = \frac{z_{22}}{y_{22}} = \frac{z_{23}}{y_{23}} = \frac{z_{31}}{y_{31}} = \frac{z_{32}}{y_{32}} = \frac{z_{33}}{y_{33}} = u^2$$

The system of equations between the coefficients ξ_n now assumes the form:

$$\begin{cases} (y_{11}\gamma^2 - z_{11})\xi_1 + y_{12}(\gamma^2 - u^2)\xi_2 + y_{13}(\gamma^2 - u^2)\xi_3 = 0 \\ y_{21}(\gamma^2 - u^2)\xi_1 + (y_{22}\gamma^2 - z_{22})\xi_2 + y_{23}(\gamma^2 - u^2)\xi_3 = 0 \\ y_{31}(\gamma^2 - u^2)\xi_1 + y_{32}(\gamma^2 - u^2)\xi_2 + (y_{33}\gamma^2 - z_{33})\xi_3 = 0 \end{cases}$$

The determinant gives us a simple root γ'^2 and a double root $\gamma^2 = u^2$. We therefore obtain two parallel systems.

As we have seen in the general case, the constant of propagation γ' gives us a partial system in which the total current of the lines is distributed over the lines in the proportions ξ_n' , which only depend upon the kilometric constants of the lines. The coefficients ξ_n' are obtained by two of the above equations by putting $\gamma = \gamma'$ and by the equality:

$$\xi_1' + \xi_2' + \xi_3' = 1$$

If i' is the total of all the currents on the lines in system γ' , we find the individual currents of the lines by the relations:

$$\begin{aligned} i_1' &= \xi_1' i' \\ i_2' &= \xi_2' i' \\ i_3' &= \xi_3' i' \end{aligned}$$

Moreover we have:

$$v_n = U_n' \left[i_0' \frac{\cosh \gamma'(s-x)}{\sinh \gamma' s} - i_s' \frac{\cosh \gamma' x}{\sinh \gamma' s} \right]$$

where

$$U_n' = \gamma' [y_{n1}\xi_1' + y_{n2}\xi_2' + y_{n3}\xi_3']$$

But the last two equations in ξ_n' give us:

$$\begin{aligned} y_{21}\xi_1' + y_{22}\xi_2' + y_{23}\xi_3' &= 0 \\ y_{31}\xi_1' + y_{32}\xi_2' + y_{33}\xi_3' &= 0 \end{aligned}$$

Consequently we have:

$$U_2' = U_3' = 0$$

and consequently:

$$v_2' = v_3' = 0$$

We thus find that:

in the partial system γ' the tensions are always equal to zero on the lines 2 and 3, i. e. on the lines which fulfil the conditions of being perfect conductors.

On these lines there are currents, but no tensions.

The root $\gamma'^2 = u^2$ being a double root, two of the relations between the ξ_n'' become dependent on the others. Thus we have only one independent equation left, to know:

$$(y_{11}\gamma'^2 - z_{11})\xi_1'' + y_{12}(\gamma'^2 - u^2)\xi_2'' + y_{13}(\gamma'^2 - u^2)\xi_3'' = 0$$

As we have:

$$\gamma'^2 = u^2$$

the two last terms disappear.

Hence we obtain:

$$\xi_1'' = 0$$

or

$$i_1'' = 0$$

The currents appertaining to the partial system corresponding to the multiple root must always become zero on the lines which do not fulfil the condition:

$$\frac{z_{mn}}{y_{mn}} = u^2$$

We have as many relations between the currents as there are lines which fulfil the above conditions. The currents on the lines become equal to zero. Consequently all the currents on the lines which fulfil the aforesaid conditions are independent of each other. Thus in our example the currents i_2'' and i_3'' are independent.

For obtaining the tensions v_n'' we must then substitute in the general formulae:

$$U_n'' i_0'' \text{ par } Z_{n2} i_{20}'' + Z_{n3} i_{30}''$$

and

$$U_n'' i_s'' \text{ par } Z_{n2} i_{2s}'' + Z_{n3} i_{3s}''$$

Now we are able to write directly the equations

which supply the solution of our problem. From what we have ascertained in the preceding we get:

$$\left\{ \begin{aligned} i_1 &= \xi_1' \left[i_0' \frac{\sinh \gamma'(s-x)}{\sinh \gamma's} + i_s' \frac{\sinh \gamma'x}{\sinh \gamma's} \right] \\ i_2 &= \xi_2' \left[i_0' \frac{\sinh \gamma'(s-x)}{\sinh \gamma's} + i_s' \frac{\sinh \gamma'x}{\sinh \gamma's} \right] + \\ &\quad + i_{20}'' \frac{\sinh \gamma''(s-x)}{\sinh \gamma's} + i_{2s}'' \frac{\sinh \gamma''x}{\sinh \gamma's} \\ i_3 &= \xi_3' \left[i_0' \frac{\sinh \gamma'(s-x)}{\sinh \gamma's} + i_s' \frac{\sinh \gamma'x}{\sinh \gamma's} \right] + \\ &\quad + i_{30}'' \frac{\sinh \gamma''(s-x)}{\sinh \gamma's} + i_{3s}'' \frac{\sinh \gamma''x}{\sinh \gamma's} \end{aligned} \right\}$$

$$\left\{ \begin{aligned} v_1 &= U_1' \left[i_0' \frac{\cosh \gamma'(s-x)}{\sinh \gamma's} - i_s' \frac{\cosh \gamma'x}{\sinh \gamma's} + \right. \\ &\quad + [Z_{12}i_{20}'' + Z_{13}i_{30}''] \frac{\cosh \gamma''(s-x)}{\sinh \gamma's} - \\ &\quad - [Z_{12}i_{2s}'' + Z_{13}i_{3s}''] \frac{\cosh \gamma''x}{\sinh \gamma's} \\ v_2 &= [Z_{22}i_{20}'' + Z_{23}i_{30}''] \frac{\cosh \gamma''(s-x)}{\sinh \gamma's} - \\ &\quad - [Z_{22}i_{2s}'' + Z_{23}i_{3s}''] \frac{\cosh \gamma''x}{\sinh \gamma's} \\ v_3 &= [Z_{32}i_{20}'' + Z_{33}i_{30}''] \frac{\cosh \gamma''(s-x)}{\sinh \gamma's} - \\ &\quad - [Z_{32}i_{2s}'' + Z_{33}i_{3s}''] \frac{\cosh \gamma''x}{\sinh \gamma's} \end{aligned} \right\}$$

With the same designations as in the general case we get for the tensions and currents at the end $x=0$ the following equations:

$$\left\{ \begin{aligned} E_1 &= [U_1' \operatorname{ctgh} \gamma's + g_1'] i_0' + [Z_{12} \operatorname{ctgh} \gamma''s + b_{12}] i_{20}'' + \\ &\quad + [Z_{13} \operatorname{ctgh} \gamma''s + b_{13}] i_{30}'' - U_1' \frac{1}{\sinh \gamma's} \cdot i_s' - \\ &\quad - Z_{12} \frac{1}{\sinh \gamma''s} i_{2s}'' - Z_{13} \frac{1}{\sinh \gamma''s} i_{3s}'' \\ E_2 &= g_2' i_0' + [Z_{22} \operatorname{ctgh} \gamma''s + b_{22}] i_{20}'' + [Z_{23} \operatorname{ctgh} \gamma''s + \\ &\quad + b_{23}] i_{30}'' - Z_{22} \frac{1}{\sinh \gamma''s} i_{2s}'' - Z_{23} \frac{1}{\sinh \gamma''s} i_{3s}'' \\ &\dots \dots \dots \end{aligned} \right\}$$

For the end $x=s$ we obtain corresponding equations.

Our solutions contain coefficients and constants of propagation which are functions of the operator $p = \frac{d}{dt}$

If the electro-motive forces are constant we get the solution of permanent state by putting everywhere $p=0$. If the electro-motive forces are of a simple sinusoidal shape, and all of the same frequency, we get the solution of permanent state by introducing complex vectors instead of instantaneous values of intensities of current and tensions, and by putting the operator p equal to $j\omega$ where ω is the angular frequency and j the imaginary unity.

The solutions are generally arrived at by the rules of Heaviside's operative calculus. As we know, this can be done differently according to the form of solutions desired.

Among the different solutions obtainable here, the solutions represented under the form of systems of outward and return waves are of particular interest.

Development of Waves.

By wave in a partial system, e. g. γ' , we understand an expression of the form:

$$e^{-[m'\gamma' + m''\gamma'' + m'''\gamma''']s \mp \gamma'x} \cdot f(t) \dots \dots (23)$$

where:

$$m' + m'' + m'''$$

is an even entire number, positive or zero, and $f(t)$ a function of time.

As previously, we assume that we have electro-motive forces only in the net-work at the end $x=0$.

If there are no losses of energy on the lines, i. e. if all the coefficients r_{mn} and a_{mn} equal zero, we find that the roots γ' , γ'' and γ''' become proportional to

$$p = \frac{d}{dt}$$

Hence we can put:

$$\gamma' = \frac{p}{u'}; \gamma'' = \frac{p}{u''}; \gamma''' = \frac{p}{u'''}$$

where u' , u'' and u''' are constants.

According to the rules of Heaviside's operative calculus we then have:

$$e^{-[m'\gamma' + m''\gamma'' + m'''\gamma''']s \mp \gamma'x} \cdot f(t) = f\left(t - \frac{m's}{u'} - \frac{m''s}{u''} - \frac{m'''s}{u'''} \mp \frac{x}{u'}\right)$$

This expression shows that minus sign before x gives us a wave which is propagated with the speed u towards increasing x without any change in the form of the wave. The plus sign, on the contrary, gives us a wave which is propagated towards $x=0$.

If the coefficients r_{mn} and a_{mn} are not zero, we

obtain waves which change form by being propagated along the line. The apex of the wave will nevertheless be propagated with a constant speed.

For obtaining a system of solutions we may as a general method develop the solutions obtained in series following the powers of:

$$e^{-\gamma's}, e^{-\gamma''s} \text{ et } e^{-\gamma'''s}$$

This is always possible in virtue of the form under which our solutions are obtained. This method is, however, circumstantial.

Instead of this we shall derive the solutions direct from the primary differential equations.

If we put:

$$i_n = A' \xi_n' e^{-\gamma'x}$$

i_n represents a wave which is propagated towards increasing x .

By inserting this expression of i_n in the system of equations (4) we see that the currents give us a system of solution whatever the coefficient A' may be. It is, however necessary that the ξ_n' comply with the system of equations (5). As before, we put furthermore.

$$\xi_1' + \xi_2' + \xi_3' = 1$$

Then the ξ_n' become the same coefficients as we have obtained in the general theory.

We also introduce the total of the currents on the lines, and designate this total by i . As before, we have:

$$i_n = \xi_n' i$$

The tensions v_n on the lines are obtained by the equations (3). We obtain:

$$v_n = U_n' i$$

where

$$U_n' = \gamma' [y_{n1} \xi_1' + y_{n2} \xi_2' + y_{n3} \xi_3']$$

We have thus found that:

in each direct wave, i. e. one that is propagated towards increasing x , the relation between the tension of one line and the total of currents on all the lines is supplied by the characteristic U_n' .

If we put:

$$i_n = B' \xi_n' e^{-\gamma'(s-x)}$$

we find furthermore that these currents supply a solution on condition that the ξ_n' are the same as before. The current i_n represents a wave that is being propagated towards $x = 0$.

If we form the expression of v_n we find, however, now the relation:

$$v_n = -U_n' i$$

Hence we have found that:

in each indirect wave, i. e. one propagated towards $x = 0$ the relation between the tension of one line and the total of currents on all the lines is equal to the characteristic U_n' , taken with the minus sign.

What we have ascertained here above also holds good for the partial systems corresponding to the constants of propagations γ'' and γ''' .

The total of a number of solutions supply always one solution.

We shall imagine that the waves of currents are formed successively in the following manner.

To start with we assume a system of current-waves issuing from the net-work at the end $x = 0$. The total of the currents in our three issuing partial systems can be written:

$$\begin{aligned} A_o' e^{-\gamma'x} \\ A_o'' e^{-\gamma''x} \\ A_o''' e^{-\gamma'''x} \end{aligned}$$

Each one of these currents generates at the end $x = s$ by reflexion new current-waves which are propagated towards $x = 0$. We shall designate these currents by:

$$\begin{aligned} B_1' e^{-\gamma'(s-x)} \\ B_1'' e^{-\gamma''(s-x)} \\ B_1''' e^{-\gamma'''(s-x)} \end{aligned}$$

At $x = 0$ we again obtain by reflexion a system of direct currents:

$$\begin{aligned} A_1' e^{-\gamma'x} \\ A_1'' e^{-\gamma''x} \\ A_1''' e^{-\gamma'''x} \end{aligned}$$

and thus in succession.

At the end $x = 0$ the equalities between the total of the currents and the tensions are of the following form:

$$E_n = g_n' i_o' + g_n'' i_o'' + g_n''' i_o''' + v_{no}$$

We shall determine the coefficients A_o' , A_o'' , and A_o''' by assuming that the issuing waves comply with the above conditions.

Then we have:

$$\begin{aligned} i_o' &= A_o' \\ i_o'' &= A_o'' \\ i_o''' &= A_o''' \\ v_{no}' &= U_n' A_o' \\ v_{no}'' &= U_n'' A_o'' \\ v_{no}''' &= U_n''' A_o''' \end{aligned}$$

Our coefficients A_o are therefore determined by the following equations:

$$E_n = (U_n' + g_n')A_o' + (U_n'' + g_n'')A_o'' + (U_n''' + g_n''')A_o''' \dots \dots \dots (24)$$

At the end $x = s$ we have a system of equations of the form:

$$v_{ns} = h_n' i_s' + h_n'' i_s'' + h_n''' i_s'''$$

These equations must be satisfied at each moment. The currents in the formulae are composed by incidental waves and reflected waves. One incidental wave is always followed by a reflected wave. In order to enable the above conditions to be fulfilled at each moment it is necessary, and suffices, that they are fulfilled by each pair of waves, one incidental and the other reflected, which follows immediately upon the first. We shall now look upon the pair of waves in which the direct wave bears the index m .

We must now put:

$$\begin{aligned} i_s' &= A_m' e^{-\gamma' s} + B_{m+1}' \\ i_s'' &= A_m'' e^{-\gamma'' s} + B_{m+1}'' \\ i_s''' &= A_m''' e^{-\gamma''' s} + B_{m+1}''' \end{aligned}$$

The corresponding tensions become:

$$\begin{aligned} v_{ns}' &= U_n' [A_m' e^{-\gamma' s} - B_{m+1}'] \\ v_{ns}'' &= U_n'' [A_m'' e^{-\gamma'' s} - B_{m+1}''] \\ v_{ns}''' &= U_n''' [A_m''' e^{-\gamma''' s} - B_{m+1}'''] \end{aligned}$$

The conditions at the end $x = s$ give us the following relations:

$$(U_n' + h_n')B_{m+1}' + (U_n'' + h_n'')B_{m+1}'' + (U_n''' + h_n''')B_{m+1}''' = (U_n' - h_n')A_m' e^{-\gamma' s} + (U_n'' - h_n'')A_m'' e^{-\gamma'' s} + (U_n''' - h_n''')A_m''' e^{-\gamma''' s} \dots \dots (25)$$

These equations supply the coefficients B_{m+1} when the coefficients A_m are known.

In considering the corresponding relations at the end $x = 0$ we must remember that we have already in the first issuing currents disposed of the electro-motive forces. Hence the conditions at this end become:

$$0 = g_n' i_o' + g_n'' i_o'' + g_n''' i_o''' + v_{no}$$

The pair of waves with the coefficients:

$$A_m', A_m'', A_m''', B_m', B_m'' \text{ and } B_m'''$$

then give us the relations:

$$\begin{aligned} (U_n' + g_n')A_m' + (U_n'' + g_n'')A_m'' + (U_n''' + g_n''')A_m''' &= \\ = (U_n' - g_n')B_m' e^{-\gamma' s} + (U_n'' - g_n'')B_m'' e^{-\gamma'' s} &+ \\ + (U_n''' - g_n''')B_m''' e^{-\gamma''' s} \end{aligned}$$

These equations supply us with A_m', A_m'' and A_m''' , when B_m', B_m'' and B_m''' are known.

By the equations we have found we are able to determine successively all the coefficients A_m and B_m . The corresponding solutions take the form (23) where $f(t)$ is replaced by a homogeneous and linear expression of the electro-motive forces E .

The equations:

$$\left\{ \begin{aligned} i' &= \sum_{m=0}^{\infty} A_m' e^{-\gamma' x} + \sum_{m=1}^{\infty} B_m' e^{-\gamma'(s-x)} \\ v_n' &= U_n' \left[\sum_{m=0}^{\infty} A_m' e^{-\gamma' x} - \sum_{m=1}^{\infty} B_m' e^{-\gamma'(s-x)} \right] \end{aligned} \right\} \dots (26)$$

give us the current and tensions in the partial system γ' , and we obtain analogous equations for the constants of propagation γ'' and γ''' .

The current:

$$\begin{aligned} i &= i' + i'' + i''' \\ i_n &= \xi_n' i' + \xi_n'' i'' + \xi_n''' i''' \end{aligned}$$

and the tensions:

$$v_n = v_n' + v_n'' + v_n'''$$

finally supply the solution to our problem.

The currents and the tensions comply with primary differential equations and also with conditions existing at the ends $x = 0$ and $x = s$.

If we assume the electro-motive forces as applied at the moment $t = 0$, the $E_n(t)$ become zero for the t negatives. By putting $t = 0$ in the expressions obtained for the currents and tensions, we find further that all the currents and all the tensions become equal to zero at this epoch, i. e. that the lines at $t = 0$ are found in a neutral state. It must moreover be remembered that the totals i and v_n are equal to zero in all the terms in which the arguments of the functions E_n become negative. We thus obtain for each t a limited number of terms.

By assuming in the equation (25) A_m'' and A_m''' as equal to zero the system of incidental waves contains only one wave appertaining to the partial system.

The formulae (24) show us, however, that this incidental wave gives rise to reflected waves appertaining to all the partial systems.

We are able to introduce coefficients of propagation for the incidental and reflected waves at the ends of the lines.

We shall designate the incidental currents at the extremity $x = s$ by \bar{i}' , \bar{i}'' and \bar{i}''' , and the reflected currents with \bar{i}' , \bar{i}'' and \bar{i}''' . Our formulae (25) can then be written under the form:

$$(U_n' + h_n')\bar{i}' + (U_n'' + h_n'')\bar{i}'' + (U_n''' + h_n''')\bar{i}''' = \\ = (U_n' - h_n')\bar{i}' + (U_n'' - h_n'')\bar{i}'' + (U_n''' + h_n''')\bar{i}'''$$

If we have for all the n the relation:

$$U_n' = h_n'$$

this formula shows us that an incidental wave of system γ' is completely absorbed in the net-work, and consequently we obtain no reflected waves appertaining to this system.

For the end $x = o$ we obtain analogous formulae.

If we designate the first issuing currents by i_o' , i_o'' and i_o''' we have:

$$E_n = (U_n' + g_n')i_o' + (U_n'' + g_n'')i_o'' + (U_n''' + g_n''')i_o'''$$

In the exceptional case where we have multiple roots we introduce instead of the total of currents appertaining to the partial system corresponding to this root the individual currents of the lines. For such an individual current, e. g. i_{vo}' , we substitute Z_{nv} for U_n , and d_{nv} for h_n . If the order of multiplicity of the root is m and p the number of lines, we obtain p currents instead of the current i_o' ; but between these currents we have $p - m$ homogeneous and linear equations. By eliminating, with the aid of these equations, $p - m$ currents we have left only m independent currents. Then the number of currents as before equals the number of lines.

By way of example, in the case where we have three lines, two of them fulfilling the condition:

$$\frac{z_{mn}}{y_{mn}} = u^2$$

we have obtained a simple root γ' and a double root γ'' . The equations between the individual currents i_n'' has given us $i_1'' = 0$; this is the reason why in the partial system we have two independent currents i_2'' and i_3'' .

The equations between the incidental currents and the reflected ones at the end $x = o$ the become as follows:

$$(U_n' + h_n')\bar{i}' + (Z_{n2}'' + d_{n2})\bar{i}_2'' + (Z_{n3}'' + d_{n3})\bar{i}_3'' = \\ = (U_n' - h_n')\bar{i}' + (Z_{n2}'' - d_{n2})\bar{i}_2'' + (Z_{n3}'' - d_{n3})\bar{i}_3''$$

It must be observed here that we have:

$$U_2' = U_3' = o$$

Permanent Sinusoidal State.

If the electro-motive forces are sinusoidal with the same angular speed ω , all the currents become equally sinusoidal in a permanent state. We would be able to obtain the permanent solution by putting $t = \infty$ in the general solution (26). The same result is obtained, however, if we introduce into these equations complex vectors instead of instantaneous values of the electro-motive forces, and by putting everywhere $p = j\omega$ where ω is the common angular speed. The tensions and currents are then obtained in the form of a sum of complex vectors, in which each term represents a complex wave. In order to arrive at a complete solution we must, however, include all the terms in the formulae (26).

By working out the solutions in the form of waves we obtain generally such a large number of reflected waves that clearness suffers by it. If we except, however, the case where the attenuation of the lines is so great that we can neglect waves that have been reflected several times, or even the case where it is desired to examine the effect of a system of particular waves, it is better to make direct use of the general solution in the closed form.

Synopsis.

In this work there has first been rendered an account of general formulae relating to the current and tension of a system of homogeneous parallel lines of the same length, which are connected at the ends by electric networks, one net-work at each end.

Supposing that the kilometric constants of the lines have been selected arbitrarily, we find that the intensities and tensions are obtained as the total of a number of partial systems, each one possessing its constant of propagation. We obtain as many partial systems as there are parallel lines.

In every partial system the intensities of currents and the tensions on the lines are found to be in a constant relation which depends only upon kilometric constants of the lines, and which is consequently independent of their lengths and the dispositions connecting the lines at their ends.

In each partial system we obtain for each line one characteristic. For a partial system the tension and

intensity of the current on a line are connected with each other in the same way as the current and tension of a single homogeneous line. We also obtain a characteristic and a constant of propagation representing the partial system. The individual tensions and currents of the lines are obtained from the said totals by factors of proportionality which are only dependent of the kilometric constants of the lines.

Every partial system can thus be represented by a fictitious homogeneous line. The general problem is reduced to a problem concerning a system of fictitious homogeneous lines which do not affect each other, and which are connected up at the ends by electric networks. The constants of these net-works have been deduced.

If the equation which supplies the constants of propagation has multiple roots, the number of partial systems grows smaller than the number of lines. In the general case where the constant of propagation corresponded to a simple root the current and tension of *one of the lines* could represent the partial system. If, on the other hand, the constant of propagation of a partial system corresponds to a multiple root, this is no longer possible. By supposing the order of multiplicity of this root equal to m the equations between the coefficients ξ_n show us that the individual currents of the lines are homogeneous and linear functions of currents upon m of our lines, and the same thing holds good for the individual tensions in this partial system. The coefficients in the linear expressions are only dependent of the kilometric constants of the lines. Thus it is necessary in this case to have m lines for representing the corresponding partial system.

The total number of fictitious lines also, as before, grows equal to the number of lines; but on the lines corresponding to a joint constant of propagation the tensions and currents are no longer as a rule connected with each other as in the case of a single line, the expressions and tensions containing a coefficient that is a homogeneous and linear function of independent m currents at the end $x = 0$, and another coefficient which we find by substituting the currents at end $x = 0$ by those existing at the end $x = s$.

As an example of this exceptional case we have treated particularly the problem where parallel lines form a cable in fours properly balanced.

Another case treated is that where the energy losses are neglected in certain lines and the earth supposed to be a perfect conductor. We then obtain a constant of common propagation γ which corresponds lines, fulfilling the abovementioned conditions; and others γ', γ'', \dots whose number is the same as the number of the other lines. Thus the number of constants of propagation exceeds by 1 the number of lines which we have not supposed as subject to particular conditions.

On the lines whose electrical constants do not fulfil the above conditions no partial current with the constant of propagation γ is obtained. On the other hand, on the lines which fulfil these conditions there is no partial tension corresponding to systems $\gamma', \gamma'' \dots$. The tensions and currents appertaining to these systems are connected between them in the same manner as in the case of a simple line. For the tensions and currents appertaining to system γ we obtain, on the other hand, a system of linear equations which connects the coefficients of the equations of tensions with the intensities of currents at corresponding ends of the lines.

A detailed investigation has been made into the form assumed by the solutions if we develop the currents and the intensities in such a manner that they are obtained as the sum of a system of direct waves and systems of waves obtained afterwards by reflexions at the end of the lines. We shall then find that a system of waves possessing a certain constant of propagation is decomposed by reflexion into as many partial systems as there are constants of propagation or lines.

In one system of waves propagated towards increasing x it fits all the lines that the relation between the tension and current of a line is expressed by the characteristic impedance. For a wave propagated towards $x = 0$ this relation is equal to the characteristic with a negative sign. Formulae of the impedance of the first system of direct waves and of the coefficient of reflexion at the end of the lines have been indicated, as well as the conditions for fulfilling that the reflexion of a partial system does not occur.

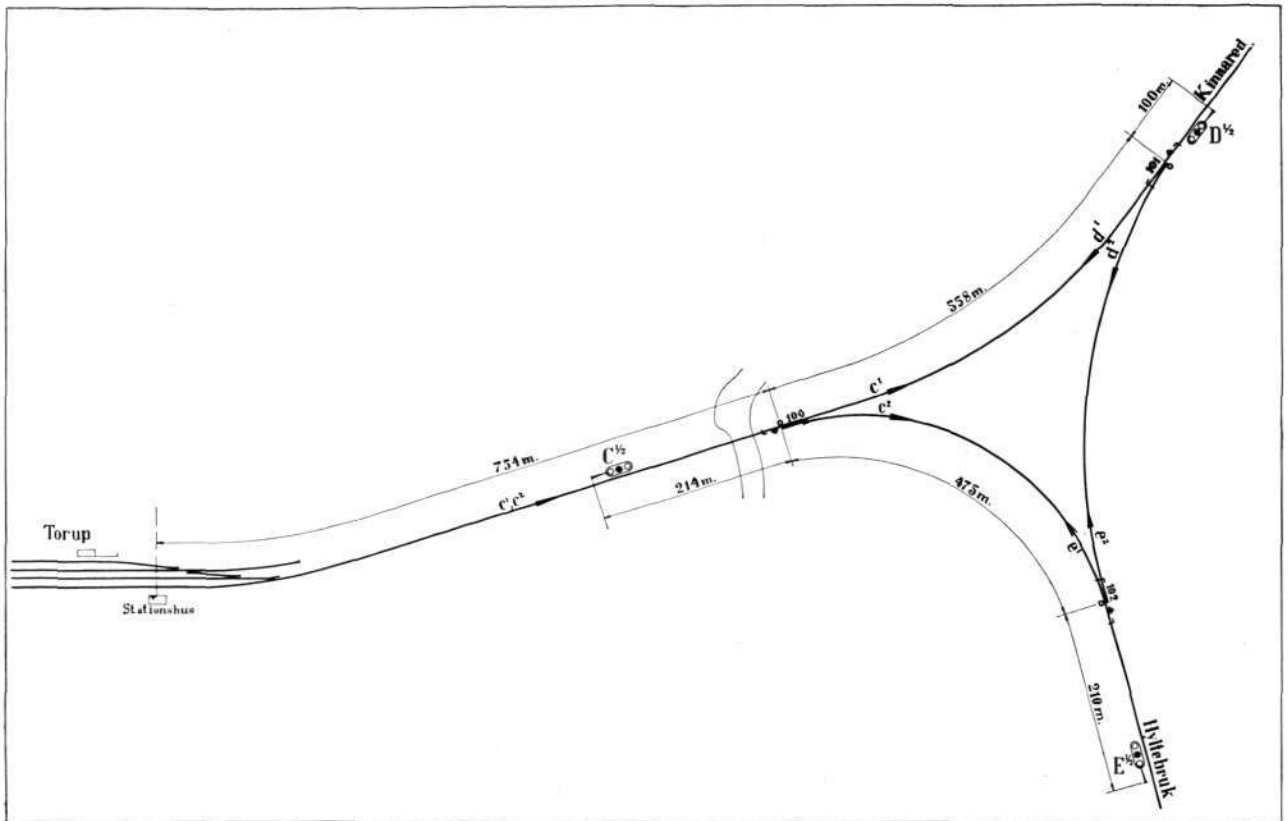
H. Pleijel

Interlocking Plant at the Track Junction East of the Torup Station.

It is now about two years since the small electric interlocking plant for a triangular track junction (fig. 1) near the Torup station on the Halmstad Nässjö R'y was put in service.

At the time this junction — which is situated about 800 metres east of the Torup station — was built,

unusual interest is the fact that the interlocking machine is located outside of the area bounded by the points and signals belonging to the plant; another feature is that the plant is designed for the unguarded passage of trains in certain directions according to the detailed description given in the following.



R 804

Fig. 1.

the question came up as to the advisability of building a suitable interlocking plant. An electric plant was found most suitable on account of its low cost of operation, this condition being obtained by placing the interlocking machine in the office of the train dispatcher at Torup, whereby no special operator was required for its manoeuvring, as would have been the case if the machine had been placed in the immediate vicinity of the junction.

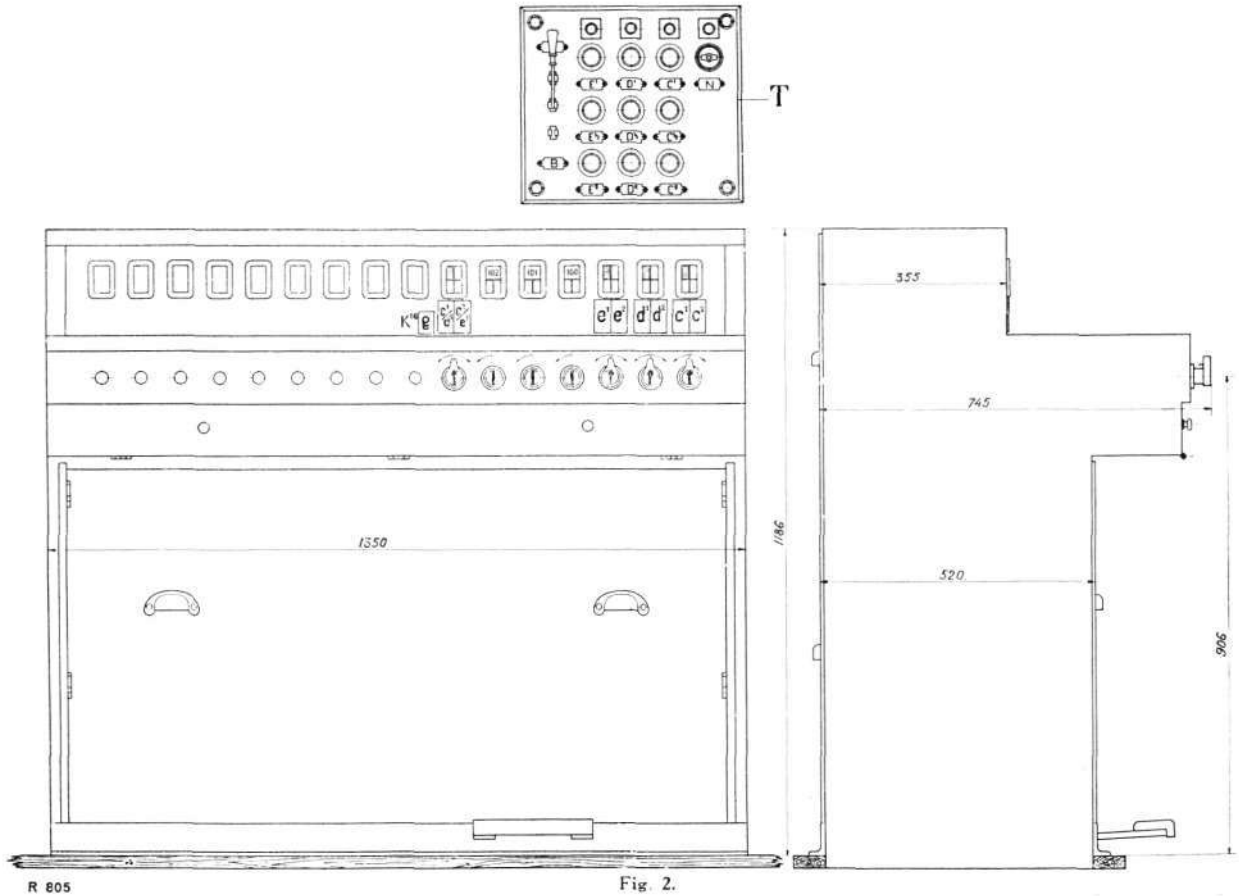
One of the features which make this plant of

The three points nos. 100, 101 and 102 — each one forming one of the angles of the triangular junction —, as well as the corresponding signals $C^{1/2}$, $D^{1/2}$ and $E^{1/2}$ which are designed as day signals, are manoeuvred from the interlocking machine (fig. 2). Behind and slightly above the interlocking machine is mounted a chart T with indicator lamps, each one connected in series with a corresponding signal lamp by means of which it is possible to ascertain whether the signal lamps are intact and which show the exact

combination of lights for which the interlocking machine has been manoeuvred. The indicator lamps are shunted so as to prevent the extinguishing of a signal lamp if the corresponding indicator lamp should be broken or removed.

In order to prevent the setting of a point during the passage of a train, the point levers in the inter-

locking machine are locked in the positions required by the directions of the trains to be considered. The special lever is moved to the left for trains from Torup to Kinnared and vice versa, in which case the signals $C^{1/2}$ and $D^{1/2}$ are set to clear, or else it is moved to the right for trains from Torup to Hyltebruk and vice versa, in which case the signals



locking machine are provided with locking devices in conjunction with an insulated track section through the corresponding point. Each track section is provided with a rail contact for the release of the track locking arrangement in the usual manner.

In order to permit — to a certain extent — the passage of trains over the track junction at such times of the day during which no one is on guard at the Torup station, the interlocking machine has been provided with an arrangement for 'unguarded passage', consisting of a special lever which can be locked in normal position by means of a special control lock, this position being the one in which the lever shall be locked when the train dispatcher is on duty. For 'unguarded passage' the lock is released and the lever can be moved at will to the left or to the right, in

$C^{1/2}$ and $E^{1/2}$ are set to clear. When the special lever is moved to the one or to the other side for 'unguarded passage' the track locking devices are disconnected to be again connected up when this lever is restored to normal.

Power is obtained from the alternating current service net, the two storage batteries — one motor and one control battery — being charged by means of rotating transformers. The signal lamps obtain the necessary current from the service net with the aid of a transformer, the motor battery serving this purpose in case of emergency.

This plant has proved to be unusually economical in operation and has been delivered through 'Signalbolaget' of Stockholm, this company having also prepared the project for the same.

G. P.

L. M. Ericsson



Ericsson

INTERLOCKING MACHINES

Signal apparatus for all systems.

Traffic and warning signals for grade crossings.

Information and offers to be requested from

TELEFONAKTIEBOLAGET L. M. ERICSSON

or its following subsidiaries —

AUSTRIA: "Ericsson, Oesterreichische Elektrizi-
tats-A. G., Pottendorferstrasse 25/27, Vienna XII.

Č. S. R.: "Ericsson", Elektrotechnicka Komanditni
Společnost, Male Nam. 1, Prague.

ENGLAND: Ericsson Telephones Ltd.,
67/73 Kingsway, London W. C. 2.

FRANCE: Societe des Telephones Ericsson,
37 Boulevard d'Acheres, Colombes.

FINLAND: Aktiebolaget L. M. Ericsson i Finland,
N. Esplanadgatan 25, Helsingfors.

ITALY: Societa "Ericsson" Italiana,
Via Assarotti 42, Genoa.

HOLLAND: Koopman & Co.,
Heerengracht 370, Amsterdam.

HUNGARY: "Ericsson" Magyar Villamossagi R. T.,
Fehervari ut 70, Budapest.

POLAND: "Ericsson", Polska Akcyjna Spolka Elek-
tryczna. Al. Ujazdowskie 47, Warsaw.

ROUMANIA: Energia, S. A. Romaneasca.
Str. Smardan 13, Bucharest.

SPAIN: Sobrinos de R. Prado,
Principe 12, Madrid.

TURKEY: The Swedish Oriental Trading Co.,
P. O. B. 565, Stamboul.

MEXICO: Empresa de Telefonos, Ericsson S. A.,
2:a Calle Victoria 53 y 55, Mexico.

SOUTH AMERICA: Compania Sudamericana de
Telefonos L. M. Ericsson S. A. Esmeralda 1000,
Buenos Aires.

Sociedade Geral de Telephones L. M. Ericsson,
Ltda., Rua Sao Pedro 106, Rio de Janeiro.

EGYPT: Bergstrand & Ahlberg,
P. O. Box 1846, Cairo.

UNION OF SOUTH AFRICA: Rogers-Jenkins & Co.,
P. O. Box 654, Johannesburg.

BRITISH INDIA: Ericsson India Office,
15 Central Avenue, Calcutta.

JAPAN: Siber Hegner & Co.,
P. O. B. "F" Central 16, Tokio.

AUSTRALIA: Ericsson Telephone Mfg. Co.,
18 York Street, Sydney.

Manufacturers of

Modern Automatic and Manual Telephone Ex-
changes.

Telephone Instruments.

Amplifiers.

Telegraph Instruments.

Electric Meters.

Cable, Wire, Cords and Line Material.

Time Recorders.

The international Chamber of Commerce and the International European Telephone Traffic.

By A. Lignell, Superintendent of Telephones in Stockholm.

At the convention of the International Chamber of Commerce at Stockholm last summer, the questions concerning the international telephone traffic in Europe aroused much interest. Commercial telephone communications between Stockholm on the one hand and London and Paris on the other had been established shortly before the opening of the convention, and these two new long distance lines — the one with London has an actual length of 2436 km. and is as yet the longest direct telephone line in Europe — were diligently used by the delegates. More recently, telephone communications for commercial purposes between England and Northern Sweden have been opened for use over an actual length of more than 4000 km., the cables across the Baltic Sea and the English Channel accounting for 120 and 156 km. respectively.

The special telephone committee of the International Chamber of Commerce makes the following summing up of the desiderata concerning the international traffic uttered at the convention "Uniform, efficient, quick telephone communications with good sound transmission between all the important commercial centres of Europe".

In its report following an investigation of European telephone conditions, the above-mentioned committee holds forth the commercial long distance service in the United States as a pattern for the European telephone service. It is of decided interest to make a closer study of American conditions in this respect as compared with conditions within the young and thriving international European telephone net.

The reference to the commercial telephone service in America by the telephone committee is couched in the following terms:

"Long distance service for commercial purposes was established between New York and Chicago — a distance of 1187 km. — in 1892, and between Boston and San Francisco — 4450 km. — in 1915.

The existing long distance telephone service in the United States is the result of a development stretching

over a period of quite a number of years. It has developed according to a certain definite business policy, of which some of the fundamental principles are as follows:

a. Good sound transmission between all localities where there already exists or may be expected to exist a need for long distance service.

b. The constant aim is to make the time required for establishing a communication between two arbitrary localities as short, alike and dependable as possible and as much alike as possible during the different hours of the day. All calls are express calls.

c. In determining the number of lines, station equipment and personnel, first consideration is given the requirements of the public, i. e. the number of calls during the busy hour.

d. No limit is set for the utilization of the lines except when the lines have been seriously damaged or on account of other unexpected conditions. Calls of thirty minutes or even several hours duration are not uncommon.

It has always been the aim to offer the public a long distance service so satisfactory to the business man from a point of view of sound transmission, efficiency and speed as to make the telephone the means of communication to which he instinctively turns whenever the necessity arises to communicate with another person.

The fact that a uniform, quick long distance service is available has led to its extensive use by business firms for sales to customers in distant cities.

During the ten years between 1915 and 1925 — in which time the population increased about 15 % and the number of subscribers about 66 % — the increase in toll calls amounted to about 156 %.

The increased use of long distance service would never have taken place unless the possibility of making quick calls had been both complete and reliable and unless its advantages had been demonstrated for the business men.

About 270,000,000 calls — local calls not included — are handled by the toll operators, with a mean waiting time of four minutes, calls from person to person being included. On lines over which the traffic is comparatively heavy and between large cities where the distances are sometimes upwards of 160 km., about 70 % of the calls are dispatched within two minutes and the mean waiting time is ten minutes.

The transcontinental calls between New York and the larger Pacific coast cities — a flying distance of about 4032 km. — are dispatched during business hours with a mean waiting time of ten minutes. Calls between Chicago and the same cities on the Pacific coast — a flying distance of more than 2806 km. — are dispatched during rush hours with a mean waiting time of six minutes.

In sum, this long distance service offers perfect sound transmission and a quick dispatch of calls, together with very short waiting times within the United States and with Canada and Cuba”.

Here ends the committee's report on conditions within the United States.

A perusal of the above, without giving the subject any deeper consideration, will lead to the conclusion — as is no doubt intended — that American toll service is very nearly ideal.

This holds true in certain respects, but clearly not in all when seen from the subscriber's point of view. As we have at our disposal certain figures touching on traffic conditions in the U. S. A. provided by the American members of the International Chamber of Commerce, we are tempted to make a somewhat closer investigation of the long distance telephone traffic in the United States as compared with the national and international long distance traffic in Europe.

In two respects, especially, do we find such an investigation yielding and interesting, as follows:

1. in respect to the intensity of the traffic, this being an excellent standard for determining the popularity of this means of communication,

2. in respect to the size of the tariff rates and their influence on the development of the traffic.

The available figures concerning the traffic are given in the following table, in which the lines of communication are classified in four groups according to the air line distance:

1. lines with a length of more than 2000 km.,
2. lines varying in length between 2000 and 800 km.,
3. lines varying in length between 800 and 500 km.,
4. lines varying in length between 500 and 200 km.

Shorter distances have not been included as they can hardly be classified as long distance lines.

The figures in this table prove beyond a doubt that the United States does not occupy a commanding position as compared with Europe when it comes to long distance telephone traffic. The proofs would undoubtedly have been even more conclusive had the corresponding figures for France and some other countries also been available.

The committee's previously cited statement that the telephone shall be that means of communication “that the business man instinctively first resorts to whenever the necessity for communicating with another person arises and that the fact that a uniform and quick long distance service is available has led to a widespread use of the same by business firms for the sale of merchandise to customers in distant localities” is not corroborated by the American traffic statistics, especially when one considers the very widespread use of the telephone in the large American cities. The American figures for distances of over 2000 km. show an unusually small amount of traffic and — which is even more striking — a negligible absolute increase of traffic during the five-year period.

The longest European line of communication as yet established is probably the one between Stockholm and London, 2436 km. actual length and opened for traffic some few months ago. Twenty calls per week day is the average over this line, this figure being the highest given for American domestic traffic. Twenty-five calls on the international line to Havanna is not much higher; but one must make allowances and give the European traffic a little more time to develop. Linguistic difficulties between the subscribers — non-existent in the U. S. A. — require some time for their elimination.

Over distances of between 2000 and 800 km. the number of European lines of communication is considerably larger. The European traffic over these lines is quite in excess of the American traffic, the only exception being the line New York—Chicago; but, according to the telephone committee of the International Chamber of Commerce, this route was opened already in 1892. The thirty-three years during which it has been in existence should show a much bigger increase in traffic than what is indicated in the table.

For lines of 800 to 500 metres and 500 to 200 metres in length, the figures show that the European traffic is far in excess of the American.

When making comparisons, however, one must bear in mind that the European international traffic routes

L. M. Ericsson

Route of communication	Flying distance	Rate for 3 min's in Gold francs	Rate in Gold francs for same distance			Average number of week day calls in both directions	
			According to tariff rates of the C. C. I.	in Germany	in Sweden	1920	1925
<i>Distances exceeding 2000 km.</i>							
New York—Havana	2120	72.35	14.80	9.38	—	—	25
» —Los Angeles	3987	82.95	25.60	16.13	—	4	20
London—Stockholm	2436**)	21.50*)	—	—	—	—	20(1927)
(Opened for traffic July 1927)							
New York—San Francisco	4206	87.45	27.40	17.25	—	7	14
» —Denver	2648	55.12	17.80	11.25	—	3	5
<i>Distances between 2000 and 800 km.</i>							
New York—Chicago	1178	24.65	8.80	5.63	3.47	274	554
Berlin—London	940	19.75***)	—	—	—	—	284(1927)
» —Paris	870	9.50	9.50	—	—	—	216(1927)
» —Stockholm	810	6.30	—	—	—	—	128(1927)
Stockholm—Luleå	800	2.78	—	—	2.78	54	93(1927)
New York—St. Louis	1418	29.68	10.60	6.75	3.47	36	68
» —Miami	1760	36.84	12.40	7.88	3.47	—	43
» —Atlanta	1192	25.18	8.80	5.63	3.47	12	34
Chicago—Dallas	1278	26.77	9.40	6.00	3.47	4	10
<i>Distances between 800 and 500 km.</i>							
Stockholm—Malmö	514	1.53	—	—	1.53	556	806
Berlin—Munich	500	3.00	—	3.00	1.53	—	721(1926)
» —Vienna	520	5.00	5.00	—	—	—	651(1927)
» —Königsberg	520	5.38	—	3.38	1.53	—	330(1926)
» —Amsterdam	580	5.70	5.70	—	—	—	321(1927)
Chicago—Cleveland	506	10.87	5.20	3.38	1.53	167	278
New York—Detroit	787	16.70	6.40	4.13	2.78	88	256
Chicago—Minneapolis	560	11.93	5.90	3.38	1.81	149	231
Stockholm—Oslo	425	3.60	—	—	—	—	182
» —Copenhagen	540	3.60	—	—	—	—	184
» —Umeå	570	1.81	—	—	1.81	56	155(1927)
Chicago—Pittsburg	675	14.31	5.80	3.75	2.22	90	134
» —Omaha	682	14.58	5.80	3.75	2.22	42	74
<i>Distances between 500 and 200 km.</i>							
Berlin—Hamburg	260	2.25	—	2.25	0.97	—	2879(1926)
New York—Boston	304	6.63	4.00	2.63	1.25	1655	2266
Stockholm—Gothenburg	403	1.25	—	—	1.25	1423	1823(1927)
Berlin—Frankfurt a/M.	420	3.00	—	3.00	1.53	—	1288(1926)
» —Hannover	260	2.25	—	2.25	0.97	—	1115(1926)
New York—Washington	326	7.16	4.00	2.63	1.25	693	879
Berlin—Düsseldorf	470	3.00	—	3.00	1.53	—	762(1926)
» —Prague	290	3.40	3.40	—	—	—	503(1927)

*) The rates for traffic with England are higher than other European rates.
 **) Actual length of line of communication.
 ***) Rates reduced after Dec. 12, 1927.

are of a more recent date and that consequently conditions have not yet by far become stabilized.

The strenuous and successful labours of the Comité Consultatif Internationale for the standardization and unification of the international toll service is now beginning to bear fruit, however, but it is unreasonable to demand that the European international telephone net shall be complete and give absolutely satisfactory service all at once. It can safely be predicted, however, that the time is not far distant when the international telephone traffic in Europe will have considerably outdistanced the American toll traffic. This statement is made on condition that the American tariff rate system remain unchanged.

A comparative investigation of the rates in the table show, that American rates are two to three times higher than the C. C. I. rates, three to five times higher than in Germany and six to ten times higher than the Swedish toll rates. According to the C. C. I. sound transmission and facilities for the public in Europe are fully equivalent to those in America, the only difference being that in Europe all toll calls do not have the same short waiting times as those with which all American toll calls are favoured. But is this not an advantage to be purchased at altogether too high a price? The all too perfect can sometimes

counter-act good results, the development of the toll traffic in America showing beyond a doubt that such in the case in this instance. If this were not so, it would be difficult indeed to explain the low intensity of long distance traffic in the foremost country of the world as regards the spread of the telephone.

The statement of the telephone committee of the International Chamber of Commerce with regard to telephone conditions in America — in which statement tariff rates were completely ignored — is responsible for these lines.

Reasonable rates, however, are of the utmost importance in business, a fact which is constantly and with good cause being pointed out by mercantile institutions and organizations.

The European business world is undoubtedly better served by obtaining international long distance calls for about one third as much as they cost in the United States, with reasonable waiting times according to the recommendations of the C. C. I. and so that only calls of a very urgent nature — which, according to actual experience, constitute but a small percentage of the total amount of calls — are dispatched with American speed and at the same rates as those charged in the United States, whether the calls are urgent or not.

A. Signell



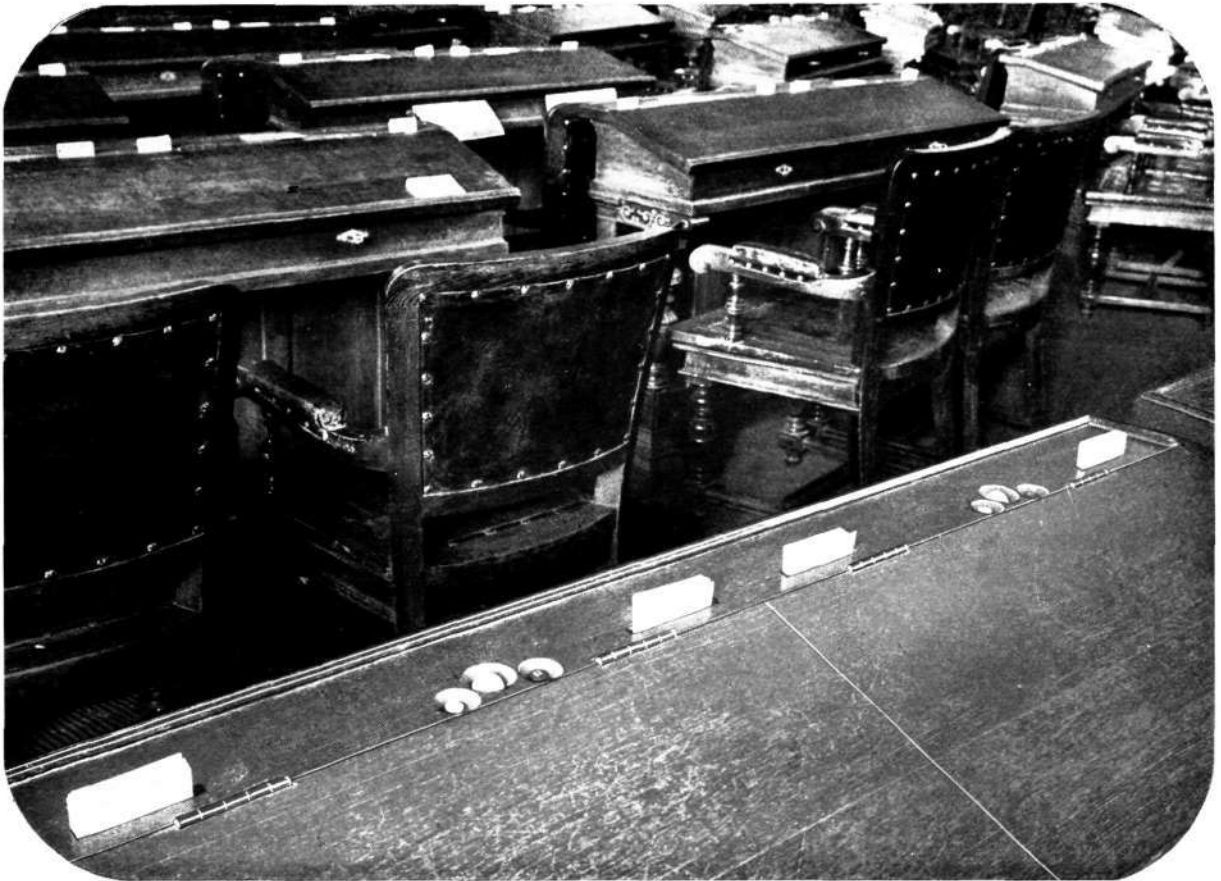
R 546

The Automatic Voting Device of the Finnish Parliament.

A voting device has recently been delivered by L. M. Ericsson to the Finnish Parliament and is now in operation. As this installation differs considerably from the one originally projected and described in 'The L. M. Ericsson Review', Nos 3

of them. A photograph of a member's desk is reproduced in fig. 1.

The *aye* and *no* votes are given by depressing either of the push buttons and if the voter wishes to cast a neutral vote, both buttons are depressed.



R 802

Fig. 1. View showing Desks with Voting Devices.

& 4, Vol. II, a description of the same may be of interest to the readers of this journal.

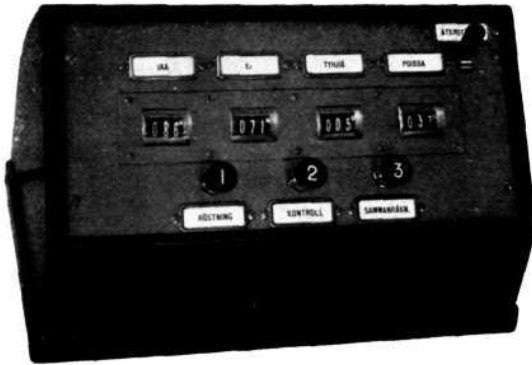
The voting device is constructed for secret balloting and is for 199 voters.

The apparatus belonging to each member of the parliament consists of two push buttons and one signal lamp. The push buttons which are marked *ja* and *ei* respectively — *aye* and *no* in English —, are mounted in the desk, the signal lamp, which is protected by an opalescent lens, being placed in front

The chairman supervises the voting by means of a control apparatus shown in fig. 2. This apparatus contains three push buttons, one key and four registering meters. These latter are similar to common telephone subscribers' meters, but are provided with an arrangement for restoring them to normal and with lenses to facilitate the reading. In addition, a green lamp, visible to all the members, has been mounted in the chairman's desk.

To the side of the chair (see fig. 3) is suspended

an indicator with illuminated numerals, on which the results of the ballot are denoted in glowing figures. The indicator contains four meters constructed on the



R 752 Fig. 2. Chairman's Control Apparatus.

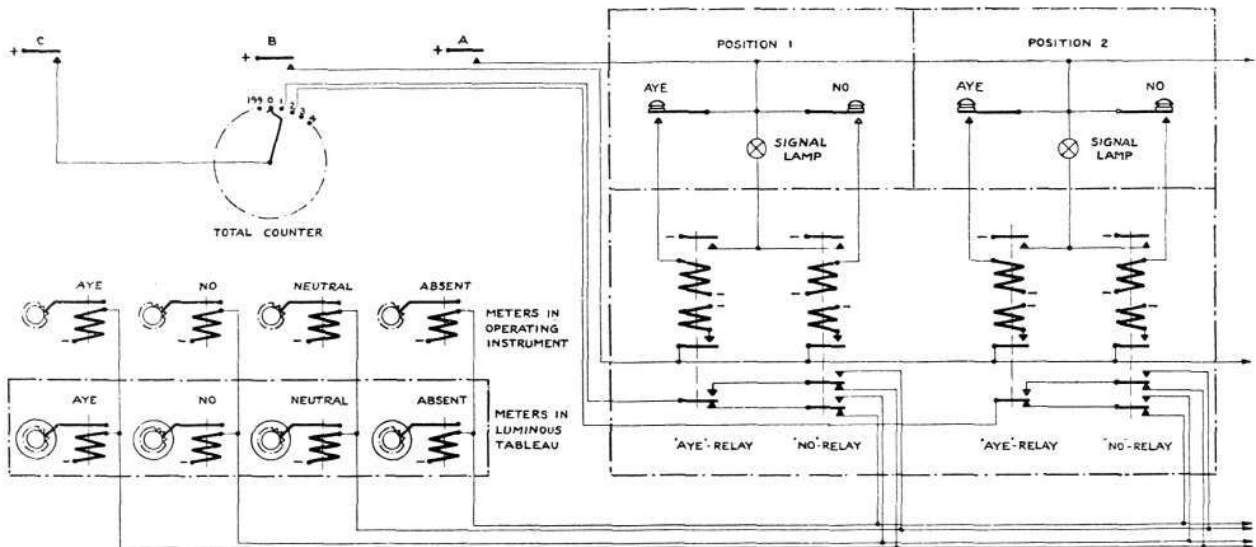


R 753 a Fig. 3. The Illuminated indicator.

same principle as those in the chairman's control apparatus. The meters of the indicator, however, are provided with rotating discs — instead of the usual drums — in which the numbers are cut out. Each current impulse received by the coil of the meter causes the units disc to rotate the tenth of one revolution. A powerful electric lamp, aided by a converging lense, throws a strong ray of light against the discs, causing the numerals to be reproduced — by means of another lens and a reflecting mirror — on the ground

to these, these are a number of actuating and control relays which — for the sake of simplicity — are not shown here. The ballots are counted by means of a motor driven meter, the relays and signal lamps being energized by means of a 28-volt storage battery.

When a ballot is about to be taken, the chairman depresses key 1 on his control apparatus, thereby actuating relays which close contacts A and B. The green lamp on the chairman's desk as well as the lamps in the indicator are simultaneously lighted. The



R 810 E

Fig. 4. Schematic Diagram of Voting Device.

glass forming the front of the indicator. The glowing numerals are easily discernible even in strong daylight.

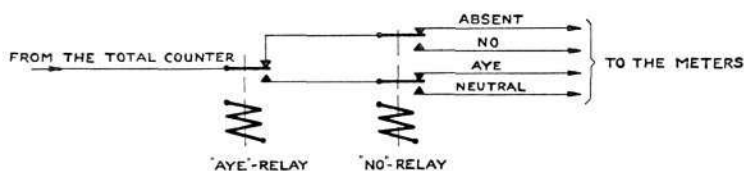
A simplified diagram illustrating the principle of the device is shown in fig. 4, in which two voters' positions are included. Each position has two relays, one *aye* relay and one *no* relay. In addition

former announces to the members that the voting may begin, while the latter show that the indicator meters are in their 0 positions when the voting starts. If an *aye* button at a voter's desk is now depressed, the *aye* relay of this desk is energized and is locked in position over its own contact and contact B. The

signal lamp of this desk is simultaneously lighted, either the *aye* button or the *no* button in depressed, i. e. independently of which vote has been cast.

As soon as the chairman has convinced himself that all who so desire have voted, he depresses button 2 in his control apparatus, thus breaking contact A. This results in the extinguishing of the voters' signal lamps and the chairman's green signal lamp, and no additional votes can now be cast since plus is no longer connected to the buttons. The *aye* and *no* relays which were actuated, however, remain energized, the locking coils being in circuit over contact B.

When the counting of the votes is to take place, the chairman depresses button 3, thus extinguishing the lamps in the indicator and actuating the contact arm of the counting meter. The movement of this latter makes a momentary connection between the + pole and each of the wires leading to the voters' positions. This position impulse passes over the switching contacts in the *aye* and *no* relays to either of the four vote meters, which one of them depending on the positions of the relays. If the *aye* relay is actuated, the meter for the *aye* votes will be actuated; if the *no* relay is energized, the meter for the *no* votes will be actuated; if both relays are energized, it will be the *neutral* vote meter and if no relay is energized it will be the *absent* meter. The switching process is made clear in a simple manner in fig. 5. After the



R 809 E

Fig. 5. Switching Diagram.

counting meter has passed all the wire contacts and the counting of the votes is completed, the counting meter stops and the indicator lamps glow so as to make the result of the ballot visible to all the members.

When the result has been put on record, the chairman manipulates the restoring key. All the meters are now restored to their 0-positions — this action being mechanical for the meters in the control apparatus and electrical for the register meters — the relays de-energized, and everything returns to normal. A new ballot can be taken immediately.

An electric voting device of this type must be reliable in every respect and absolutely free from all manner of hidden faults. In order to obtain the highest

degree of efficiency, therefore, this device has been composed chiefly of such parts as have already been used and thoroughly tested in the manufacture of other instruments. Also, the relays and counting meters are of a reliable, standard construction.

The efficient operation of the voting device was established by means of rigorous tests carried out by the inspection board of the Finnish parliament, previous to the acceptance of the installation. More than one hundred ballots were taken, all of them with correct result.

No matter how reliable a device may be, however, a fault of some kind is always possible, and a number of control devices have been provided to enable the immediate observation of a fault. As already mentioned, in addition to the *aye*, *no*, and *neutral* votes, the *absent* positions are also counted. This provides a most effective control, since the sum of the numbers given by the four indicator meters must always equal the number of members positions, or 199. Any trouble which may arise during the counting of the votes is immediately disclosed by means of this arrangement.

The signal lamp mounted in each voter's position also serves a purpose of control. The lamp glows when one of the position relays energizes, thereby giving notice that the vote cast from this position has been registered. An eventual fault in the push button or the corresponding relay, or on the line between these two is announced by means of this device.

The following figures give ample proof of the value of the automatic voting device. During 1925, the Finnish parliament took three hundred secret ballots for which a total time of seventy-five hours was required. With the voting device, the counting of the votes for one ballot requires but one and a half minutes. If one half minute — which should be sufficient — is allotted to the casting of the votes and the putting on record of the result, we arrive at a total of two minutes for each ballot taken. As a result the above three hundred ballots can be taken in a total time of ten hours with the electric voting machine, giving a direct saving in time of sixty-five hours. Also, the voters are given much less trouble by not having to step up to the ballot box to deposit their ballots. After a long debate, some times reaching far into the night, it often happens that a number of ballots must be taken; with the voting device these are disposed of very quickly, which certainly is a great advantage.

The voting device which has been installed in the

Finnish parliament is of the most simple type of construction.

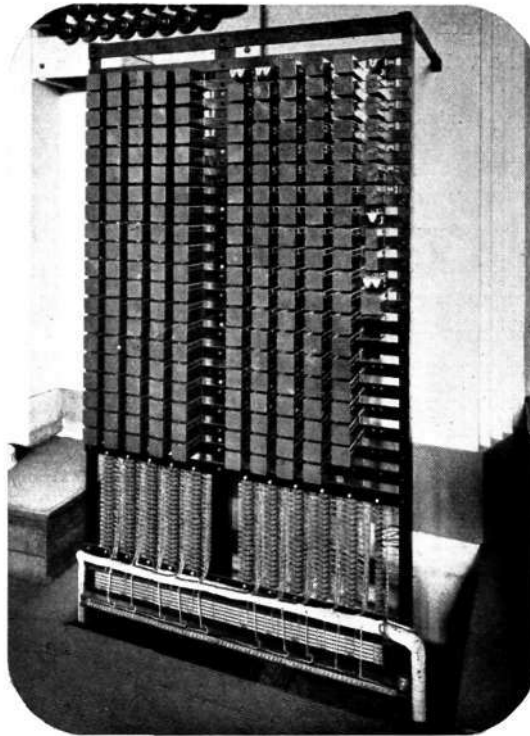
By means of suitable arrangements which can be added at will, it is possible to adapt this device for the taking of open ballots, the recording of the results, the separation of a casting vote etc.

While visiting Stockholm last October, prime minister Tanner of Finland was interviewed by the Stockholm papers. During the course of this interview, the subject of the voting machine was broached, and we take pleasure in quoting the following from one of the interviews:

“The prime minister then went on to praise the electric voting machine now installed in the Fin-

nish house of parliament and delivered by L. M. Ericsson. ‘It is simply wonderful’, he said, ‘It not only saves time, but also forces the members of the parliament to attend to business. A ballot may be taken at any moment, and then it is absolutely necessary for them to be present, as they otherwise lose their vote, thanks to the voting machine’. And with a compliment to the Swedish firm and to Sweden, the Finnish premier dismissed the reporters in order to have his baggage examined by the customs and leave for the city together with his both travelling companions.”

E. H. L.



R 903

Fig. 6. Relay Rack.

CONTENTS: The International Exhibition in Como. — In Memoriam: Leo Spøerhase. Stanislaw Grodzki. Anselm Van Minden. — Person to Person Long Distance Calls. — General Theory on Homogeneous Parallel Lines. — Interlocking Plant East of the Torup Station. — The International Chamber of Commerce and the International European Telephone Traffic. — The Automatic Voting Device of the Finnish Parliament.

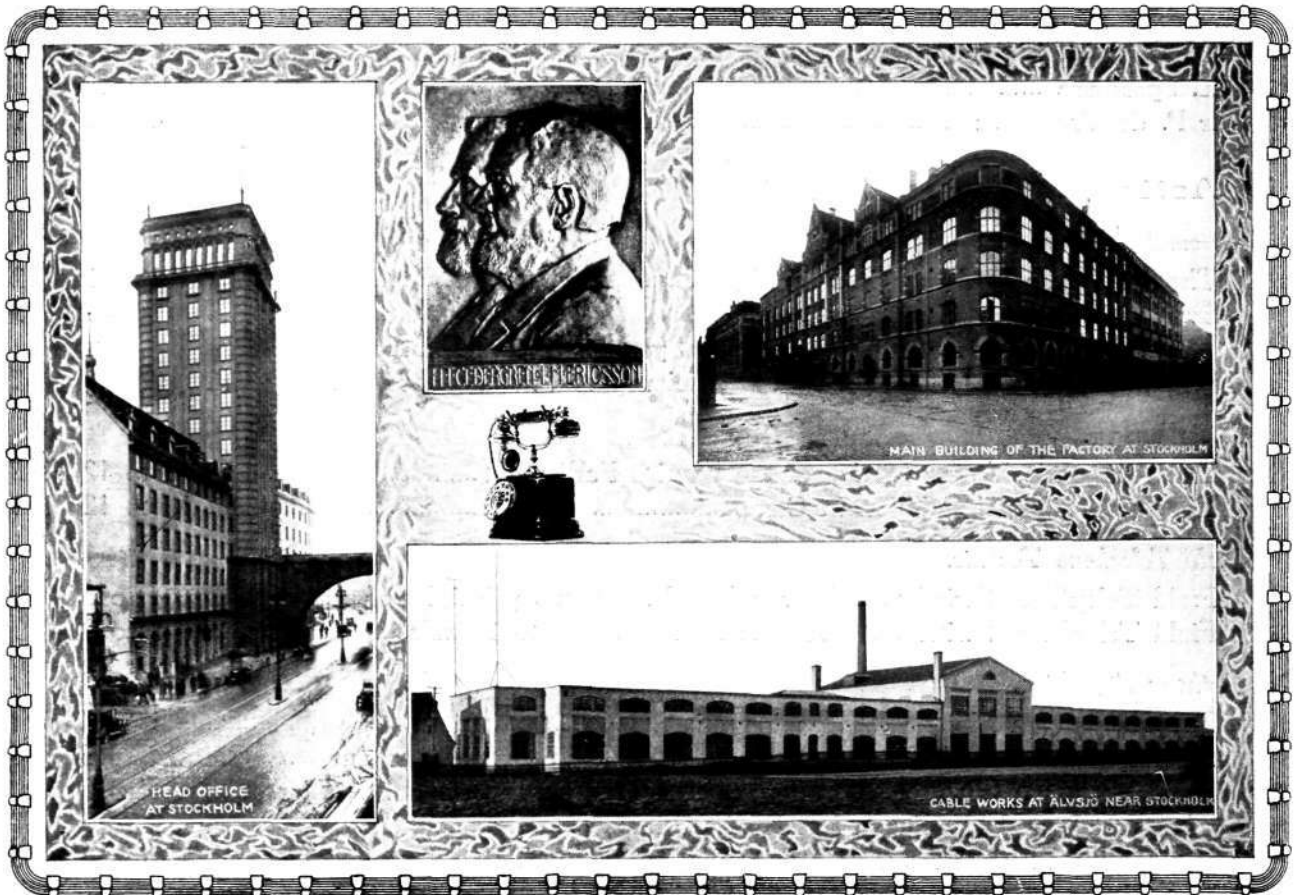
Vol. IV, 1927.

CONTENTS.

I. Biographical data.	Nos.	Page.
Per Edvard Allvén 50 years	4 to 6	32
Constance Andersson 60 years	1 to 3	21
The Burial of Erik O. Sandberg	7 to 9	81
Gustav Wettermark 50 years	4 to 6	32
E. G. Windahl 50 years.....	4 to 6	32
<i>Obituary.</i>		
Patrick Walter d'Alton	4 to 6	30
Carl Johan Andersson	7 to 9	78
G. d'Aulnis de Bourouill	4 to 6	31
S. Grodzki	10 to 12	116
A. Van Minden	10 to 12	116
Erik Oskar Sandberg	7 to 9	79
L. Spørhase	10 to 12	115
Ir P. de Vries D. zn.	4 to 6	31
 II. Articles.		
<i>Automatic Exchanges.</i>		
The Automatic Exchange in Forli, Italy.....	1 to 3	12
Swedish Telephones in Angora	1 to 3	5
The L. M. Ericsson Automatic Telephone System. Experiences from the Stockholm telephone net concerning the efficiency and maintenance of the system	7 to 9	82
<i>Miscellaneous.</i>		
The Automatic Voting Device of the Finnish Parliament.....	10 to 12	147
The International Exhibition in Como	10 to 12	114
<i>Field Telephone Technic.</i>		
Field Telephone Switches and Switchboards. Various principles of construction	4 to 6	51
Field Telephone Switchboard for Buzzer and Magneto Signals.....	7 to 9	79
<i>Railway Signalling.</i>		
The Hässleholm Electric Interlocking Plant	1 to 3	14
Automatic Section Blocking on the Line Stockholm Östra—Stocksund	4 to 6	41
Electric Light Signal Installation for the Electric Railway Stockholm—Djursholm	4 to 6	49
The Skövde and Herrljunga Interlocking Plants	7 to 9	87
Interlocking Plant at the Track Junction East of the Torup Station	10 to 12	140
<i>Private Intercommunication Installations.</i>		
Local Telephone Installations with Push Button Intercommunication Telephone Instruments	7 to 9	99

L. M. Ericsson

<i>Wireless.</i>	Nos.	Page.
On Various Principles of Receiver and Loud-Speaker Design II	4 to 6	34
<i>Outside Plant.</i>		
Projecting City Telephone Nets. According to the Ericsson System of Cable Distribution	7 to 9	105
<i>National and International Toll Service.</i>		
American and European Toll Traffic	1 to 3	22
The International Chamber of Commerce and the International European Telephone Traffic	10 to 12	143
Person to Person Long Distance Calls	10 to 12	117
<i>Design.</i>		
Dial Type of Impulse Transmitters	1 to 3	26
<i>Time Control.</i>		
Time Control and Efficiency	7 to 9	94
<i>Theoretical.</i>		
General Theory on Homogeneous Parallel Lines	10 to 12	123



R. 659