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On the Cover: Telephone Instrument supplied to the Military Club, Teheran, for H. M. Reza Chah Pahalavi

Automatization of the Suburban Telephone Network of Stockholm

N. RÖNNBLOM, ADMINISTRATIVE ENGINEER, ROYAL BOARD OF TELEGRAPHS, STOCKHOLM

The suburban area of Stockholm is an area outside Central Stockholm but within a distance of about 15 km from the centre of the city. More than 30 000 subscribers are at present connected to the telephone system of this area, in which the conversion to the automatic system was started methodically and now has developed so far, that the fourth of the automatic exchanges of the district has been put into service. These exchanges are, like the exchanges of Stockholm, made by Telefonaktiebolaget L.M. Ericsson. They are of the Ericsson machine-driven system with 500-line selectors. After the completed automatization the district will have some 23 automatic telephone exchanges. The following report on the planning and the carrying out of this automatization is reproduced from a lecture given before the Swedish Society of Electrical Engineers on February 26, 1936.

General Planning

The free-traffic district of Stockholm, or the area, including Stockholm, inside which all subscribers are allowed to call one another without paying anything above the fixed subscription rate, covers a very extensive area. This district has about 120 telephone exchanges with about 40 000 connected subscriber lines outside Central Stockholm. The part of the district outside Central Stockholm but situated within a distance of 15 km from the centre of Stockholm contains about 80 % of those subscriber lines. Although the latter part of this district also includes parts of the city of Stockholm, it will here for the simplicity be regarded as the suburban area of Stockholm.

Once the automatization of the network of Central Stockholm was thoroughly commenced, the Royal Board of Telegraphs in 1929 started extensive investigation into the conversion to the automatic system of the remaining part of the free-traffic district. To begin with great advantages, both technical and economical, from the automatization of the suburban area of Stockholm could be expected. It was thus advisable to plan and to carry out this automatization in immediate connection with that of Central Stockholm. Regarding the other part of the free-traffic district on the other hand the question of the automatization is at present being discussed in connection with the present planning of the automatization of the telephone system of the whole country.

As to the technical advantages of the automatic telephone the subscribers of the suburbs will no doubt have only one opinion. Earlier this area was provided with telephone exchanges exclusively of the local-battery system. The suburban inhabitants, having good connections with Stockholm, have thus had very good opportunity to compare the service of these exchanges with that of the automatic exchanges of Stockholm. On this comparison the automatic telephone of course must appear to be highly superior because of the immediate clearing after a finished call and the very low percentage of wrong connections. In addition to this the subscribers of the small exchanges also get the much appreciated advantage of all-night service.

The choice of the number series for the suburban automatic network was not difficult to make, and it was decided that the subscribers of this area should also be allotted numbers of the six-digit series used for the subscribers of Central Stockholm. A good reason for this is that the suburban subscribers to a large extent have their work in Stockholm and their telephone-traffic chiefly connected with that city. The alternative possibility of allotting every exchange a special number to be dialled before the extension number when calling from another exchange would have been more inconvenient to all of the subscribers than the six-digit numbers.

As the automatic telephone exchanges of central Stockholm were delivered by Telefonaktiebolaget L. M. Ericsson and are of the Ericsson system with 500-line selectors, it was desirable from the maintenance point of view to use the same system also for the suburbs. The exchanges with 500-line selectors delivered by Ericsson for foreign countries have always been for 24 V and with the selector made for multiple frames with 7 mm between the line groups. The system used in Central Stockholm is made with microphone feeding and operation at 48 V, and it also has comparatively big selectors, their size being due among other things to the multiple frames with 9 mm between the line groups. However when ordering the material for the suburbs the Royal Board of Telegraphs has gone over to the normal Ericsson type. The suburban exchanges delivered up till now are thus for 24 V and with the smaller type of selector.

A great deal of work bas been devoted at the Royal Board of Telegraphs to fixing the suitable size of the areas for the automatic suburban exchanges. From this it has appeared that the arguments technical as well as economical generally are in favour of larger exchange areas than was possible when the exchanges were manual. For calls between subscribers of different manual exchanges the name of the exchange has first to be ordered and then the subscriber's number. In such circumstances it is necessary to a large extent to take into consideration the natural wishes of the subscribers to be able to call a telephone exchange with the name of the suburb where the wanted subscriber lives. For instance a subscriber at Saltsjö-Duvnäs does not like that a caller from Stockholm has to call him by ordering Ektorp, at which suburb the telephone exchange is situated, and also the caller of course will find it easier to call Saltsjö-Duvnäs in this case. Consequently every suburb with a reasonable number of subscribers has to be provided with its own telephone exchange, as long as the exchanges are operated manually. When all calls are made by using numbers not indicating the name of the exchange, this relation between the name of the exchange and that

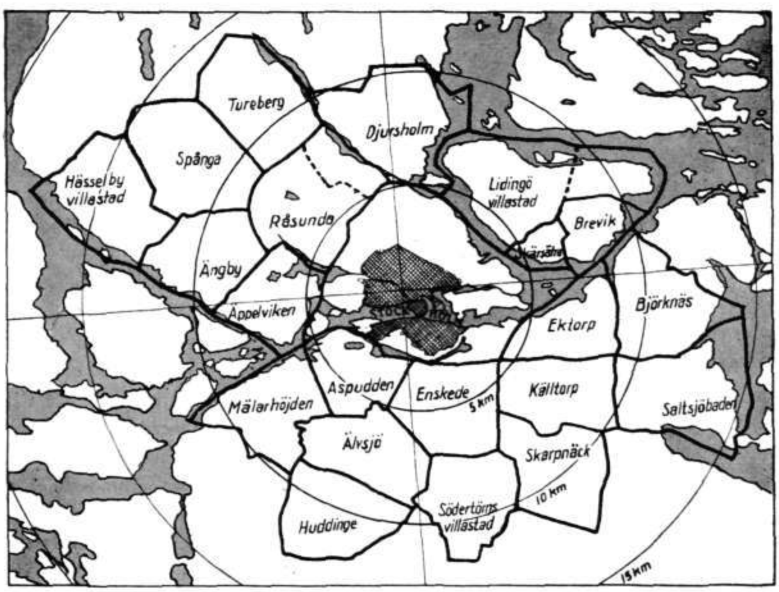

Fig. 1 X 5283
Map showing the Stockholm suburban district

of the suburb disappears, and the exchanges can be arranged at places and with exchange areas being most advantageous from technical and economical point of view.

When fixing suitable exchange areas for the suburbs it is necessary to take into consideration, on the one hand, that a certain saving of erection cost for the exchanges and their junction lines with Stockholm is achieved by the exchanges being made bigger, and, on the other hand, that the local network will be more expensive with increase of the area. Finally the areas cannot be chosen too large on account of the attenuation of the feeding and speech currents not being allowed to exceed a certain limit. Considering these reasons and the position of the suburbs and their population, the exchange areas can be chosen, which would probably be most suitable.

On the map, Fig. 1, the exchange areas are shown as hitherto decided or proposed for the automatization of the suburban area. If the proposed areas prove to be suitable at the further investigation now going on, before the final decision is made, there will be a total of 23 automatic exchanges within the suburban area, which then will replace 55 manual exchanges. Below some figures are given regarding the four exchanges which are already completed, and the Enskede exchange, which is now being put up. For the Äppelviken exchange a first extension of an additional 2 000 lines is already ordered.

	Subscribers' Lines	
Exchange	January 1, 1936	First Stage
Lidingö villastad		2 000
Lidingö-Brevik	1 578	500
Lidingö-Skärsätra		500
Äppelviken	5 152	7 000
Enskede	3 424	5 500

General Technical Arrangement

When the automatization of the network of Central Stockholm was planned initially, there was no possibility to figure the most suitable details of an automatic system also including the suburbs. The maximum number of subscribers that can be connected to a local system, is dependent upon the stages of selectors and the registers, and therefore a maximum capacity of 220 000 subscriber numbers was chosen. This number is not sufficient to include also the suburbs. Therefore it was necessary to alter the registers slightly in Stockholm for the carrying out of the suburban automatization. This alteration was made in such a way that the registers at present can give at least 430 000 subscriber numbers in the same six-digit number system. It proved to be very simple once it was facilitated by changing the subscriber numbers in Stockholm beginning with the two digits 36, 38, 55 and 67 by letting them begin with 32, 33, 51 and 62 respectively. The alteration included 1 168 registers. The registers manufactured after 1932 were made for the greater capacity. Later they can be altered to a capacity of at least 600 000 subscriber numbers simply by a simple reconnection of the circuits, which is sufficient for the whole free-traffic district of Stockholm. Further it was impossible to start the automatization of the suburbs of Stockholm until a number of technical problems were solved, which in many cases has led to the introduction of new designs for the mechanical equipment.

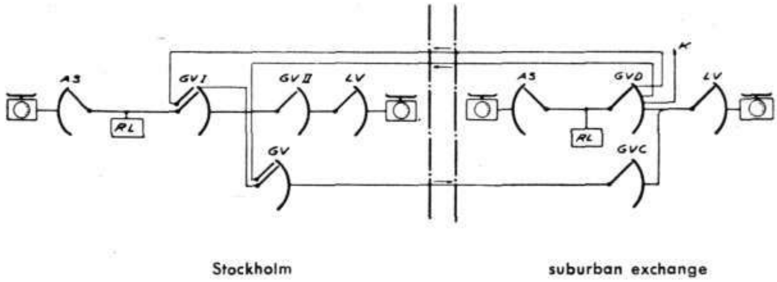

Fig. 2 X 5275

Diagram of the automatic ways of the suburban network

- AS call finder
- GV additional group selector
- GVI first group selector
- GVII second group selector
- GVC group selector for local traffic from Stockholm
- GVD group selector for traffic within and from the suburban exchange
- K junction lines for short-cut traffic
- LV final selector
- RL register for local traffic

Fig. 2 shows the circuit diagram of the selector arrangement, on which the automatization of the suburbs has been based. The original selector arrangement for Central Stockholm is still used for effecting connections between its subscribers, and it includes line finders *AS*, first and second group selectors *GVI* and *GVII* and final selectors *LV* and in addition to this the local registers *RL*. To the right in the diagram the selectors on a suburban exchange are shown. For the local connections at this a series selectors is used, incorporating line finders *AS*, group selectors *GVD*, final selectors *LV* and then also registers *RL*, which are in some ways different from the Stockholm registers. For the group selectors *GVD* a maximum number of 20-line groups or multiple frames are used for the local traffic. As the final selectors are of the 500-line type, the natural maximum capacity of an exchange unit in the system thus becomes 10 000 subscriber lines. Some of the 500-line groups of this unit can be made as satellites to a suburban exchange arranged as main exchange, as the case is at Lidingö.

For traffic from the subscribers of Central Stockholm to the suburban subscribers a number of selectors is used consisting of besides line finder and group selector also an extra or third group selector *GV* in Stockholm connected over the first multiple frame of the selector *GVI*. From the group selectors *GV* line groups radiate to the various 10 000-line groups of the suburban exchanges. At a suburban exchange each such line group is connected to group selectors *GVC*, which operate parallel with the mentioned group selectors *GVD*. Between the selectors *GVD* and *GVC* there is the difference that at the first mentioned the last twenty and at the latter the first twenty multiple frames are connected to the selectors *LV*. This is to enable the calls from the suburban subscribers to Stockholm and other exchanges to be led via the first multiple frames of the selectors *GVD* in order to reduce the switching time. Further it is evident that the increase in the available number series has been achieved by introducing the extra group selector *GV* at Stockholm.

The connections from the suburban subscribers to the subscribers of Central Stockholm are made via line finders *AS* and group selectors *GVD* at the suburban exchange via the junction lines to Stockholm and then over group selectors *GVI* and *GVII*, and final selectors *LV*. In order to avoid switching over too many selector stages at connections between subscribers of the different suburban exchanges there have been made arrangements for the introduction of short-cut connections, shown at *K*, between suburban exchanges with high intercommunicating traffic. A special bundle of junction lines from the selectors *GVD* at a suburban exchange to the group selectors *GV* at Stockholm is also arranged for this reason, and this bundle is used when the register at a suburban exchange receives the number of a subscriber at another suburban exchange, to which short cut connection is not available.

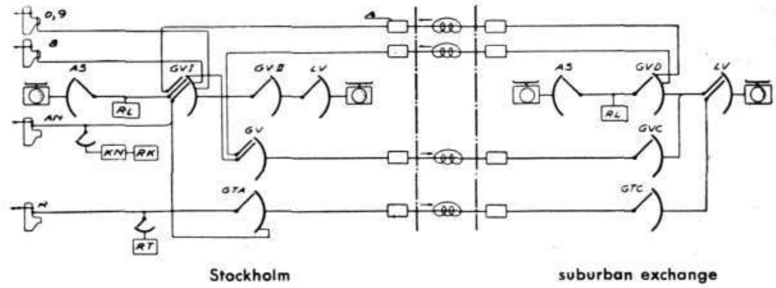

Fig. 3 X 5276

Diagram of the automatic and manual ways of the suburban network

AN incoming junction-traffic
AS call finder
GV additional group selector
GVI first group selector
GVII *second group selector*
GVC group selector local traffic from Stockholm
GVD group selector for traffic within and from the suburban exchange
GTA trunk group selector
KN key-set exchange
LV final selector
R trunk exchange
V *relay repeater*
RK register for the key-set exchange
RL register for local traffic
RT register for the trunk exchange

The extra group selectors *GV* at Stockholm and also the group selectors *GVI* used in Stockholm for the connection of calls from the suburban exchanges are mounted in a special telephone exchange called the automatic junction-traffic exchange. The mounting of those selectors together in one exchange of course is because the line bundles between Stockholm and the suburbs ought not to be split to the different local exchanges of Stockholm on account of economical reasons.

Fig. 3 shows a more complete diagram of the traffic ways of the suburban automatic system, as used for instance at the Äppelviken exchange. In this diagram the outgoing line groups are also shown, which lead from the selectors *GVI* to the special manual exchanges in Stockholm indicated by *0, 8* and *9,* and over which connections are effected from the Stockholm as well as the suburban subscribers to name-call subscribers, subscribers of manual suburban exchanges, and for ordering trunk calls. Connections to the suburban automatic exchanges from manual exchanges within the free-traffic district outside Central Stockholm are switched at a special exchange *AN,* the incoming junction-traffic exchange in Stockholm, to lines terminating in group selectors *GVI,* being then completed via selectors *GVI, GV, GVC* and *LV,* which in this case are operated from a special branch of the key-set exchange in Stockholm, where certain operator's positions for the purpose are fitted with six-digit key sets *KN* and registers *RK.* The connections from the still manual exchange Norr in Stockholm to the automatic suburban exchanges are effected in a corresponding way.

At the first mounted exchange at Lidingö villastad a manual switchboard is provided, over which the trunk-call connections are effected. Trunk-call connections however to the satellite exchanges at Lidingö are switched via selectors at those exchanges by the operator at Lidingö villastad, see Ericsson Review No 4, 1933. Yet at Äppelviken, Enskede and probably also the future exchanges it is arranged for automatic switching of the trunk calls. The trunk operator in Stockholm switches as shown in Fig. 3 to a line terminating in a special selector *GTA* at the trunk exchange, and then the wanted connection can be established over this selector and then over special group selectors *GTC* and final selectors *LV* at the suburban exchange in question. The operation of the selectors is directed by registers *RT* at the trunk exchange, which registers are manipulated by the trunk operators. The connections established in such a way allow the operator to cut off a local connection as usual.

The junction lines connecting the suburban automatic exchanges with the junction traffic exchange of Stockholm or running between those first mentioned exchanges are two-wire lines, or in some cases they are also phantomized, this by way of distinction from the lines between the automatic exchanges of Stockholm, which are three-wire lines. In the first place this of course is due to economical reasons. In one special case, *viz.,* for the lines between the Lidingö exchanges, three-wire lines proved to be less suitable from a technical point of view because of the electrical railway system of Lidingö causing considerable voltage differences between the earth plates of the exchanges and thus disturbing the circuit of the third wire.

The circuits of calling and clearing signal, the remote operation of the selectors etc. are transmitted with the two-wire lines over the same wires as used for the conversation. These operation signals are furthermore transmitted via the loop in order to avoid the disturbing effect on the lines close by and also disturbances caused by different earth potential at the exchanges. As the same operation signals are transferred by the selectors over three or four wires and with two or four mutually independant circuits, it is quite evident that the two-wire lines at each end have to be provided with relay sets or repeaters for transforming the operation signals to or from a condition suitable for the two-wire loop. For the same reason repeaters have to be arranged where the operation signals have to be transmitted with AC. Repeaters of this type are shown at *r* in Fig. 3, and for the installed exchanges these repeaters were designed and delivered by Ericsson.

Installation and Transfer

The first automatic exchange in the suburbs of Stockholm was Lidingö villastad, which was put into service for local traffic and outgoing calls to and via Stockholm on February 3, 1933. Calls from Stockholm were switched at the manual switchboard until January 12, 1934, when the automatic equipment for the last mentioned traffic direction could be put into service as well as the satellite exchanges Lidingö-Brevik and Lidingö-Skärsätra. The exchanges Lidingö Villastad and Skärsätra are installed in existing buildings, but for the exchange at Brevik a special exchange house, Fig. 4, has been built. The small satellite exchanges not having permanent maintenance staff of course only require small houses with a small room for the selector racks and main distributing frame and a place for the batteries. The selector equipment at Lidingö is of the Ericsson unit system, which has one rack for each 500-line group, containing line relays, line finders *AS*, group selectors *GVD*, registers *RL* and final selectors *LV*. Special racks are provided for the repeaters, the group selectors *GVC* and the registers of the satellites.

As a speciality for the Lidingö exchanges the lines Stockholm—Lidingö are arranged for the transmission of the operation signals with 50 c/s AC only. In such a way the physical as well as the phantomized circuits of the junction cable could be used. The design of the repeaters for these circuits is very interesting because of the remote operation of the selectors being controlled by revertive impulses, which means, that a selector starts its movement after receiving a start impulse from a register. During the movement it is sending signal impulses back to the register on reaching each line or line group. These revertive impulses are produced by the selector as DC impulses, which are transformed to AC impulses in the repeater at the beginning of the line and then again re-transformed to DC impulses at the end of the line. The last mentioned impulses are then transmitted to the register. During the operation of the revertive impulses a stopping signal can be transmitted over the line from the register to the selector, so that every selector movement can be stopped, when a position is reached corresponding to the number dialled into the register. A further description of the revertive-impulse control used for these repeaters is to be found in the Ericsson Review No 3, 1934. Transmission of operation signals with AC is especially intended for long lines, where something may be gained by using the phantom lines.

Fig. 4 X 3573
Lidingö-Brevik telephone exchange

The fourth automatic suburban exchange has been installed at Äppelviken, where it is intended to replace the old manual exchanges Nockeby, Ulvsunda, Ålsten and Äppelviken. It was ready in the beginning of 1936, and already from the beginning it was put into service as a sort of relay exchange. The distribution of the Stockholm telephone directory starts early in January, and in the directory of 1936 the subscribers of the Äppelviken district have been furnished with six-digit numbers. The subscribers of the district then at once could use their new numbers for their calls. For this purpose the final selectors of the automatic exchange have temporary been connected parallel to the calling devices of the remaining manual exchanges, where the operators after re-informing about the subscriber number can complete the connection. On February 21, 1936, all the subscribers of the manual exchange at Äppelviken were cut over to the automatic exchange. The remaining three exchanges will be cut over successively during the months March—May.

The Äppelviken automatic exchange is accommodated in a new building, Fig. 5, which has been built especially according to the requirements. It has two stories and a basement. Similar buildings will be put up for the remaining bigger suburban automatic exchanges. The first floor accommodates the selector equipment of the exchange. Regarding the mounting it is to be noticed, that there is a special rack, Fig. 6 and 7, made for each 1 000-line group of subscribers. Those racks have been placed straight across the selector room and contain line relays, line finders *AS*, group selectors *GVD*, registers *RL* and final selectors *LV*. This grouping enables a better disposition for bigger exchange units than the 500-line groups. Special racks are mounted for the repeaters of the junction lines and the group selectors *GVC* and *GTC*. Another speciality in the mounting of the racks is the sound insulation. The Ericsson system is no doubt one of the most noiseless automatic systems, but in order to make the rooms arranged on the ground floor quite sound-proof the racks have been insulated from floor, ceiling, pillars and walls with cork plates 60 mm thick. The selector and relay equipment is of the same type as for the Lidingö exchanges with a few exceptions due to the arrangement for automatic switching of trunk calls. Thus the upper part of every panel for final selectors is provided with four wires per line in the multiple two on each side of the contact arm, to such an extent that maximum 10 final selectors with four-wire contact arm can be inserted for trunk call connections. The fourth wire enables the arrangement of special functions for the trunk calls. Thus a subscriber line can be kept busy for trunk calls and at the same time be disengaged for local calls, this during the time when the trunk exchange has switched on to the line for preparing of a trunk call. Further the fourth wire has been used for an operating circuit, by means of which the trunk operator gets a special reference tone from subscriber lines which are not allowed to order or to

Fig. 5 X 5278
Äppelviken telephone exchange

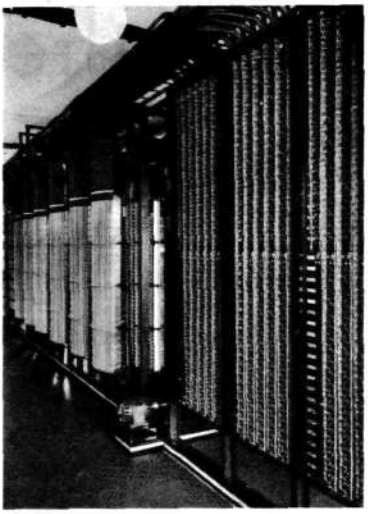

Fig. 6 X 3574
Back view of 1 000-line unit row a the Äppelviken automatic exchange

receive certain trunk calls. It has also been used for another operating circuit enabling a queue service of successive trunk calls to the same subscriber. The group selectors *GTC* are of the earlier mentioned big type. They also have four wires per line in the multiple, but three of the wires are here placed on the same side of the contact arm.

The ground floor of the Äppelviken exchange accommodates the main distributing frame, a public room for the expedition of telephone calls and telegrams and a flat for the mechanic. In the basement there is a battery room, garage and store rooms.

As earlier mentioned the trunk exchange in Stockholm has also been provided with additional equipment to enable the switching of trunk calls via the selectors. This equipment, which also contains several technical novelties, has been made by the Royal Board of Telegraphs, was considered the most suitable, as it had to be fitted into the other complicated technical equipment of the trunk exchange. As mentioned the trunk operators have to indicate the wanted number themselves to the registers *RT*, by means of which the selector operation is directed. For this purpose every operator's position has a special key set, consisting of a round frame with an outer diameter of 80 mm. On the top side it is fitted with 10 self-restoring keys numbered *0—9*. Once the trunk operator has plugged up the cord or a corresponding device, she is connected to a register *RT*, which is indicated by dialling tone from this register. Then she has only to momentarily press the keys in the proper sequence according to the digits of the six-digit number. In doing this a register *RT* immediately receives the number indication. This register consists of selectors of the construction of the Royal Board of Telegraphs, and it is made in such a way that it is operated immediately and without preceding selector movements into positions corresponding to the pressed keys. The part receiving the revertive impulses consists of relays. The registers *RT* are further made in such a way that they permit a switching straight from the trunk operator's positions to subscribers of Central Stockholm via selectors *GTA* and local selectors *GVI*, *GVII* and *LV*, thus giving a new possibility for switching of trunk calls at nights inside Stockholm without using a manual switchboard. For this however it is necessary to give up the facility of cutting off existing local connections. The selectors *GTA* at the trunk exchange are of the Ericsson design and of the same type as the selectors *GTC*, *i. e.*, with four-wire lines. The fourth wire is needed to transmit an operating signal for cutting off on behalf of trunk calls from the trunk operator's positions and also for the transmission to those positions of the signal which indicates if the connected subscriber has lifted his receiver or not.

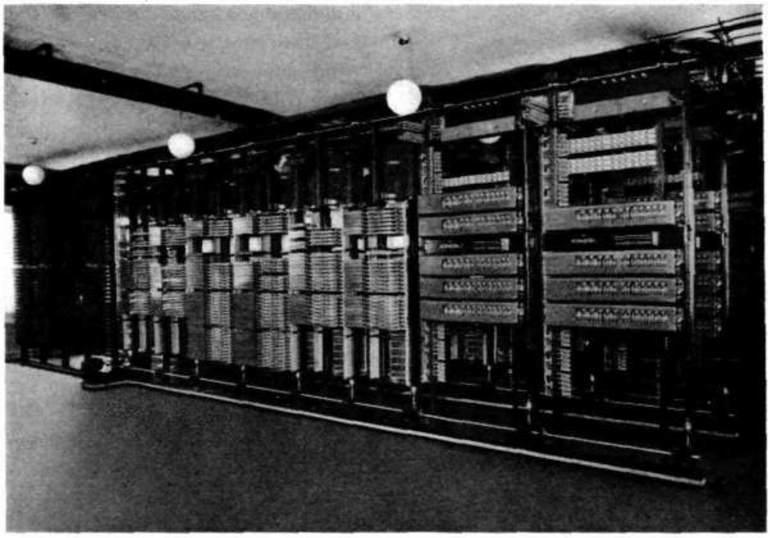

Fig. 7 X 3277
Front view of 1000-line unit row at the Äppelviken automatic exchange

Automatic Exchange on the Ericsson System in Morocco

HJ. NORÉN, TELEFONAKTIEBOLAGET L. M. ERICSSON, STOCKHOLM

The local telephone network of Tangier and neighbourhood has for some years been owned and operated by a Spanish company, Rotondo y Cía. In 1933 this company commissioned Telefonaktiebolaget L.M. Ericsson to construct an automatic telephone exchange and a new network of subscribers' lines in Tangier. This new equipment was put into service on December 22nd, 1935 and since that date has operated very satisfactorily.

Fig. 1 X 3570
Tangier telephone exchange

The old equipment, which was on the LB system, had also been entirely supplied by Ericsson. As it was still in good condition when it became superfluous for Tangier, it will probably be set up in some other part of Morocco. The new telephone exchange, which also comprises a manual switchbord for trunk traffic with the French and Spanish zones in Morocco, is located in a large new building which also contains offices, storehouse, dwellings, etc.

The automatic exchange is on the Ericsson machine-driven system with 500-line selectors and is built in unit racks for 500 lines each. Each 500-line group has place for 10 registers, 40 cord circuits with line selectors and group selectors, together with 40 final selectors. The installation at present comprises three 500-line groups, *i. e.* a total of 1 500 lines. The exchange can be extended to take up to 5 000 lines. In view of the present intensity of traffic, only 7 registers, 25 cord circuits and 25 final selectors have been put in per 500-line group. With these devices the maximum of calls that can be handled simultaneously by the exchange is 75. The registers are made for four digits and five special directions. The special numbers have two digits. Thus *01* is used for ordering trunk calls and *02* for complaints. The other special positions have not yet been put into use.

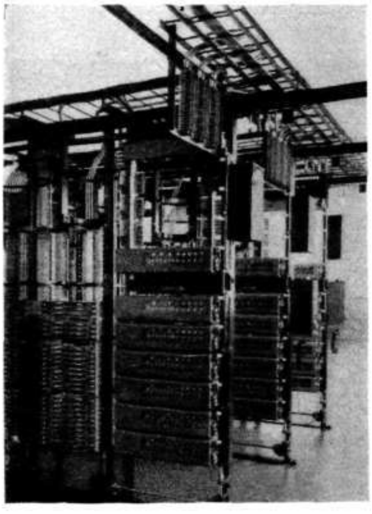

Fig. 2 X 3553
Automatic exchange
with the three 500-line unit racks

Ten junction lines lead from the manual switchboard to the automatic exchange for the establishment of trunk calls. These junctions come into the automatic exchange on ten of the ordinary subscribers' lines. The registers and the cord circuits are specially equipped to enable them to deal with trunk connections. The final selectors are thus the same for both trunk and local connections. They are so designed that on trunk call they test on a subscriber engaged locally without, however, interrupting the conversation which is in progress. In such case the operator can communicate with both the local subscribers. The local call can be cut off and trunk connection is then made with the called subscriber. When a call comes for a subscriber engaged by a trunk call the final selector does not test. Short buzzer signals in the operator's instrument indicate that the subscriber is engaged by a trunk call. In addition to the ten junction lines, the manual switchboard has ten order lines from the automatic station and ten connecting lines to the French and Spanish trunk exchanges in Tangier. All the lines connected to the switchboard terminate in jacks. Operation is by cords.

The equipment is provided with two 24 V batteries which are used alternately. Each of the batteries has a capacity of 360 Ah. There are two charging units, one driven by an electric AC motor fed from the town mains and the other, intended as reserve, driven from a petrol engine.

Fig. 3 X 5283
Interior of the automatic exchange
left, rear of unit racks; right, main distributor

For supervision of the subscribers there are in the exchange two traffic supervision boxes. These are equipped with lamps which indicate how each connection in the exchange proceeds. Subscribers can be assisted from the traffic supervision boxes to obtain the required number and, if it appears that they are unable to operate their instruments properly, they can be given instructions. The automatic exchange is in addition provided with alarm devices in the form of lamps and signal bells, which attract the attention of the exchange staff when faults or blocking of the connecting devices occurs. For the testing of the lines and the subscribes' instruments there is a test apparatus with test instruments and test batteries, and for the testing of all the connecting devices of the exchange a portable test apparatus is provided. The installation also comprises a tool cabinet with the necessary tools.

Seeing that there are already more than 1 000 subscribers in Tangiers and their number is increasing rapidly, extension of the exchange will become necessary fairly soon.

Some Methods of Testing Electricity Meters

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

A short description of Ericsson's testing department for electricity meters was given in Ericsson Review No 3, 1935. Below will be found a brief survey of the most usual methods of adjustment together with a description of how electricity meters manufactured by Telefonaktiebolaget L.M. Ericsson are adjusted and tested before leaving the factory.

Like weights and measures and measuring instruments in general, electricity meters require to be adjusted and tested in order to ensure that they fulfil their purpose properly. By *adjustement* of an electricity meter is understood the setting of the regulating devices on the meter itself so that errors may be as small as possible and in any case not outside fixed limits, the limits of error. By *testing* of an electricity meter on the other hand is understood the ensuring that the error of the adjusted meter does not exceed the fixed limits on certain determined conditions of load, and ensuring further that the meter fulfils other stipulations concerning its operation.

Adjustment with Stop-Watch and Wattmeter

A number of different methods for adjusting electricity meters have been evolved. All these methods are in principle based on the same principle: the meter is adjusted with the help of an accurate stop-watch and one or more wattmeters when kWh meters are to be adjusted or ampère meters when Ah meters are concerned. Single-phase kWh meters, when adjusted by this method, are connected up as shown on Fig. 1 and 2, while three-phase meters for different phase loads are connected according to Fig. 3 and 4. The current generator G_I feeds the current coil of the meters with low-tension current disconnectable at will. In the same way the tension generator G_E feeds the tension coil of the meter with the meter's indicated tension. One of the generators, usually the tension generator, is provided with such arrangements that phase shift between current and tension can be arranged at will. For this purpose it is necessary that both generators be mounted on the same shaft. The generators can naturally be replaced by transformers with tappings and an induction regulator for adjusting the phase shift. The transformers and the induction regulator must be fed with AC of constant tension and frequency. After the meters have been connected up and put under load and they are running continuously adjustment may begin.

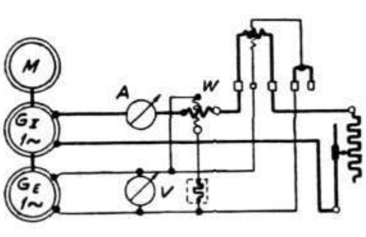

Fig. 1 X 3555
Connection diagram for adjustment of single-phase meter
one-pole connection

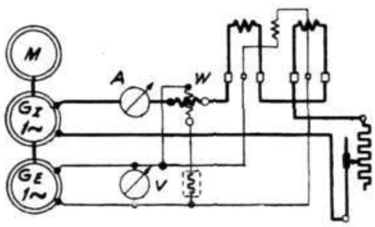

Fig. 2 X 3556
Connection diagram for adjustment of single-phase meter
two-pole connection

To find the error of the meter with a certain load it is necessary to determine: the load, the time the load is applied, the corresponding number of revolutions of the rotor disc, together with the number of revolutions per kWh which the meter rotor disc should make if the error were zero. Suppose that
W = load in watts according to the wattweter,
N = the number of revolutions made by the rotor disc at this load,
t = the time in seconds required by the rotor disc to make N revolutions when the load is W watt and the error zero,
t_1 = the time in seconds, according to the stop-watch, taken by the rotor disc to make N revolutions when the load is W watt,
C = the number of revolutions the rotor disc must make for 1 kWh with load W watt and error zero,
C_1 = the number of revolutions the rotary disc must make for 1 kWh with load W watt,

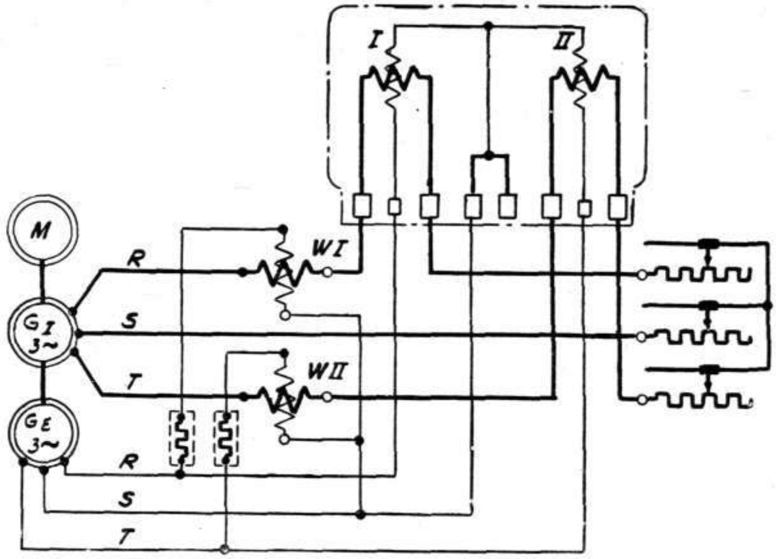

Fig. 3 X 5268
Connection diagram for adjustment of three-phase meter
for unbalanced load without neutral

then $C_1 = \frac{N \cdot 3\,600 \cdot 1\,000}{t_1 \cdot W}$ turns

If $\triangle$ = error of the meter in %,

then $\triangle = \frac{C_1 - C}{C} \cdot 100\ \%$

or, if $C_1 = \frac{N \cdot 3\,600 \cdot 1\,000}{t_1 \cdot W}$

and $C = \frac{N \cdot 3\,600 \cdot 1\,000}{t \cdot W}$

then $\triangle = \frac{t - t_1}{t_1} \cdot 100\ \%$

If t is greater than t_1 then the meter runs too fast (positive error).
If t_1 is greater than t then the meter runs too slow (negative error).

Thus by observing the load W of the meter, the number of revolutions made by the meter rotor disc at this load and the corresponding time, it is possible to determine the margin of error of the meter and adjust it.

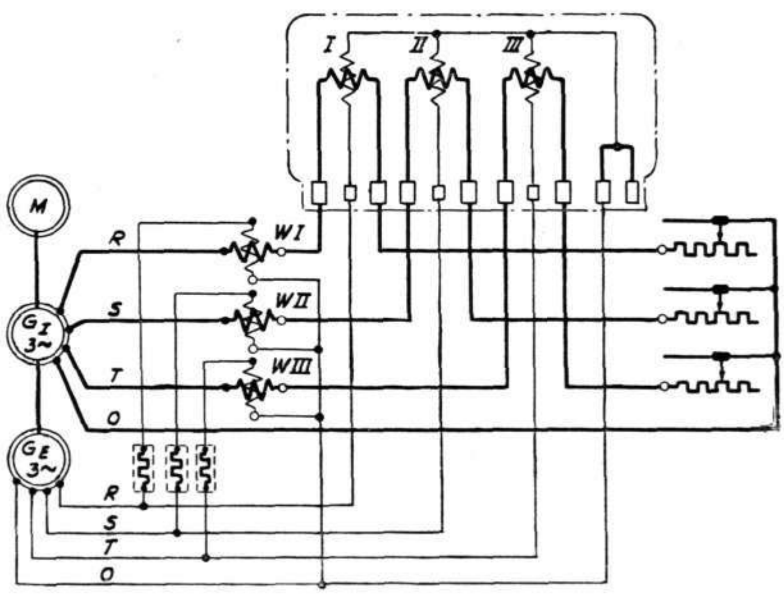

Fig. 4 X 5269
Connection diagram for adjustment of three-phase meter
for unbalanced load with neutral

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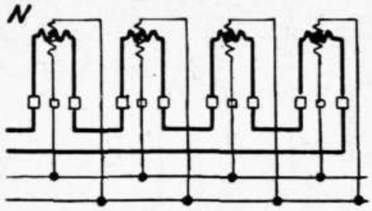


Fig. 5 X 3557

Connection diagram for synchronous adjustment of single-phase meter with standard meter

Synchronous Adjustment with Standard Meter

This is another method often employed for adjustment of electric meters since it calls for a very small amount of instruments. The adjustment is made with the help of a standard meter, *i. e.*, a meter identical to the meter to be adjusted but which has been accurately adjusted on the above-described method. The standard meter *N* and the meter to be adjusted are connected with the current coils in series and the tension coils in parrallel to the same tension supply, this last having the same voltage as the nominal tension of the meter, see Fig. 5.

While the meters are without current and tension all the rotor discs are set so that the marks made on them are in the same position. Current and tension are then connected, after which the meters are allowed to run for a convenient time, say 30 s, with the nominal tension, the smaller the load the longer the time of running. The current and tension are then cut off and it is observed whether the unadjusted meter's rotor disc takes up the same position as the disc of the standard meter. The process is repeated with longer and longer times of rotation until the standard meter and the unadjusted meter run synchronously within the permitted limits of error.

Synchronous Adjustment with Standard Meter and Stroboscope

This is a third method which has recently been much used, particularly for adjustment of electricity meters on a large scale. With this method also a standard meter is used, the current coil being connected in series with the current coil of the unadjusted meter and the tension coils being connected in parallel, see Fig. 6.

The rotor discs of both the standard meter and the unadjusted meter are provided with a large number of slits or holes evenly distributed round the peripheries of the discs. By the use of various stroboscopic devices a light beam can be made to flash in accordance with the holes or slits of the standard-meter disc. If this light beam in one way or another be projected on the disc of the unadjusted meter there is obtained a picture turning in one sense or the other as the meter is running too fast or too slow. When the picture is motionless the two meters are running at synchronism. By this method very good adjustment may be obtained in a very short time, 30—60 s, if the load is not too small.

Adjustment with Adjustment Meter

The adjustment meter is an electricity meter, often provided with special counter by which the energy consumed may be read off after a short period. The adjustment meter and the meter to be adjusted are connected with the current coils in series and the tension coils in parallel. Current and tension are connected up, whereupon the number of revolutions of the rotor disc of the unadjusted meter is counted. When a certain number of revolutions has been counted, the adjustment meter is stopped. The number of revolutions counted is converted into kWh and compared with the kWh number given by the adjustment meter. This method is much the same as that first described: the adjustment meter taking the place of the stop-watch and the wattmeter. It is most suited for adjusting electricity meters mounted in place.

The three methods last described have a great advantage over the method with stop-watch and wattmeter, *viz.*, that the load can without inconvenience be varied during the period adjustment is being made, which cannot be done when stop-watch and wattmeter are used.

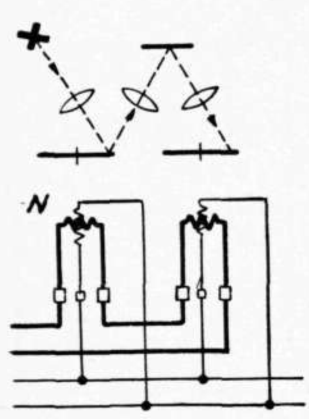


Fig. 6 X 3558

Connection diagram for synchronous adjustment of single-phase meter with standard meter and stroboscope

The Ericsson Adjustment Method

This is a combination of the three first methods described. The adjustment is divided up into a number of operations, each operation being carried out at a special bench and with the method suited for that particular operation. Thus during the process of adjustment the meter is moved along from one bench to another. The adjustment work for single-phase meters is divided into the following operations: warming up and general inspection, phasing and rough setting of the low load, adjustment at nominal load, adjustment at 5—10 % of nominal load, testing of no-load running and adjustment of the meter's starting power, tension test and overall test.

At the bench where the meter is warmed up, *i. e.*, is run with nominal load long enough, about 60 min, to reach working temperature, there is place for 30 meters at one time. The meters are connected up in such a way that they may be connected or disconnected without disturbing the others. As adjustment proceeds the meters are disconnected from position 1. Each meter disconnected is replaced by a fresh one. Connection and disconnection is done in a fixed order so that each meter gets warmed up. After that the meter is connected for phasing at position 2, which is close by. This position is provided with an induction regulator, so that current and tension can be varied at will in relation to each other. The phasing is done with indicated load and 90° inductive phase shift and with the aid of a standard meter. Two standard meters are used to allow for the possibility of error in one of them. Rough setting for low load is done at this position by means of a friction compensation device which is adjusted so that the meter remains stationary or moves very little forward when the current coil is without current but the tension coil is under tension.

The meter is now ready for the next operation, adjustment at nominal load, for which it is passed on from position 2 to position 3. The meter is here adjusted on the synchronous adjustment method with standard meter and stroboscope. Here also two standard meters are employed and these are checked at regular intervals one with the other in the stroboscope. From this position the meter goes on to position 4 for adjustment at low load, which is done by the synchronous method with standard meter. The meters are connected in two series separated one from the other, each series comprising a standard meter and four of the meters to be adjusted. The rotor discs belonging to the meters in the one series are set as described above, after which the meters are set going; the other series is dealt with in the same way. The meters in the first series are now stopped and the positions of the rotor discs in relation to the disc of the standard meter are noted. The meters which are considered to pass the test are disconnected and replaced by other meters coming up from position 3. Meters not passing the test are re-adjusted: the rotor discs are set anew, after which the meters are once more started. The second series meters are now stopped and dealt with in the same way as those of the first series, and so it goes on.

The meters as they leave position 4 proceed to position 5 where they are connected up in two different series of 15 meters each, one for no-load test and the other for starting test. The two series are connected in such a way that when one series has been tested for no-load and the other for starting, the series can be changed about in a single operation without exchanging the meters, so that the series tested for starting can now be tested for no-load.

The meters are now fully adjusted and, after they have been tested for tension they are passed on to the inspection. Only a certain number of meters is inspected, one in ten as a rule. Testing is done with stop-watches and wattmeters at a special test bench. In order that the inspection shall be completely effective, it is not enough that it shall be carried out by skilled responsible persons, but these must have at their disposal measuring instruments of which the error is always known. For this purpose there are in this department both standard instruments and test instruments. The standard instruments are built in to a special concrete base and checked on the spot with compensator. After compensation the instruments must not be removed from their places. The checking with compensator is carried out at regular intervals. The standard instruments are used only for calibrating the test instruments and should not themselves be used as test instruments. The test instruments are checked at shorter intervals, or as soon there is the least suspicion that the error has changed.

Carrier-Frequency Telephone Equipment for the Spanish Northern Railways

C. G. AURELL, TELEFONAKTIEBOLAGET L.M. ERICSSON, STOCKHOLM

In Ericsson Review No 2, 1935, a description is given of a carrier frequency system operated on selective-calling circuits. During the past year a similar installation has been made for the Spanish Northern Railways, Caminos de Hierro del Norte de España, which still further demonstrates the great suitability of this system to special demands which may be made on the arrangement of communications.

The Caminos de Hierro del Norte de España which is the largest railway company in Spain and employs a staff numbering about 46 000, owns railway lines in north and east Spain. Its principal lines serve, as may be seen on the map, Fig. 1, the important towns of Coruña, Oviedo and Bilbao in north Spain, the frontier station with France, Irún, and the Mediterranean towns of Barcelona and Valencia. The main route in this system consists of the Y-shaped lines Madrid—León—Miranda with Venta de Baños as junction.

The railway telephone network along these lines consisted at the beginning merely of iron conductors which allowed of telephoning only over comparatively short distances because of the great line attenuation. In recent years, however, a selective-calling network has been developed employing 3 and 4 mm copper conductors. At present this network extends from Madrid to León and Miranda and from Miranda over Zaragoza to Barcelona. In addition the railway administration has access to a similar line between Zaragoza and Valencia.

In view of the more and more comprehensive change-over from telegraphy to telephony these selective-calling circuits have become very heavily utilised, and a continually increasing need for new circuits has made itself felt. In particular have the difficulties been severe between Madrid and the two important junctions of León and Miranda. At these two last-named places are stationed the chief inspectors who are responsible for train movements, coordination of trains and administrative questions in their districts, and they are in the highest degree dependent on direct connections with Madrid for receipt of communications from the railway administration, for making reports, etc. Such direct telephone traffic is subjected to difficulties over selective-calling circuits for two reasons. In the first place, the large number of way stations cannot fail to cause interruption, partly because they cut in and call the main stations when a pause in conversation gives the impression that the line is clear, partly because variations in attenuation on the through circuits arise when one or more selective-calling instruments is connected or disconnected for listening-in, altogether a deal of time is often wasted in getting a through connection because of the amount of traffic between the way stations. Secondly, these direct conversations are often of such a nature that it is desirable they should be secret, as for instance when they deal with administrative questions, staff matters, etc. Moreover, these circuits are often subjected to noises from power lines which in conjunction with the relatively high line attenuation often made intelligibility poor on direct connections. The requirement was therefore separate through connections with good speech quality and low noise level.

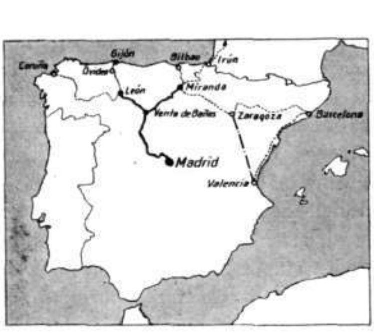


Fig. 1 X 3564
Map of the Spanish Northern Railways

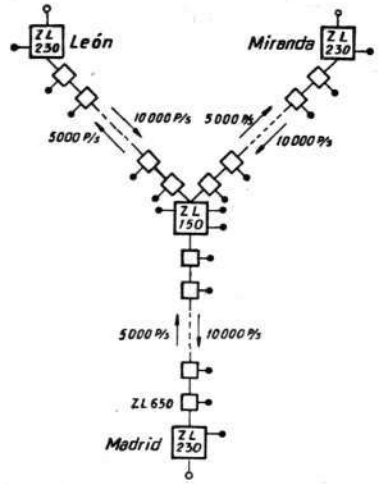


Fig. 2 X 3565
Diagram of the carrier-frequency installation
• selective-calling telephone instruments
o carrier-circuit telephone instruments

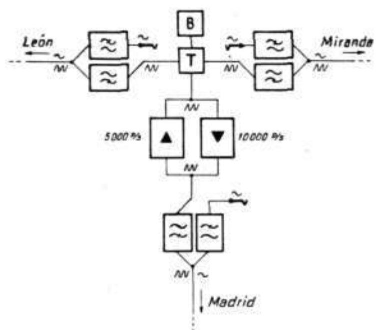


Fig. 3 X 3566
Connection ot single-channel intermediate repeater equipment, Type ZL 150, at Venta de Baños
B balance
T differential transformer

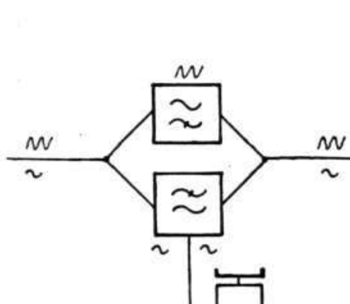


Fig. 4 X 3587
Way-station filter, Typ ZL 650

The railway company decided to obtain a carrier-frequency telephone system of the Ericsson single-channel type, comprising three terminal equipments, Type ZL 230, at Madrid, León and Miranda, and one intermediate repeater equipment, Type ZL 150, for Venta de Baños, together with some seventy way-station filters, Type ZL 650, which last were intended to be installed at all the tappings for the selective-calling instruments along the lines. Thus on the section Madrid—Venta de Baños, 286 km, there are 32 way-station filters, on the section Miranda—Venta de Baños, 173 km, 20 way-station filters, and on the section León—Venta de Baños, 122 km, 18 way-station filters.

The arrangement of the system is shown broadly by Fig. 2, from which it may be seen that the same carrier frequency, 10 000 c/s, is transmitted from León and Miranda, while both these stations receive 5 000 c/s carrier frequency from Madrid. The object aimed at was to be able to cheapen the installation considerably by not selecting separate circuits for Madrid—León and Madrid—Miranda, but to install the system so that Madrid should come into connection simultaneously with both León and Miranda. In fact, the intensity of the traffic is not so great for these through connections that León and Miranda need to be able to exchange conversations with Madrid at one and the same time. To enable Madrid to indicate which station is required, a single ringing signal is used for León and a double ringing signal for Miranda.

The arrangements for this special deviation from the normal system may be seen from the general diagram for Venta de Baños, Fig. 3. The voice-frequency circuits are taken out at this station as it constitutes a limit for the three selective-calling sections. By means of a suitable arrangement of low-pass and high-pass filters it has been arranged that León and Miranda are connected together only through the carrier channel and that consequently no voice-frequency cross-talk occurs between these sections. The way-station filters are in principle made up of a high-pass part and a low-pass part according to Fig. 4. The carrier frequency circuit is thus shunted past the way-station. The impedance of the filters is ohmic and equal to 600 ohm for all frequencies.

Madrid often requires to exchange direct conversations with other important places, specially Bilbao, Irún, Zaragoza, Barcelona and Valencia. This was formerly only possible by relaying through one or two intermediate stations as the line attenuation was too high for direct conversation. A special arrangement has been made at the Miranda carrier terminal to provide for these special transmission circumstances. The voice-frequency output of the carrier channel has been carried from the rack to two jacks in the exchange, between which an attenuation pad of 1 neper is connected, as may be seen on Fig. 5. The overall attenuation for the whole circuit Madrid—Miranda has been adjusted to 0 neper in one of the jacks, so that it becomes 1 neper in the other, this latter figure being suitable only for exchange of conversation between Madrid and Miranda. By connecting to the amplifying jack the lines proceeding from Miranda, the section Madrid—Miranda does not affect the total circuit from the attenuation point of view. Consequently a conversation Madrid—Barcelona is heard just as well as a conversation Miranda—Barcelona. For further improvement of the communications on this important route there has been inserted at Zaragoza a rural line repeater, Type LOD, with an amplification of 0.8 neper, by which the attenuation Miranda—Barcelona, which is the same as the attenuation Madrid—Barcelona, is reduced from 2.5 to 1.7 neper at 1 000 c/s. In this connection, an additional advantage of the carrier telephone system may be pointed out: seeing that it functions in principle as a four-wire circuit, low overall attenuation and even low overall amplification can be obtained without the system becoming unstable or subject to self oscillation. By the use of a two-wire repeater on a selective-calling circuit only a limited amplification can be attained, *e. g.*, 0.8 neper, on account of the difficulty in balancing the exceptionally variable line impedance.

The delivery included also a complete set of measuring instruments for detecting faults and supervising the lines both for voice frequency and for the high frequency range used. Especially noteworthy is a newly designed

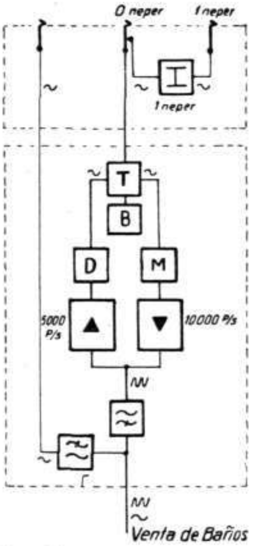


Fig. 5 X 3568

Diagram of single-channel carrier-frequency terminal equipment, Type ZL 230, in Miranda

B balance M modulator
D demodulator T differential transformer

level measuring set, Type ZB 453—454, for voice frequency. With this device it is possible to carry out measurements of line attenuations up to 4 neper and overall attenuations between — 2 and + 2 neper. The instrument consists of two parts, a transmitter set which chiefly contains a voltage adjuster with an instrument which indicates the output to the line, and a level indicator set consisting of three fixed attenuation pads of 1—3 neper and a frequency-independent rectifier connected to a sensitive DC instrument. The scale of the instrument is divided into 10 divisions of 0.1 neper. The characteristic impedance is 600 ohm.

Measurements of the overall attenuation of the carrier channels have been carried out at different frequencies. Two typical curves are shown on Fig. 6, which hold good for the whole carrier circuit from the voice-frequency side of one terminal to the voice-frequency side of the other. In addition the line attenuation at voice frequency has been measured before and after the insertion of the way-station filters. The additional attenuation due to these filters has been found to be well within the guarantee, which allows an increase of attenuation of 0.03 neper maximum per way-station filter within the voice-frequency range. At 1 000 c/s the overall attenuation, including all the filters, for the circuit Madrid-León is about 2.7 neper and Madrid—Miranda about 3.0 neper. The additional attenuation for the carrier channel in south to north direction, 5 000 c/s, is about 0.015 neper and in north to south direction, 10 000 c/s, less than 0.01 neper per way-station filter. The terminals are provided with automatic level regulation, permitting an increase in the line attenuation of 1 neper without more than 0.05 neper overall-attenuation increase for the carrier channel.

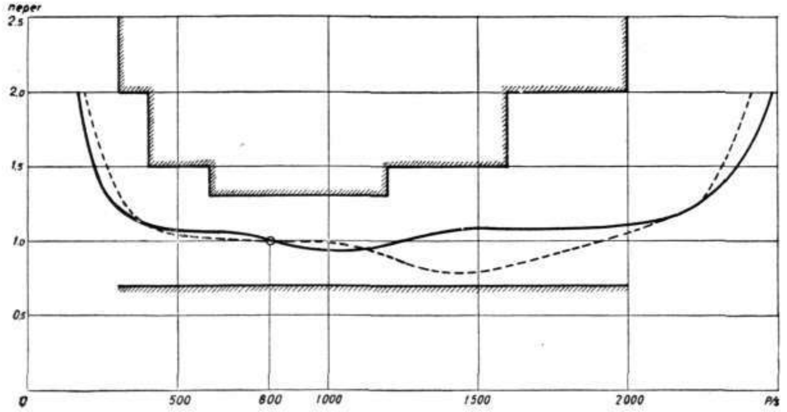
The new circuits were put into service in the middle of November 1935 and have shown themselves to fulfil in a most satisfactory way the stipulations regarding reliability of operation, good speech quality and low noise level; this last is much lower than on the voice-frequency selective-calling circuits. As regards maintenance the following may be stated: the current consumption of the AC mains-supply panel is low, about 70 W in each station. The valves are of telephone type with a long life, as a rule exceeding 10 000 h, so that they will seldom require replacement. Naturally there is no extra upkeep required for the lines as these are unaltered. It has been estimated that if these new circuits had been provided by stringing new copper conductors on the existing poles it would have involved a cost 3 to 4 times as much as for the carrier-telephone system.

Fig. 6 X 5271

Overall-attention curve for carrier-frequency circuit

— León—Madrid (408 km, 3 mm copper conductor, 50 way filters)

---- Miranda—Madrid (459 km, 3 mm copper conductor, 52 way-station filters)



Principles of Construction for Transmission Equipment

Å. JOHANSSON, C. KIHL & S. ANDERSSON, TELEFONAKTIEBOLAGET L.M. ERICSSON, STOCKHOLM

Equipment utilised for long-distance telephone and telegraph purposes is of a special character due to the wide frequency range employed, the great differences betveen input and output levels, the accuracy af adjustment required etc. This calls for special design of the equipment itself and the the integral elements thereof. The problems thus facing the designer have to be solved on certain general lines which are exemplified below.

To telecommunication belong equipment for telephone and telegraph carrier-frequency systems, two and four-wire repeaters, power plants, measuring instruments, etc. Two and four-wire repeaters operate with voice frequencies and carrier systems with higher frequencies, while measuring instruments for both high and low frequencies as well as for DC are employed in the daily supervision of lines and equipment.

In a number of apparatus, such as amplifiers, filters and attenuation networks, there are great differences in amplitude between input and output voltages. The greater the difference and the higher the operating frequency, the more difficult it is to make the apparatus in such a way that their operation is not adversely affected or even made impossible because of electromagnetic or electrostatic coupling between the different elements or the cabling between them. Thus amplifiers may be subject to self-oscillation, attenuation curves for filters may assume values not calculated with, while standard attenuation sets and similar measuring instruments may give wrong measurements.

Most of the apparatus require accurate electrical adjustment. It is important that the various constructive elements be so designed that this adjusment is easy to carry out. The adjustment should not be affected by transport, by age or by the influence of climate. When intended for tropical countries, in particular, coils and condensers should be moisture proof so that insulation defects cannot arise, power factors do not increase, winding capacity and condensers do not alter their values etc. In many cases several parts require to be adjusted together. Among other things, this is often the case with filter elements, the resonant circuits of which must be adjusted to the desired resonance frequency. It is important that the apparatus should be assembled in such a way that adjusted resonant frequencies are not subject to variation on account of the capacity between the connecting wires being too great.

The above remarks apply to some problems of a more general character which are constantly arising in one form or another. Naturally, individual apparatus give rise to their own special problems, but it would take up too much space to deal with these here. By designing constructive elements which enable the general problems to be solved, the solution of the special problems is often simplified. Moreover, a series of standardised elements is obtained and this tends to simplify manufacture. Hence it is the shape given to the constructive elements which constitutes the basis for the design of the apparatus. In this connection experience and knowledge derived from earlier developments should be applied. It is not only the purposes and requirements placed on the final apparatus in respect of shape, appearance, cabling and operation which should be considered. Account must also be taken of the electrical and magnetic demands to be made on the individual parts. If a compromise is inevitable, then the advantages of uniform design for the parts and the resulting accessibility of cabling should be weighed against the disadvantages of nonfulfilment of demands on the electrical or magnetic dimensions due to the standardisation of parts.

Apparatus forming this group consist chiefly of valves, condensers, coils and transformers, resistances and switches. These are mounted on panels of suitable standard dimensions, the extent of projection being limited by the panel cover or the instrument case. The rapid development of trunk exchanges has led to demand for more and more concentration and economy of space in mounting methods. The smallest area of panel for a certain apparatus is obtained if the space available under the cover is completely filled up and this can be managed if all the components are given the shape of a parallelepiped of suitable height. Such a method of mounting is certainly convenient from the point of view of cabling, but it takes far too little account of electrical and magnetic properties. It is therefore more convenient either to combine several parts into units or to assemble them in several layers. It should not be overlooked that this involves greater demands on the designer of the apparatus as there is the danger that some of the parts may have to be so placed that connections are too long or in some other way inconvenient. Good connection is, as a matter of fact, one of the most important conditions for satisfactory operation of the equipment. It is evident, however, that the parts may be designed with a view to the possibility of suitable combination with other parts, in order to minimise as far as possible this risk. In view of the fact that the size and shape of electron valves are fixed, it is the condensers, the coils and transformers, the resistance and switching devices which require planning by the designer.

Condensers

For a long time *paper condensers* have had the form of parallelepiped blocks. In the case of wireless receiving sets with their great numbers of mass-produced parts, it is an advantage to build the condensers together into large blocks furnishing all capacities required for the set. In telephone practice, dealing with numerous different apparatus, however, it is preferable to make each condenser as a unit of fixed dimensions, with only the thickness varying on a certain scale according to the capacity. The necessary number of condensers is mounted on shelves or in holders, from which they can easily

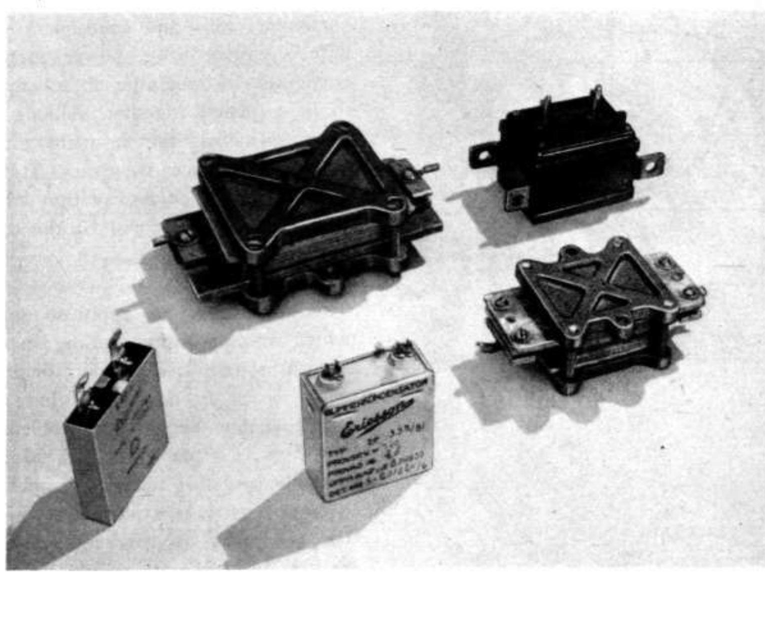


Fig. 1 X 5257
Condensers
in foreground, paper and mica condensers of new type; in background, three mica condensers of earlier make

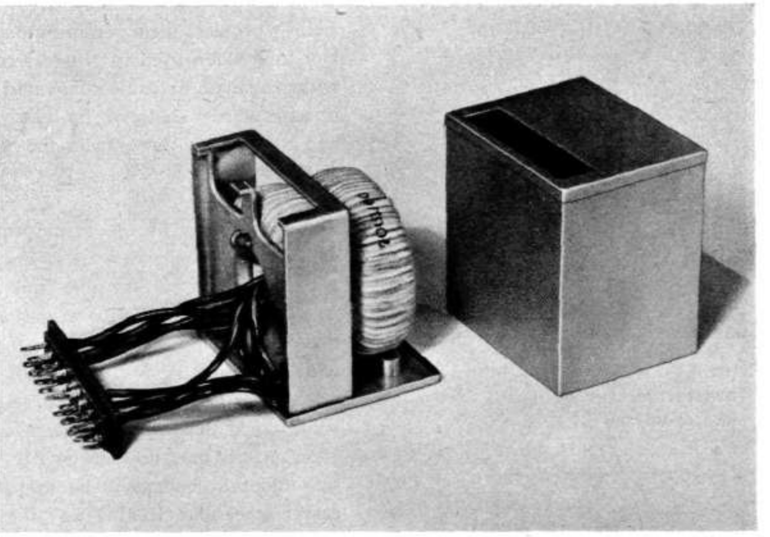


Fig. 2 X 5256
Transformer set
left, coil set with terminal block; right, case

be removed for adjusting the apparatus. *Mica condensers* have given rise to more trouble. Earlier designs were extremely cumbersome and unshapely, with projecting clasping screws, fixing-clips and lugs, etc. Ericsson has, however, produced a design in which the dimensions are the same as for paper condensers. The appearance of this condenser type may be seen in Fig. 1, which also shows paper condensers and mica condensers of the older type. Both the paper condensers and the mica condensers are protected against moisture by special insulating compound around the windings and the packet.

Coils and Transformers

Coils and transformers should, to give the greatest efficiency, be shaped in accordance with theoretical demands. It is obvious that the size and shape they thus assume often give rise to difficulty in the striving of the designer to combine different elements into compact constructive units suitable for cabling. It has often been found advantageous to assemble several coils and transformers into units, *transformer sets,* with a common terminal block for all the coils. A special transformer set has been designed for pure filter work, this being intended for two or three coils with ring-shaped cores, *toroidal coils.* The transformer set, Fig. 2, contains an angle-shaped frame acting as holder for the terminal block and the coils, which latter are held in place by a clip. The position of the coils on the frame is fixed by a pressure cone which fits into the centre hole of the coils. The bottom of the cone is cut out and through the hole thus made the windings of the coils are taken to the terminal block. This last is intended for 16 soldering tags arranged in two parallel rows. To facilitate connection, the terminal block and the upper part of the frame have been so formed that the block can be lifted up when making the connection and turned round, to be returned to its place after the connection has been made. It is then held clipped between frame and case, thus ensuring tightness. The case is made of sheet-iron and is designed to screen the coils from electric and electromagnetic

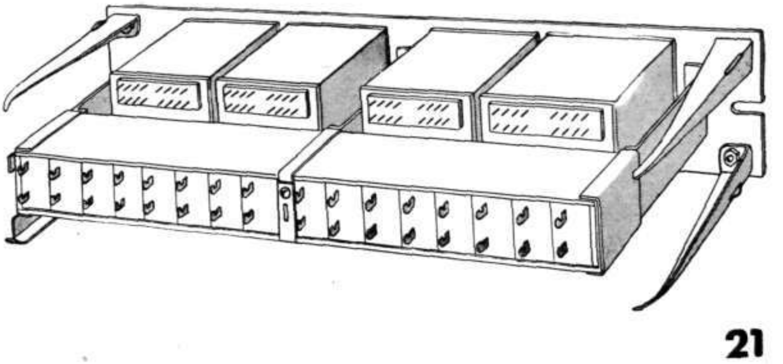


Fig. 3 X 5241
Filter panel
upper row, transformer set; lower row, condensers

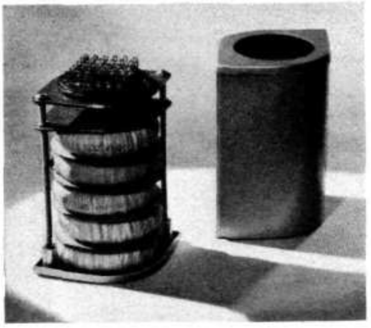


Fig. 4 X 3540
Transformer set
with toroïdal coils

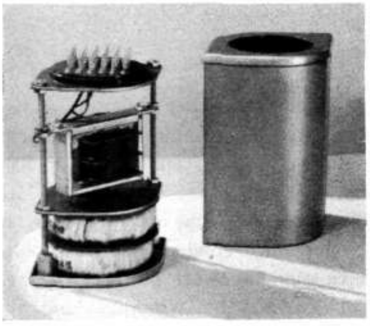


Fig. 5 X 3541
Transformer set
with toroïdal coils and transformer with cylindrical winding

fields, protect them from damage, and, perhaps most important, against moisture when used in tropical countries. In the last event, the case is filled with ozokerite or cable compound through a filling hole in the bottom, which is afterwards soldered up. To screen the various coils from each other and to insulate them from the case, space has been provided for insulating and screening sheets.

The dimensions of the transformer set are determined by the standard dimensions of the panels used. As an example, it may be stated that a panel with a height of 88.1 mm and a length of 482.6 mm can take four such transformer sets. By investigation of several filter types it has been found that the number of coils taken by such a panel is adequate, even for filters which electrically are rather long. The condensers belonging to the filters are placed on a shelf which stretches over all the transformer sets and is so designed that the condensers can easily be removed for replacement or inspection. As may be seen on Fig. 3, all the soldering tags on the transformer sets and the condensers lie in parallel rows in a manner which makes them easily accessible. In this way the panel cabling can be arranged near enough to the ideal either by a through string having branches to the transformer sets and the condensers, or, in cases where the additional cabling capacity might affect the adjustment of the filter, by short bare-wire connections.

Fig. 4 shows another transformer set specially designed for valve panels. The lay-out is in the main similar to the smaller type. What has been said regarding cabling, screening etc., for the smaller set also applies to this type. As regards space, it may be stated that it takes a maximum of six coils of the type already referred to. On several occasions, however, parts of other kinds have been placed in such a case with advantage, see Fig. 5. The two-wire repeater, Fig. 6, gives an idea of how the transformer set in question is suited for panel design. It also shows how an easily accessible, short and well separated while at the same time well screened cabling is obtained, as all the terminals are arranged to be easily accessible on a common plane.

Potentiometers

Potentiometers and other variable resistances are also designed on the principles outlined above, that is to say with small demands on panel area but with comparatively great height. The moving contact is screw-shaped and consists of a screw thread with a rise of 75 mm for a 5/6th of a turn. The resistance element is wound on a steatite core and is interchangeable. When

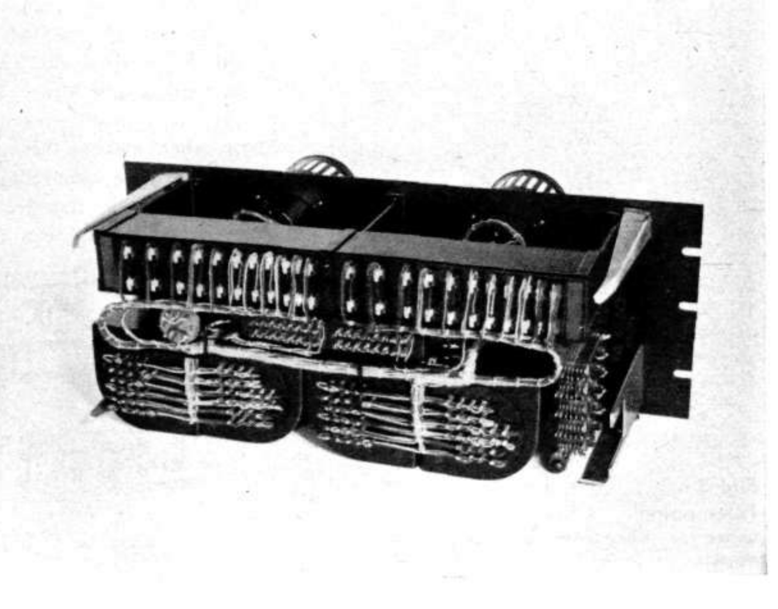


Fig. 6 X 5258
Two-wire repeater

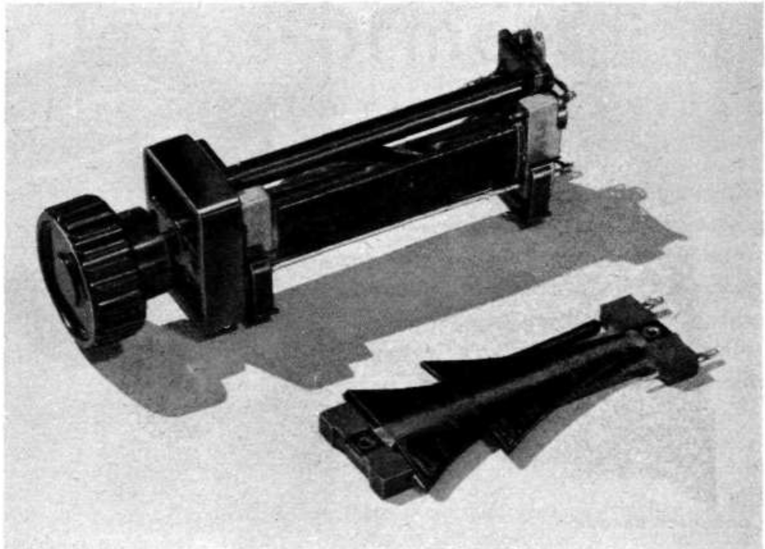


Fig. 7 X 5259
Potentiometer
in background, with element for linear resistance variation; in foreground, with element for logarithmic resistance wariation

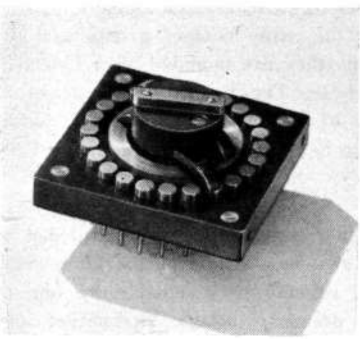


Fig. 8 X 3542
Brush switch

in position the wire turns are perpendicular to the axis of the screw. This ensures the least possible wear on the wire, since the screw thread moves lengthways to the wire. The design of the potentiometer may be seen from Fig. 7; the two holding springs keep the resistance element pressed against the screw, thus giving a good contact, while at the same time the element is held in place. The element may vary in shape, and Fig. 7 shows a design which admits of a logarithmic variation of the resistance.

Switches

In this connection we shall limit ourselves to *brush switches,* as described previously in the Ericsson Review No 1, 1933, and the units built up with them. Since the above-mentioned was written a new switch, Fig. 8, has been produced, of the same design in the main but with the dimensions brought down to about 60 % of the former one. The number of contact studs has been kept at 24. The switch base is of moulded bakelite and provided with the necessary flanges for ensuring the same low leakance between the contacts. By reducing the contact studs and the contact segments in the same proportion as the base, the capacity between them has been kept down to practically the same value as in the older switch with larger dimensions.

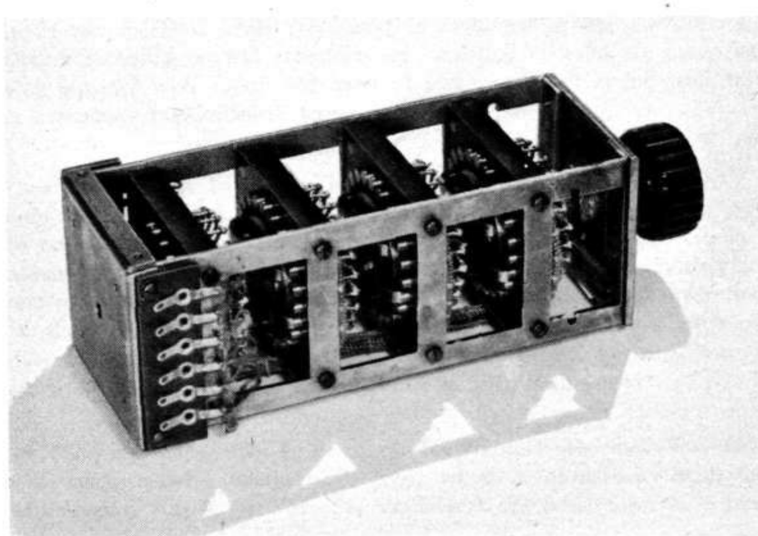


Fig. 9 X 5261
Tandem switch

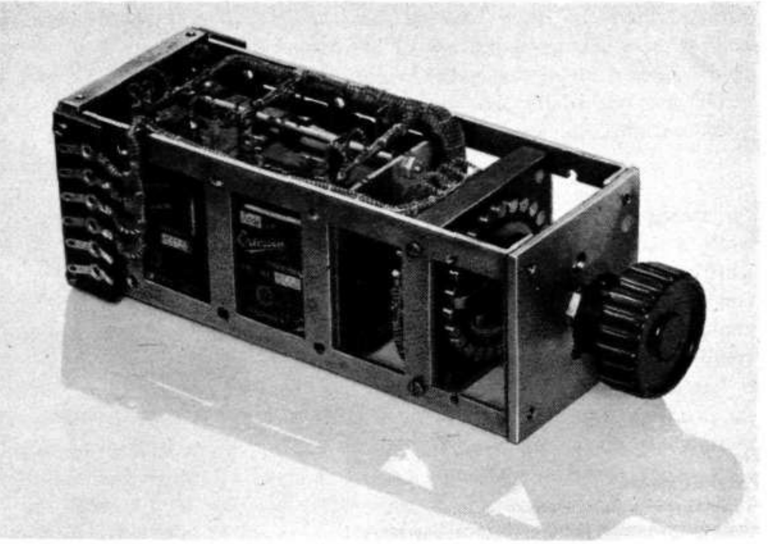


Fig. 10
Condenser decade

X 5262

It is often convenient to combine the elements, *i. e.*, resistance, condensers and transformers, with the requisite number of switches, to a single unit, with a view to shortening the connections to the many contact groups and obtaining a unit suitable for testing. For this they are mounted on a U-shaped sheet-iron frame with end pieces welded on. The height of the frame is convenient for mounting under the cover of the panel. The terminal blocks are placed at the top of the frame so as to be level with the terminals of the other constructive elements.

Among the many possibilities of combination which may be obtained can be mentioned: tandem switches, *i. e.*, several switches turning on the same shaft, various combinations of condensers and resistances switchable by one or more switches, condenser and resistance decades, variable attenuation sets, transformers with variable output, etc. Fig. 9 shows a tandem switch with four switches, the greatest number that can be taken by the frame. The number of switching positions possible with this device is sufficient for practically every demand for which switches of this type are required, as, e. g., the capacity-unbalance meter and the splicing commutator, described in Ericsson Review No 3, 1933. A simple shaft coupling makes it possible for each switch to be taken out separately from the frame for adjustment or repair. For resistance and condenser decades, only one switch is employed. The remainder of the space is taken up by the resistances and the condensers, see Fig. 10.

Condenser-Transformers

E. WASTENSON, SIEVERTS KABELVERK, SUNDBYBERG

In Ericsson Review No 1, 1933, and No 3, 1935, the use of high-tension condensers as protection against atmospheric overvoltages and as coupling condensers was dealt with. They can, however, be used also as capacitive potentiometers in combination with voltage transformers and for voltage and power transformation at high operating voltages, which constitutes another important sphere of employment. The article below, after giving a description of the design of condenser-transformers, discusses their technical properties and practical use.

From the point of view of design there is no difference in principle between protection condensers, coupling condensers and capacitive potentiometers for transforming purposes. All these condensers are designed as single-phase condenser piles and made up of a number of cylindrical condenser elements, connected in series along their axes. The condenser elements are wound in spiral of a number of layers of aluminium foil with layers of specially made cellulose paper between. The thickness of the aluminium foil is 0.007 mm, while the number of insulating layers of paper and the thickness vary to suit the operating voltage.

By dividing up each condenser element into a suitable number of partial capacities, it is avoided that the effect of the tension on the edges of the metal foils attains a value dangerous to the insulation. Fig. 1 shows in principle the design of the condenser element. By deplacing the aluminium foils to each side of the insulating layer, so that they only cover each other partially, a division into series capacities is obtained within the element. The projecting aluminium foils at the ends of the element are flattened, so that axial series connection may be achieved in a simple manner by putting the elements one above the other and pressing them together with suitable tension. In this way the inductive and ohmic resistances of the condenser pile are reduced to a minimum.

The condenser pile is enclosed in a cylindrical container of sheet-iron, porcelain or bakelite. Metal containers are chiefly used for line voltages up to 33 kV. The top condenser terminal is connected to a porcelain bushing at the top of the shoulder, while the lowest is connected to the container. For voltages exceeding 33 kV, containers of insulating material are used, these being provided with covers and bases of cast-iron which at the same serve for connecting the condenser terminals.

When the elements have been inserted in the container the condenser is ready for impregnation. This is done in a special impregnating oven in which the condenser is first carefully dried at a temperature of 110° C and in vacuum. When it has been ascertained that the condenser is completely free from moisture and gas, impregnation is carried out with a specially refined, easy-flowing mineral oil, still under vacuum. After impregnation the container is hermetically sealed by a patented rubber-metal packing, thus obviating all risk of penetration of moisture or dirt from outside.

X 3559

Fig. 1
Design of condenser element

The following values may be given for the finished condenser: loss factor max. 0.005, capacity tolerance ± 5 %, variation of capacity with temperature max. 0.03 % per °C. The condensers are made for two different

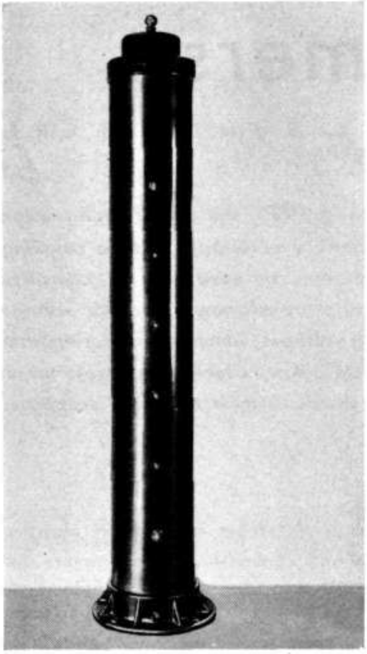


Fig. 2 X 3560
Capacity potentiometer for indoor mounting, 66/√3 kV, 0.035 μF

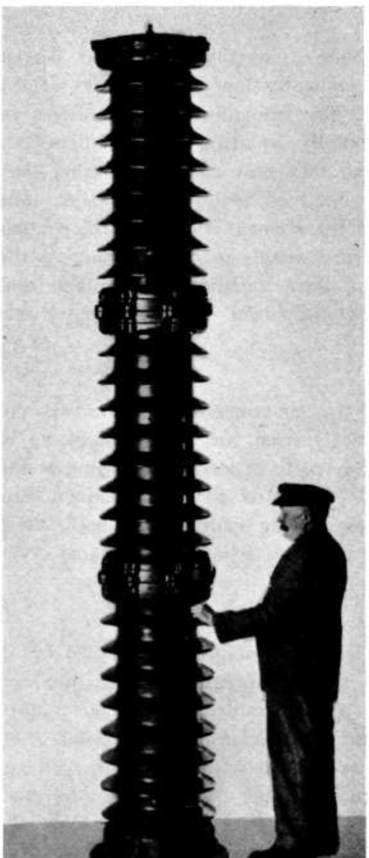


Fig. 3 X 3561
Capacity potentiometer for outdoor mounting, 220/√3 kV, 0.0095 μF

testing rules, either for the German VDE rule, or for the test voltages answering to the Swedish transformer rules SEN 4. The condensers are dimensioned to stand all overvoltages likely to occur, whether due to the permanent earth fault or to lightning, and they may therefore be connected to the line without the use of fuses or cut-outs.

Capacitive potentiometers hardly come into question for voltages below 44 kV. They are always made with containers of insulating material. Fig. 2 shows a condenser with bakelite case, designed for indoor mounting. The bakelite cylinder fits tight round the condenser elements and is provided at the top with an expansion chamber for the oil. The tapping is made in the form of a through bolt, hermetically tightened to the bakelite cylinder by means of rubber-metal packings. The condenser shown on Fig. 2 is designed for laboratory use and has a tapping for each condenser element; capacitice potentiometers are normally made with one tapping only. In view of the fact that it is to be mounted indoors it is provided with a over-pressure-protection device in the shape of a gauge which signals by means of a contact device if the pressure allowed inside the container is exceeded.

In Fig. 3 there is shown a porcelain-cased condenser for outdoor use. To facilitate transport, testing and the keeping of spare parts, the condenser is made up of one or more condenser units, in this case three, which are placed one above the other and coupled together both electrically and mechanically. Each unit consists of 3—5 condenser elements connected in series. The two outside units are connected with the cast-iron flanges of the porcelain cylinder, and the series connection of the units is simply done by putting them on top of each other and screwing them together. Each unit composes an independent condenser, hermetically sealed and provided with expansion chamber for the oil. A cover is bolted on to the top condenser unit while the lowest unit is provided with a bottom-plate to enable it to be screwed down to the base. The potentiometer tapping is in the form of a bolt connected through the porcelain cylinder to the lowest unit.

The upper condenser unit is connected to the line by a connecting bolt in the top of the condenser. When the condenser is to be used only as overvoltage protection or as capacitive potentiometer the lowest condenser unit is connected direct to the earthed base. When used as a coupling condenser the lowest unit is insulated from its bottom-plate and connected to earth over the filter of the high frequency equipment.

The division of the condenser into equal partial capacities connected in series given even axial voltage gradient between the upper and lower units. By tapping over one or more of the partial capacities it is thus possible to obtain an arbitrary partial voltage. With designations as in Fig. 4, the relation between total voltage and partial voltage, the ratio, is obtained as

$$N = \frac{C_1 + C_2}{C_2}.$$

The partial voltage can be measured direct by means of a voltmeter of small consumption, *e. g.*, a static voltmeter. Such measuring devices have been used to a certain extent in laboratories for measurement of very high voltages.

The use of the capacitive potentiometer in conjunction with the tapping of power from a network is, however, of greater importance. The load can be connected direct to the part voltage, though the use of an intermediate transformer as in Fig. 4 is an advantage from several points of view. Leaving out of account the effect of no-load current, the following relation between the mains voltage and the voltage on the secondary side of the transformer is obtained

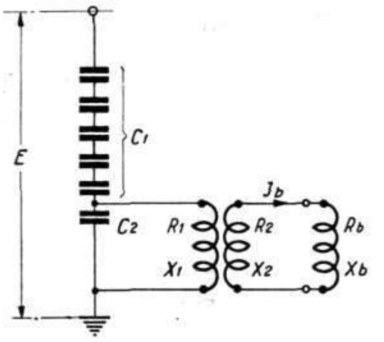


Fig. 4 X 3562
Connection of condenser-transformer

$$E = N \cdot V'_2 \left[1 + \frac{R_1 + R'_2 + j\left(X_1 + X'_2 - \frac{1}{\omega\ (C_1+C_2)}\right)}{R'_b + jX'_b} \right] =$$

$$= N \left[V'_2 + (R_1 + R'_2) I_b \cos \varphi_b + j \left(X_1 + X'_2 - \frac{1}{\omega\ (C_1+C_2)}\right) \cdot\ I_b \sin \varphi_b \right]$$

The index' indicates that the values have been reduced to the primary side.

To have as little error of measurement as possible it is necessary to match the condenser reactance $\frac{1}{\omega\ (C_1 + C_2)}$ to the stray reactance $X_1 + X'_2$.

If the stray reactance is fully compensated for, the error of measurement depends only on the short-circuit resistance $R_1 + R'_2$. The condenser reactance may even be written $\frac{N-1}{\omega\ C \cdot N^2}$, where C represents the total capacity of the condenser. The greater C and N are, the smaller the stray reactance has to be to compensate for the condenser reactance and the smaller the influence of deviations in the nominal frequency on the error of measurement.

For Sievert condenser-transformers, single-phase voltage transformers are used where the stray reactance is matched to the condenser reactance. The transformer windings are provided with tappings by means of which the stray reactance can be matched to the condenser reactance with an accuracy of ± 5 %. For line voltages up to 132 kV voltage transformers with $11/\sqrt{3}$ kV primary voltage are used; for higher line voltages $22/\sqrt{3}$ kV is used. The secondary voltage is normally $110/\sqrt{3}$ V. The voltage transformers are made with specially low no-load consumption, less than 25 VA at nominal voltage, and as low short-circuit resistance as possible. The table below gives a number of values for Sievert condenser-transformers. The maximal error of measurement refers to a secondary load of 0—100 VA at $\cos \varphi = 0.8$ and ± 2 % variation in nominal frequency.

Line Voltage kV	Test Voltage		Condenser Capacity kVAr	N	$\frac{1}{\omega(C_1 + C_2)}$	Measuring Accuracy	
	Class	kV, 50 c/s 1 min				Transfer error, %	Loss Angle, min
220	VDE	450	48	10	30 000	± 0,5	± 30
220	SEN	625	32,3	10	44 000	0,7	40
165	VDE	340	48	7,5	21 500	0,4	30
165	SEN	450	32,3	7,5	33 500	0,5	35
132	VDE	274	48	12	9 400	0,6	35
132	SEN	380	32,3	12	13 500	0,7	45
110	VDE	230	40	10	9 000	0,6	40
110	SEN	325	27	10	13 000	0,7	45
77	VDE	164	28	7	8 700	0,6	40
77	SEN	235	18,9	7	12 000	0,7	45
66	VDE	142	24	6	8 300	0,6	40
66	SEN	200	16,2	6	12 300	0,7	45
55	VDE	120	20	5	8 100	0,6	40
55	SEN	170	13,5	5	11 900	0,7	45
44	VDE	98	16	4	7 600	0,6	40
44	SEN	145	10,8	4	11 200	0,7	45

In spite of the simplicity of the principle, considerable difficulty has been encountered in developing the condenser-transformers for practical use. In particular resonance phenomena due to connection in series of a capacity and an iron-cored inductance were hard to overcome. These phenomena are connected with the irregular form of the magnetising curve and reveal themselves in the form of strong harmonics in the current curve. They cause errors in the voltage measurement and can effect such great rises in current that the windings of the voltage transformer are burnt.

Fig. 5 X 3569
Condenser transformers at the Gothenburg substation

Thorough investigation has shown that the greater the ohmic resistance and the capacitance in the resonance field, the weaker the resonance oscillations. By the connection of an attenuating resistance matched to the capacitance in series with the primary winding of the voltage transformer and by suitable selection of the shape of the magnetising curve, the risk of resonance oscillations has been completely removed. To avoid voltage drop in the attenuating resistance, this has been shunted by a filter circuit matched to the operating frequency. The whole has been combined in an attenuation network which is made in the form of a separate apparatus or built in with the voltage transformer. The resistance of the attenuation network at the operating frequency is negligible, but it constitutes a sufficiently great resistance to all harmonics to completely prevent them.

Fig. 6 shows the complete connecting diagram for a three-phase condenser-transformer equipment with attenuation network inserted in the primary winding of the transformer. The transformer has been provided with two secondary windings: the star-connected secondary windings are intended for measuring the line voltage, while the series connected secondary windings permit of direct measurement of the system's zero voltage to earth.

Condenser-transformers in many cases offer considerable technical and economic advantages over the usual voltage transformers, particularly as the condensers may be employed at the same time for overvoltage protection, improvement of capacity and coupling purposes. The condenser-transformers have found widespread use for voltage measurement and the feeding of relays, but also for capacity and energy measurement at high line voltages. The Swedish Royal Board of Waterfalls has at present in service some forty condenser-transformers for 55 and 77 kV line voltage. Fig 5 shows some of the condenser transformers at the Gothenburg secondary station.

Condenser-transformers may even be used for direct power tapping of the high-tension network. The output taken is limited, however, by the voltage drop. By increasing the capacity of the condenser, the stray reactance and the resistance can be reduced so that the voltage drop can be kept within convenient limits even at high outputs.

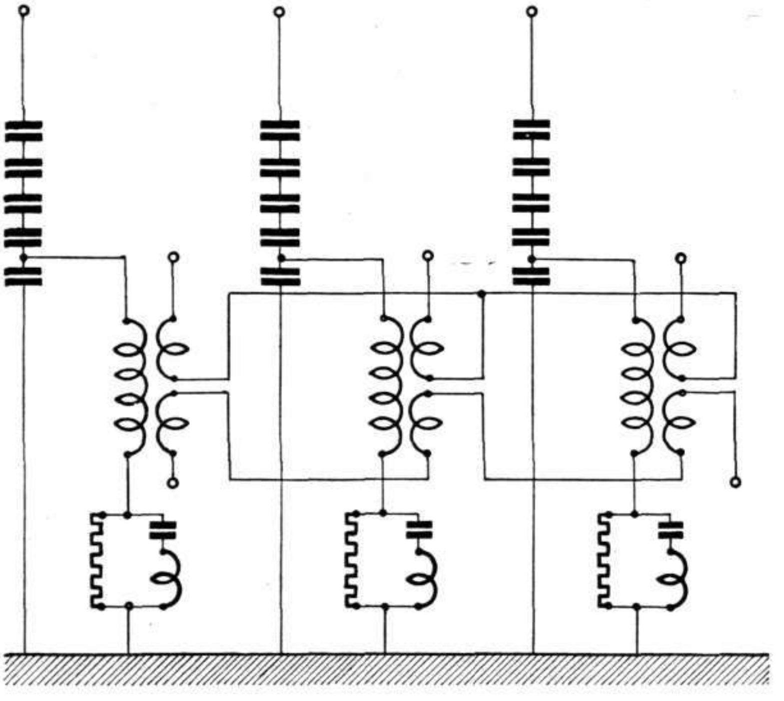


Fig. 6 X 5270
Diagram of three-phase condenser-transformer equipment with attenuation network

Utilisation of Fire-Alarm Installations for Police Telephone Communications

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

A telephone installation intended solely for police purposes would involve far too much expense for the majority of communities and, Telefonaktiebolaget L.M. Ericsson has therefore worked out a police telephone system for connection to fire-alarm installations on the Morse system. The fire-alarm boxes and the fire-alarm board are provided with apparatus for telephone calls and communication direct with the police station, without signals being given to the fire station. In addition the installation can be extended to allow the police stations to call policemen on beat by means of flash signals in lamps at the fire-alarm boxes. In connection with this it is a simple matter to arrange for the illumination of the fire-alarm boxes to be lit or extinguished from the fire station.

In towns and communities where there is a fire-alarm system and the fire-alarm boxes connected to it are provided with telephone arrangements, it is customary for the policemen on the beat to have a key to the fire-alarm box in order to be able to make use of the telephone in case of need. When a policeman required to communicate with the police station from a fire-alarm box, he had first to call the fire station, after which he was connected through to the police station. The police could not therefore make great use of this telephone facility as it entailed far too much work on the fire-station operator. Ericsson has therefore worked out a system by means of which the telephone call can be made direct to the police station and replied to from there. The equipment is not expensive and is simple to instal, even when the fire-alarm system is already in existence, and this fact should ensure extensive use for the system. The greatest care has been taken to make sure that the police telephony in no way interferes with the reliable operation of the fire alarm.

When the fire-alarm system is already installed, there are required for the police telephony certain additions to the fire-alarm boxes, to the fire-alarm board and to the telephone arrangements at the police station. In each fire-alarm box there is fitted a resistance, together with a press-button which normally holds the resistance short-circuited. When the button is pressed the resistance is connected in series with the fire-alarm box loop. The parts are held in the box by the same screw which holds the telephone base, so that there is no necessity to bore a special fixing hole in the box. At the fire-alarm board there is required a relay, a switch, a press-button and a signal lamp. The relay is connected into the supervisory circuit in series with the supervisory relay. Over the contacts of the relay the circuit to a calling bell at the police station is closed. The switch has a calling position and a speaking position for direct telephone communication between fire station and police station. Via the pressbutton the fire-alarm-box telephones remain directly connected to a police telephone line. When the button is pressed the fire-alarm-box telephones are connected to the fire-alarm board. The signal lamp lights up to indicate that the switch or the press-button have been actuated. If there is more than one supervisory circuit

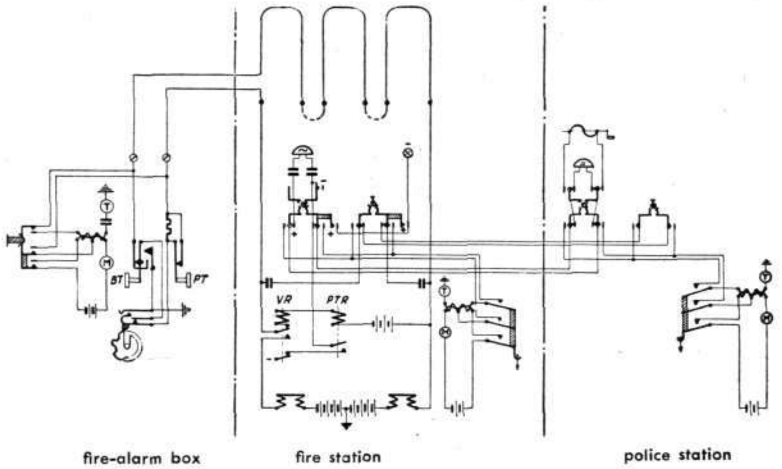


Fig. 1 X 5265
Diagram of police-telephone installation applied to fire-alarm circuits
BT fire call **PTR** police-signal relay
PT police call **VR** supervisory relay

at the fire station then there is required a press-button with connections for each supervisory circuit. Between the fire station and the police station there are thus required a two-wire line for call signals and for direct communication between fire station and police station and also one two-wire line for each supervisory circuit at the fire-alarm board, for direct communication between the alarm box telephones in the respective supervisory circuit and the police station. A magneto telephone instrument is installed at the police station, with a DC bell to replace the AC bell. In addition the telephone apparatus is supplemented by a switch together with a press-button for each supervisory circuit at the fire alarm-board. The switch is used for calling and for communication with the fire station. By means of the press-buttons the police-station telephone apparatus is connected to the telephone instruments in the fire-alarm boxes of the corresponding supervisory circuit for conversation.

The supervisory current should normally be 15 mA, by means of which current both the supervisory relay *VR* and the above-mentioned relay connected in series with it, the police-signal relay *PTR*, are held attracted, see the diagram, Fig. 1. When calling from a fire-alarm box to the fire station use is made of the ordinary call button *BT* in the box, whereupon the loop is broken and earthed. Both relays at the alarm board then fall and signal is received at the fire station but not at the police station. Actually the contacts of the police signal relay close the circuit to the signal bell at the police exchange over a contact on the supervisory circuit relay, which is broken when the relay is released. Telephone calls from a box to the police station are made by pressing the button *PT*, whereupon the resistance is connected to the loop. The supervisory current is then reduced to about 8 mA, with which current the supervisory circuit relay remains attracted but the police-signal relay is released. In this case a signal is received at the police station but not at the fire station.

It may often be desirable to supplement the above-described telephone system with arrangements for calling to patrolling policemen from the police station, and Ericsson has worked out two different systems for this purpose. In both systems the calls are made by the sending out of flash signals in lamps conveniently mounted at the boxes. The lamps may be used at the same time for illuminating the boxes and indicating their position. As a rule such lamps are already fitted for illumination in existing installations and no fresh ones need to be provided.

In the first system, with lamps permanently connected to the lighting mains and lit the whole day long, see the diagram, Fig. 2, polarised relays are inserted in the supervisory circuit, consisting of a double relay with mechanical locking and electro-magnetic release. The two coils of the relay are connected to a rectifier in such a way that, when current goes through the alarm-box loop in one direction, one of the coils attracts and is locked mechanically. The mechanical locking holds the armature in attracted position

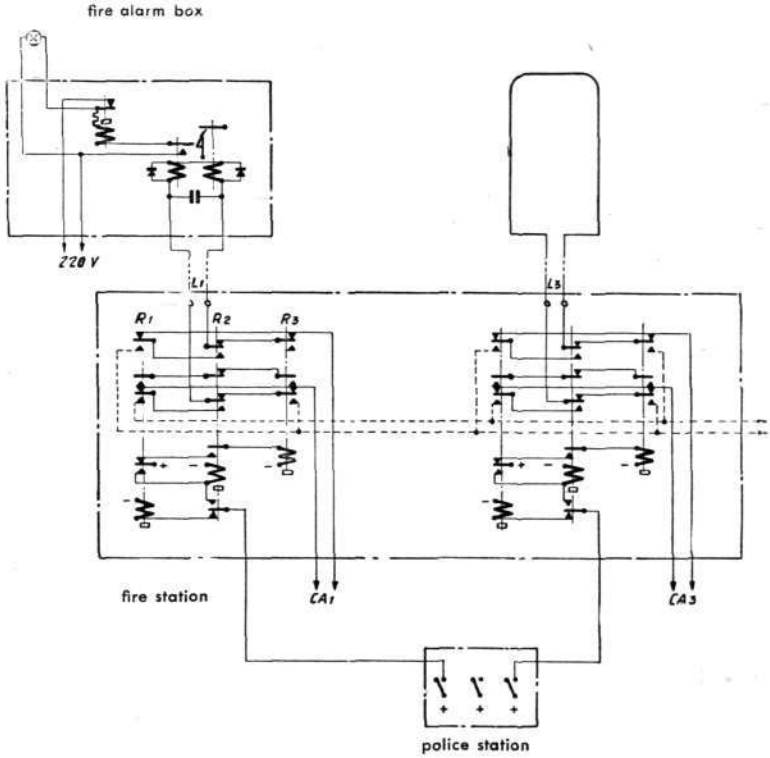


Fig. 2 X 5266
Diagram of police-telephone system with lamps constantly alight
CA_1, CA_3 alarm-board loops
L_1, L_3 alarm-box loops
R_1, R_2, R_3 relays

until an impulse in the reverse direction actuates the release coil. The relay is adjusted for attraction at about 150 mA, so that it is not affected by the supervisory current.

There is connected to each polarised relay a mercury-contact relay over which the calling lamp normally receives current. When the polarised relay is attracted a circuit is closed between the coil and the contact of the mercury relay. The relay attracts and breaks the current through the lamp and the one coil. The relay then releases and once more closes the current through the lamp and the coil. In this way the lamp continues to light up and go out so long as the polarised relay is attracted. To make telephony over the line possible the two coils of the relay are shunted by a condenser.

Call and restoring impulses to the relays may be sent out independently over the loops. This necessitates at the alarm board three relays for each loop, which by means of a common single-wire line are joined to the switch at the police station. When the switch for a certain loop is thrown, current to the corresponding relay group at the fire-station exchange is closed. Relay *R1* attracts, whereupon the loop is short-circuited inwards to the exchange and emission of a signal impulse from a 36 to 48 V battery is prepared. Current goes to relay *R2* which attracts and connects the loop to the call battery over the contact of relay *R1* whereupon the polarised relays are connected and the lamps begin to flash. The signal line from the police station is connected over from relay *R1* to relay *R2* so that the latter is held over the switch thrown at the police station. Relay *R1* releases and the loop is connected over from the battery to the alarm board. Relay *R2* attracts and prepares for the emission of a restoring impulse in reverse direction to the call impulse.

When the switch at the police station is restored, the current through relay *R2* is cut off and the relay releases. The loop is short-circuited inwards and a restoring impulse is sent out over contacts of relay *R3*, the polarised relays are released and the flash signals cease. The current through relay *R3* is cut off, the relay releases and the loop is connected over from the battery to the alarm board.

All the relays are made with copper mantled cores to obtain delayed action, though the time the loop is disconnected from the alarm board is so short

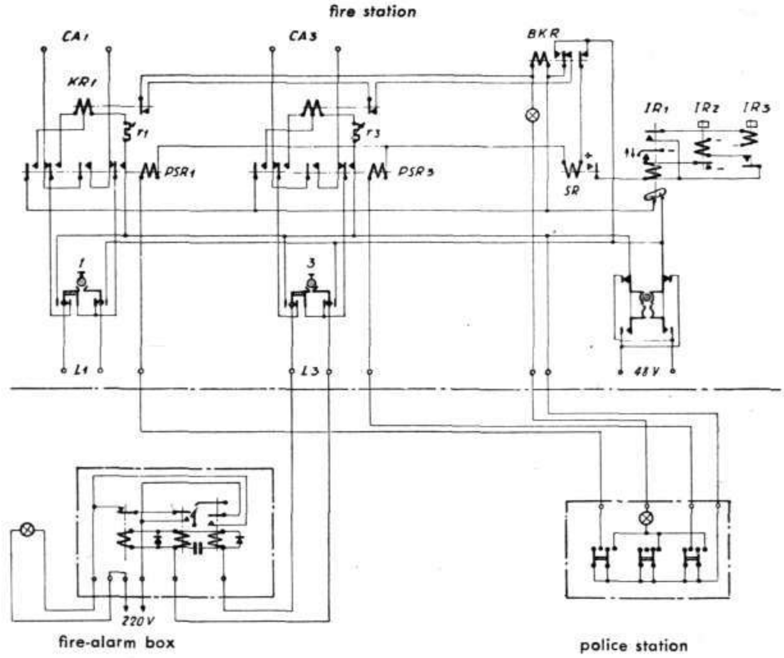


Fig. 3 X 5267

Diagram of police-telephone system with lamps operated from the fire station

BKR	control relay
CA_1, CA_3	alarm-board loops
IR_1, IR_2, IR_3	impulse relays
KR_1	control relay
L_1, L_3	alarm-box loops
PSR_1, PSB_3	police-signal relay
r_1, r_3	rheostats
SR	starting relay

that proper reception of a fire-alarm signal sent out during the connections is never endangered.

In the second system, in which the lamps are lit and extinguished from the fire alarm board, see the diagram, Fig. 3, polarised relays are connected into the supervisory circuit, similarly to above, but the release relay is provided with a make contact. In addition a relay with a break contact is connected in parallel with the connecting relay.

At the alarm board there is fitted a press-button for each loop together with a common two-way switch with a night and a day position. When the switch is in the night position and the buttons are pressed the current from a 36 to 48 V battery is connected through the loop in such a direction that the connecting relays and the relays connected to these in parallel attract. When the button is released the armatures of the connecting relays are held by the mechanical locking, the parallel-connected relays release and the lamps light up. When the switch is in day position and the buttons are pressed, the current is closed through the loops in the reverse direction, the release relays attract, and when the buttons are released the lamps are extinguished.

For sending out flash signals from the police station there is required a two-pole switch for each loop and a common control lamp. At the fire-station exchange there is connected for each loop a police-signal relay *PSR1* and a control relay *KR1*. In addition there are three common impulse relays *IR1*, *IR2* and *IR3*, a starting relay *SR* for these, and a control relay *BKR*. Between the fire station and the police station there are required a single wire-line for each loop and two common single-wire lines.

When the switch for a loop is thrown at the police station the circuit for the corresponding police-signal relay *PSR1* is closed and, in series with this, current is received by the starting relay *SR* for impulse relays *IR1*—*IR3* and it attracts. The police-signal relay short-circuits the loop to the alarm board and connects it to the impulse line from the impulse relays. In addition the control relay *KR1* is connected, and this has two windings working in opposition in such a way that one of the windings lies directly over the impulse line in series with an adjustable resistance *r1*. The other winding is connected over the impulse line in series with the alarm-box loop. The resistance is so arranged that the ampère-turns of both windings are the same.

Noise-Measuring Set

J. LJUNGBERG, TELEFONAKTIEBOLAGET L.M. ERICSSON, STOCKHOLM

In Ericsson Review No 3, 1934, a description is given of a noise-measuring set designed by Telefonaktiebolaget L.M. Ericsson in conformity with the recommendations then made by CCIF. Certain changes were, however, made at the CCIF meeting in Budapest, the most important of which relates to the form and tolerances for the sensitivity curve as a function of the frequency, as well as the insensitivity of the instrument for unsymmetrical noise voltages and external fields. The Ericsson noise-measuring set has therefore been redesigned in order to conform to these new conditions.

Fig. 1 X 3589
Noise-measuring set, Type ZB 175

The new noise-measuring set, Type ZB 175, Fig. 1, consists mainly of an amplifier with four valves and four different filter devices which together give the required sensitivity curve. The filters are, reckoned from the input side, a high-pass filter which is active in the range 50 to 300 c/s, a low-pass filter active between 2 000 and 5 000 c/s, and two anode loading impedances dependent on the frequency and active in the range 300 to 3 000 c/s.

The high-pass filter, see Fig. 2, consists of one filter-link incorporating the screened and balanced input transformer *5*; the filter has been adapted to the series resistances *6* and the grid potentiometer *7* in such a way that the attenuation curve has the desired gradient at low frequencies. The caracteristic impedance of the filter and the series resistances are so selected that the input impedance throughout the whole frequency range is greater than 10 000 ohm. By inserting the high-pass filter in front of the first valve all the valves are protected against overloading from incoming low frequencies of high amplitude. The low-pass filter is not required to give the same degree of protection as the high-pass filter and it has therefore been possible to place it after the first valve. This valve, moreover, has larger grid space than valves *2* and *3*. The low-pass filter *9* also consists of one filter link, matched to the internal resistance and the anode resistance of the valve in such a way that the attenuation curve attains the desired gradient. The anode load impedances *10* and *11*, both dependent on the frequency, by means of which the middle section of the attenuation curve is formed and the curve as a whole finely adjusted, have been calculated according to the method for graphic frequency transformation described in Ericsson Technics No 5, 1934, and No 2, 1935. There has thus been used as a basic element a shunt consisting of a resistance connected in series with a condenser. The shunt between the second and third valves has been obtained from the basic type by means of one frequency transformation

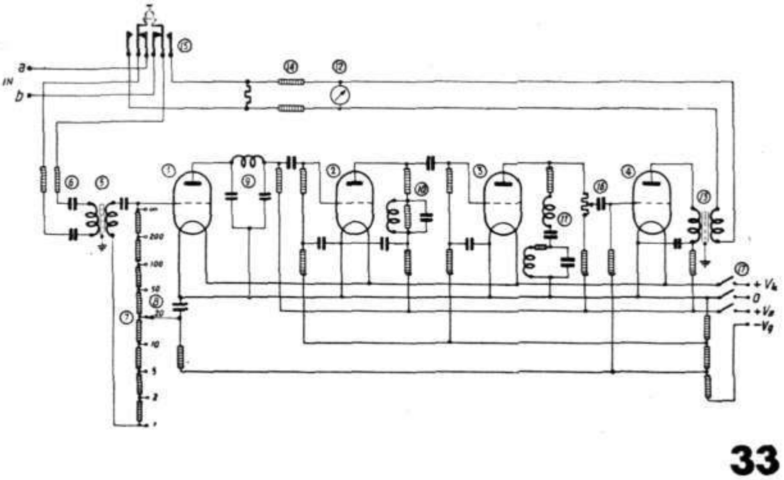


Fig. 2 X 5240
Diagram of noise-measuring set
1—4 amplifying valves
5 input transformer
6 series resistance
7 grid potentiometer
8 switch
9 low-pass filter
10, 11 anode impedances
12 indicator instrument
13 output transformer
14 pad
15 switch for amplification adjustment
16 potentiometer for amplification adjustment
17 switch

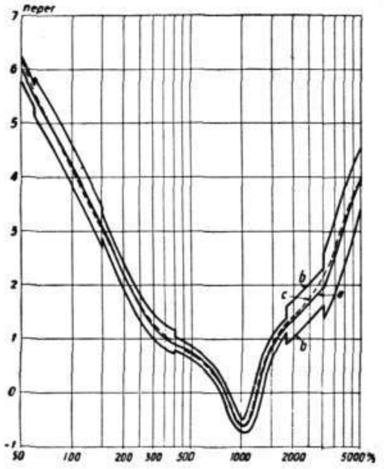


Fig. 3 X 3538

Sensitivity curves for noise-measuring set

a curve recommended by the CCIF
b tolerances allowed by the CCIF
c curve measured on Type ZB 175

and the shunt between the third and fourth valves by means of three different frequency transformations, all with different frequency functions. The indicator instrument *12* is connected to the output valve *4* over the output transformer *13*; suitable matching ensures that the deflection increases very nearly with the square of the input voltage, so that the instrument may be graduated for the effective value of the noise voltage. The instrument is graduated in mV and by means of the switch *8* the sensitivity can be set to 1, 2, 5, 10, 20, 50, 100 and 200 mV for full deflection at 800 c/s. Amplification of the amplifier is adjusted on the feed-back method. By pressing switch *15* a feed-back through the pad *14* is obtained, whereupon potentiometer *16* is adjusted until indicator *12* shows 1 mV when the switch *8* is put into the 1 mV position. The amplifier then has the correct amplification and may be used after releasing switch *15*.

The new sensitivity curve recommended by CCIF for noise measuring sets is shown as curve *a* in Fig. 3. The sensitivity curve may, however, vary within the tolerances shown by curves *b*. Curve *c* is the sensitivity curve for the noise measuring set designed by Ericsson. As will be observed this accords well with the curve recommended by CCIF.

The filament voltage required for the instrument is 2 V, the total filament current being 0.6 A. For grid and anode voltages an anode battery of 110—120 V is required; the total anode current is about 8 mA.

Fig. 4 gives a rear view of the instrument. In spite of the good utilisation of space, all parts are easily accessible. The noise measuring set is made as a portable instrument, see Fig. 1. The right-hand knob and the press button below the indicator instrument are used for adjustment of the amplification and the left-hand knob for selecting suitable sensitivity. The case is of wood and measures 325 × 265 × 250 mm. The weight of the instrument is about 16 kg.

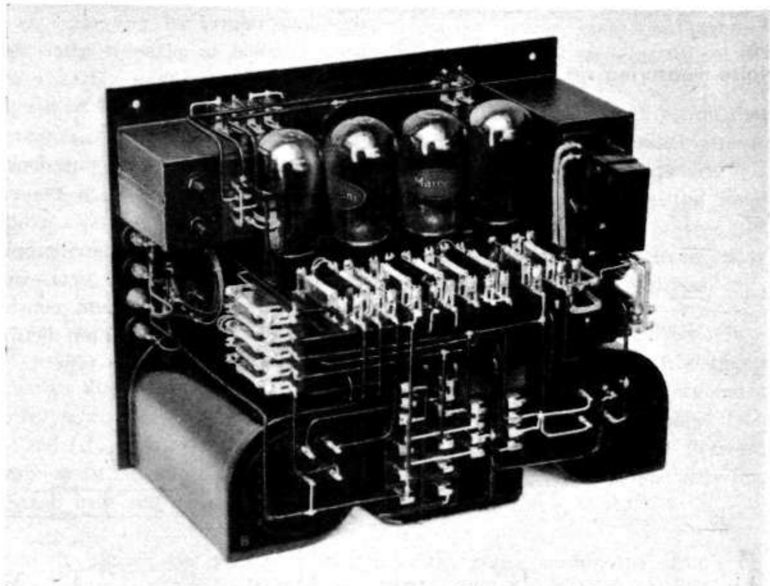


Fig. 4 X 5255

Panel of the noise-measuring set

bottom, filter coils and condensers; middle, shelf with valves, resistances and small condensers; top, input and output transformers

The Clock as an Advertising Medium

N. SUNDEVALL, ERICSSON SALES COMPANY, STOCKHOLM

Publicity is the watchword of the times and is perpetually seeking new ways to attract the attention of the public. A thing to which people's glance is always turning is a clock: one must know the time and preferably in the most convenient way possible. It is therefore only natural that efforts should be made to combine advertising with the clock, and for this purpose it is evident that the electrically driven clock presents considerable advantages over that driven by clockwork, when it is a matter of producing an effective publicity clock.

Church clocks, which in former times were visible all over towns and districts, are hidden now by the large buildings while their chimes are drowned in the noise of traffic, but in the hurry and bustle of the present day the need of correct time is greater than ever: always must we be on time, trains and busses leave »on the dot», the lunch interval is measured in minutes, and time-recorders are waiting to check us up at the place of employment. People on the way to work or to amusement want to be sure of the time, and the need of something which tells the hour on the streets and public squares is very great; an advertisement combined with clear and correct time indication can therefore invariably be counted on to attract attention and impress itself on the minds of the public.

If a clock is to have publicity value, *i. e.*, if it is to attract the eye to it and at the same time to the advertising text, it must above all things be a *distinct* clock, with the clock-face and the hands free from unnecessary ornamentation; the hours should be indicated by strokes or figures — it is not advisable to put in letters forming the name of the goods or of the firm, as everybody sees the time by the position of the hands without noticing how the hours are marked.

The advertising matter is best placed in direct connection with the clock, for example as a sign around the clock face, and should comprise the minimum of text, not more than can be taken in during the instant a person is glancing at the clock. The words imprint themselves on the mind of the passer-by and it is a common thing for advertising clocks to be used by the public to indicate places: »I'll meet you on High Street under Anderson's clock» or »it's in Trafalger Square just by the Cunard clock».

Ericsson have been making advertising clocks for many years and these have become exceedingly popular. The clocks are made with minute-impulse movement driven from a master-clock. In this way it is possible to locate the master-clock in an unexposed spot which ensures very great correctness in running, while the advertising clock itself is set up in the spot most convenient from the advertising point of view, without any need to consider the effect on merchanical parts as is the case with a clock driven by clockwork.

The accompanying photographs illustrate some Ericsson publicity clocks. As may be seen the effect is very good whether with daylight or artificial lighting.

X 5282

X 5281

X 5280

Electric Time Indicator

C. W. WILMAN, ERICSSON TELEPHONES LTD, LONDON

Since the article on electric indicators published in the Ericsson Review No 4, 1934, was written, a new form of the individual-drive type has been developed by Ericsson Telephones Ltd, London. Although the new indicator has been primarily designed for electric indicators, it has a wider sphere of use as, e.g., for the electric time indicator described below.

Fig. 1
Electric time indicator

X 3543

The indicator constructed by Ericsson, London, differs from other similar designs in that the figures are printed on a flexible endless band instead of upon the edge of a circular drum. Obviously, the diameter of such a drum must be large compared with the size of the figures and the indicators will take up a great space; the Ericsson indicator, however, does not take up more room in height than that required for the figure. Furthermore as the display surface is perfectly flat, the figures on adjacent indicator units do not tend to mask one another, and the angle from which a complete indicator board can be satisfactorily viewed is very wide. Tests have proved that the most easily read figures are those in white on a black ground, and this is the standard type. Any other colours, and also black figures on a white ground, can, of course, be supplied if required.

The electric time indicator, Fig. 1, is built up from four indicator units, driven by electric impulses, the movement of each band being effected by two specially shaped armatures rotated by the alternate energisation of a pair of field magnets. The armature spindles are mounted on ball bearings, and as there are no ratchet wheels, pawls, or similar parts, the action is almost noiseless. A view of an indicator unit with one side plate removed to disclose the interior arrangement is shown in Fig. 2.

The clock is controlled from a one-minute impulse circuit of the usual type, a small motor being employed to supply the driving impulses for the indicator field magnets. There are no controlling switches, and a special feature of the circuit is the method of transferring the drive from one indicator unit to the next at the end of the appropriate periods, *e. g.*, every tenth and sixtieth minute. This is accomplished under the direct control of perforations in the indicator bands, no separate relays or other intermediary apparatus being employed.

The height of the displayed figures is three inches (7.5 cm) and their simple form ensures the utmost visibility.

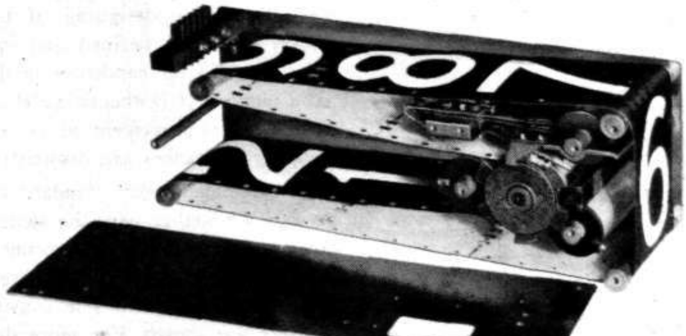


Fig. 2
Indicator unit

X 5260

New Catalogues

Four new supplements to the general catalogue of Telefonaktiebolaget L.M. Ericsson have just been published. These supplements comprise a few entirely new catalogue sections, as well as particulars of various newly designed apparatus, some of which has already been described in the Ericsson Review.

Supplement 1 deals with *program-distribution systems,* describing program-distributors for small as well as large installations.

Supplement 2 also introduces a new catalogue section describing *church-telephone systems* and *hallway telephones.*

Supplement 3 contains two new sections, one dealing with material for *luminous signals for hotels,* department stores, hospitals etc. and the other with *line material,* mainly dealing with material for indoor mounting.

Supplement 4 contains descriptions of some new material designed since the printing of the general catalogue, and in several cases describing material intended to replace older types of apparatus. For instance, this supplement includes a *magneto table telephone* in bakelite, which was described in the Ericsson Review No 3, 1935. Two new types of *subscriber's amplifying set,* for LB and CB systems, have been added. The section dry cells and battery boxes has been extended with material for these amplifying sets.

Another new thing is the *call-transfer relay,* which was described in Ericsson Review No 1, 1935, and which is used when it is desired to transfer a ringing signal from one to the other of two instruments, connected to the same line, when the first instrument has not replied to a call after a certain interval. Further, a *charging unit* for DC has been added.

The press buttons for *automatic fire alarm* have been redesigned and adapted for current voltages, thus enabling the number of types to be reduced. A slow-striking DC bell for use in fire-alarm installations has also been added. The earlier supervision box for *burglar alarm* has been replaced by a new type enclosed in a sheet metal hood and provided with telephone. An intermediate contact for use when wiring has to be taken over doors and windows has been added.

An engaged indicator contact for use in connection with *engaged-signal systems* is also included in this supplement. The contact enables a visitor wishing to call on the occupant of the room to see that he is engaged at the telephone and not to be disturbed.

Sieverts Kabelverk has issued a new catalogue dealing with static condensers for improvement of power factor, which is intended at the same time to be of assistance in selecting the condenser equipment most suited to each individual case.

The present Catalogue 512, »Static Condensers for Improvement of Power Factor», in addition to data and descriptions of current types of condensers and accessories, contains details of the compensation problem and instructions relating to the designing of the most suitable condenser equipment. The power factor is defined and various methods for measuring it are given. The effect of the condenser in the installation is explained and, with the help of a number of mathematical examples, the technical and economic advantages which the improvement of power factor by condensers produce under different circumstances are demonstrated.

The catalogue covers standard types of condensers for operating tension up to 22 kV together with the switches, disconnecting links and discharge resistances necessary for their connection. The mounting and connecting of the various types of condensers are dealt with thoroughly and illustrated by a number of diagrams. The construction and electrical properties of the condensers are shown. For more detailed information reference is made to the pamphlet issued by Sieverts Kabelverk and entitled »Condensers in Power Technics», which is presented in Ericsson Review No 1, 1935.

Ericsson Technics

Ericsson Technics No 1, 1936.

T. Laurent: Le filtre zig-zag — un nouveau filtre passe-bande trouvé à l'aide des transformations fréquentielles.

This work opens with examples of frequency transformations, together with an exposition of the general principles of these transformations. It goes on by subjecting to more detailed examination the newest variations of frequency transformations.

These variations have shown themselves particularly useful for the investigation and computation of the important band-pass filter links with one or two impedance peaks arbitrarily situated in the frequency scale, and the rest of the work is therefore devoted to such problems. In dealing with these questions there has been evolved a method of building band-pass filters on a new principle.

The new band-pass filter obtained in this manner, which has been given the name of zig-zag filter, will be simpler and cheaper to manufacture than the types of band-pass filters hitherto known and may therefore be expected to be of great importance in practical work. Thus the new much discussed quartz-crystal filters can with advantage be made as zig-zag filters.

In view of the fact that the greatest part of the cost of carrier-frequency telephone and telegraph equipment is represented by the cost of the band-pass filters used, and that the tendency is for carrier-frequency transmission to become predominant in future telecommunication practice, the zig-zag filter has prospects of assuming great economic importance.

Technical Information

Aktiebolaget Alpha, Sundbyberg, has recently issued the first of a series of technical communications which under the name of »Technical Information» are to be sent out from time to time and will deal with the various manufactures of the company.

In common with other firms, A.-B. Alpha has up to now been printing and distributing to clients various printed matter, in the form of circulars and price-lists. It has been found, however, that this printed matter cannot cover all the different products of the firm, partly because of the many spheres of application for them and partly because of the very rapid developments and the constant improvements made. For this reason the company has decided to provide a series of technical communications to be issued from time to time in the English language under the title of »Technical Information». These communications, which will be multigraphed, will comprise text, diagrams and illustrations, and it will be the aim of A.-B. Alpha to make the contents of such value that the communications will be preserved by the readers to build up gradually a handbook of the company's manufactures, constantly brought up-to-date.

These technical communications are naturally chiefly designed to assist the representatives of A.-B. Alpha in their work, but at the same time »Technical Information» will gladly be sent to all expressing a desire to receive them, and the company will be pleased to consider any suggestion from readers with a view to making the contents of the publication as useful as possible.

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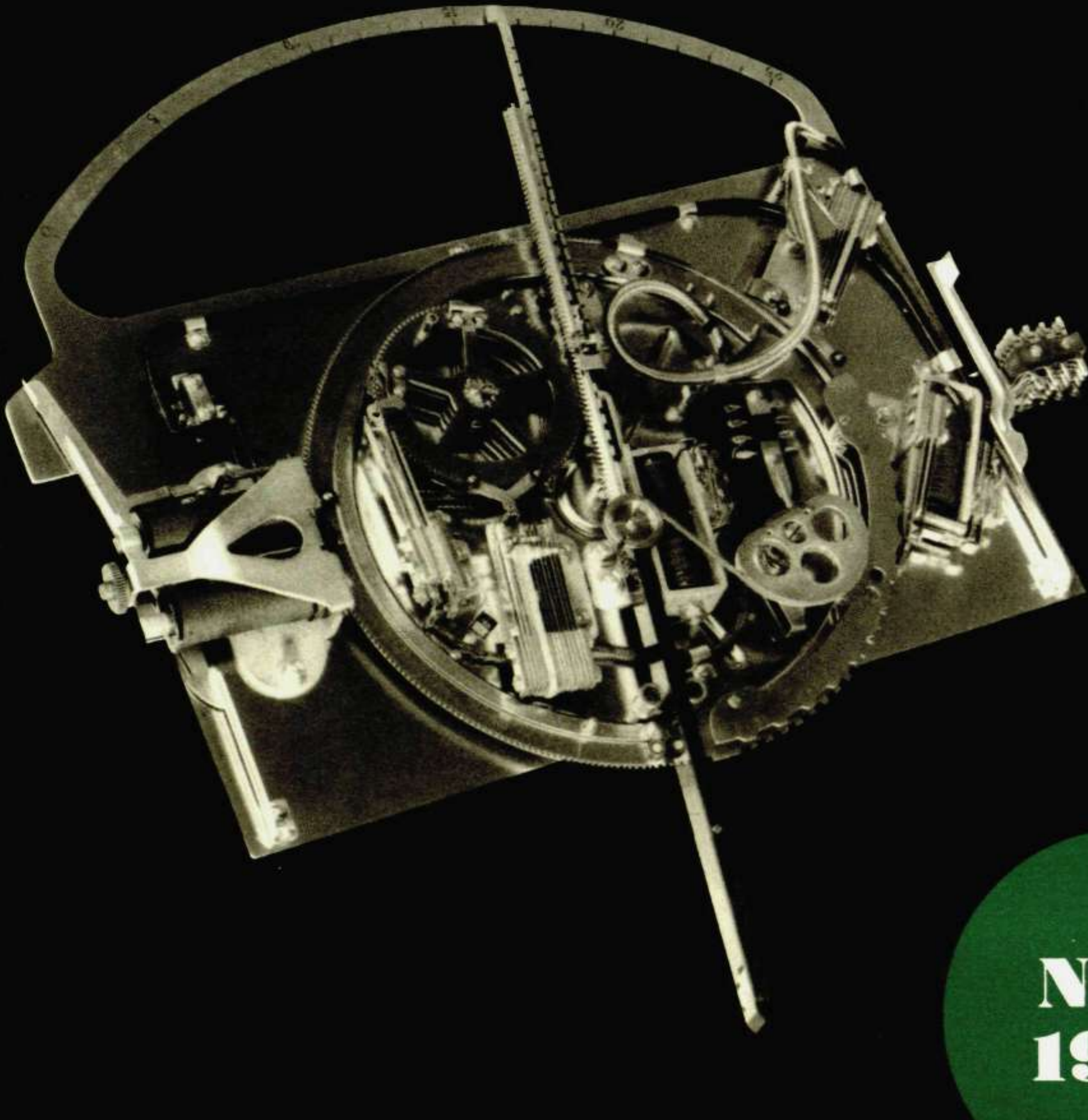

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1936

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Ericsson 1876–1936

HEMMING JOHANSSON, TELEFONAKTIEBOLAGET L. M. ERICSSON, STOCKHOLM

The 1st April of this year marked the completion of 60 years since Lars Magnus Ericsson began the activities which were to develope into what is now called the Ericsson Group. The beginning could hardly have been more modest than it was: the staff consisted only of Ericsson himself and a single assistant. It might be tempting at this stage to follow the history of the enterprise, but that must be reserved for another occasion.

All the same it is of interest to cast a hasty glance backwards and make a closer examination of the circumstances which have rendered possible the development from a small home workshop into a great industry, a development which in its essentials occurred during the period when Ericsson was himself directing the undertaking. Such an investigation will show that these circumstances were both external and internal in nature. There can be no question that the conditions of the times were not favourable for Ericsson. To make this clear it is only necessary to recall some data, well known to the electro-technician but to which he has perhaps not given very close consideration.

When Alexander Graham Bell on 14th February 1876, that is the year Ericsson laid the foundations of his undertaking, presented his well-known application for patent for the magneto-electrical telephone, electrotechnics were still in their infancy. Quite a number of the properties and effects of electricity were well-known, and Maxwell had shortly before presented his brilliant investigations into electricity and magnetism, thus laying solid foundations for the theoretical treatment of the study of electricity. Certain practical applications of electrical activity had also appeared, such as the electric telegraph to which Ericsson directed great attention from the beginning. Still electrotechnics in the true meaning of the word could not be said to exist before Gramme in 1870 made his revolutionary invention, and other pioneers, like Werner von Siemens, Edison and Bell, by their profound research and illuminating discoveries laid the practical foundations from which electrotechnics could be built up.

The whole development of electrotechnics — both power technics and telecommunication — from the first halting steps right up to the extraordinary achievements of the present day consequently falls within the last 65 years, i. e., within the span of a by no means abnormally long human life. No branch of technology has in such a short time spread over such a wide domain of human sphere of activity as has electrotechnics.

At the beginning Ericsson's activity was directed to the electro-mechanical sphere, the production of instruments for telegraphy and for various kinds of electric signalling. But when the news of Bell's invention reached him, he threw himself with eagerness and energy into the new field of enterprise which opened itself before him, the future prospects of which he realised, at least to some extent, even if he, like many others, little imagined how unlimited these possibilities were later to prove themselves. Ericsson became the real pioneer in Sweden of that branch of electrotechnics which has received the name of telecommunication. As a result he belonged to the favoured few who have had the advantage of being in at the outset when a new field of enterprise was opening and he was in a position to throw himself into that field at the right moment.

But if outside circumstances were thus favourable for Ericsson, his progress must still be attributed to a large extent to other causes. He possessed to a high degree the qualities, consciousness of his aim, energy and capacity for work, which combined with a particularly well grounded knowledge of his trade predestined him for advancement in the sphere he chose, even had outside conditions been less propitious. He set to work with two empty but skilful hands; after 27 years work he retired from a undertaking which, judged by the standards of the times was both great and prosperous, and into which during that long period but a few thousand kronor of outside capital had been invested, an illuminating example of the capital-building value of work, not the only one of its kind in Swedish history it is true, but still one of the most striking.

The history of the Ericsson group during the 60 years just completed constitutes an important and integral part of the history of electrotechnics. Whenever this latter comes to be written, an interesting chapter will be that dealing wih the Ericsson group, its foundation and its development. Many paragraphs in that chapter will be a song of praise in honour of labour and evidence of its paramount importance as foundation for the improvement of material — and thereby also indirectly of spiritual culture.

Ericsson Telephones throughout 60 Years

The present-day telephone instrument is the result of development work constantly pressing forward to improvement. The line of telephone instruments produced by Ericsson during the last sixty years indicates how each type reflects the taste of its time and how new materials have affected the shapes.

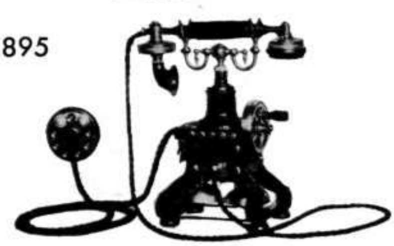
1878

1881

1884

1892

1895



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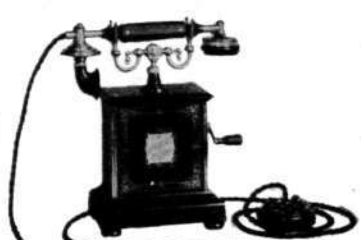

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1931

1935

Portable Field Telephone Switchboards

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In the intense development work during recent years in telephone technics in general and the exchange technics in particular, the branch comprising portable switchboards has by no means been neglected, and quite a number of new switchboard types have been designed lately.
The portable telephone switchboards described below are designed according to different schemes with the object of meeting the requirements of different clients, and therefore they vary somewhat in design and way of operation.

Portable telephone switchboards which are made only for the local battery system are usually divided into two classes according to their weight. The lighter class comprises switchboards intended to be carried long distances by one man. They are usually provided with carrying strap, but they very seldom have transmission equipment. A portable telephone set is used instead for conversation and signalling purposes. As a rule switchboards of the lighter class are not equipped for more than 6 lines. On the other hand they are often made in such a way that, for instance, two switchboards with five lines can be placed together and operated as one switchboard with ten lines. The heavier class includes switchboards which normally are to be transported by vehicles available and can be carried only short distances by one or two men. These switchboards are usually provided with handles, and they always have transmission and signalling equipment consisting of microtelephone, generator, battery etc. Switchboards of the heavier class are usually not made for more than 20 lines.

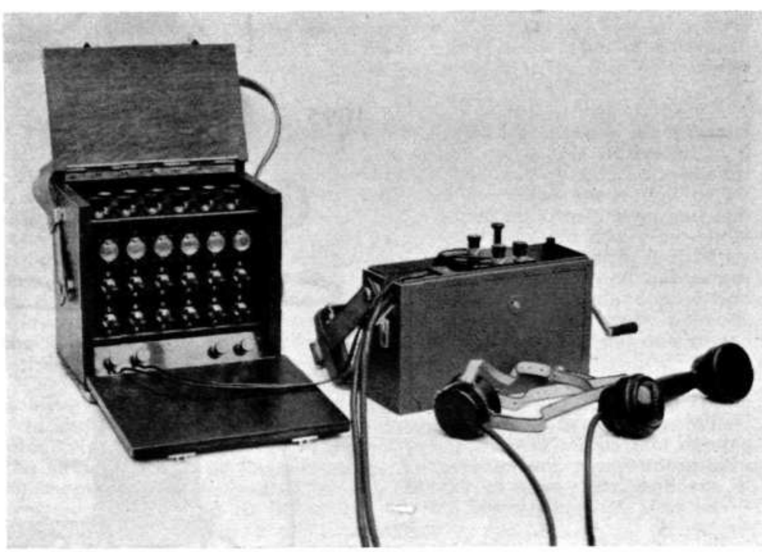


Fig. 1 X 5263
6-line field telephone switchboard and field telephone instrument from Ericsson, Stockholm

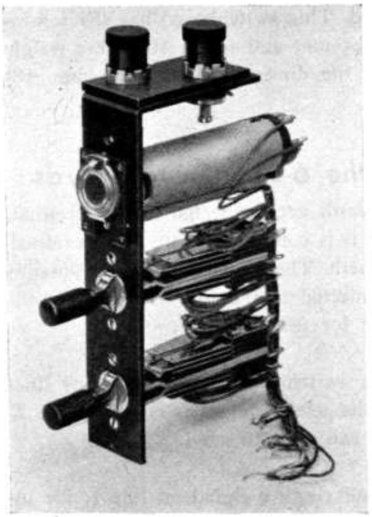


Fig. 2 X 3544
Line unit for field telephone switchboard from Ericsson, Stockholm

Field Telephone Switchboards from Ericsson, Stockholm

In the design of these switchboards special attention has been paid to the use of as many as possible of the construction parts used for the field telephone set described in the Ericsson Review No 2, 1935. This for instance is the case with screw terminals in the smaller switchboards and with microtelephone, induction coil, generator, batteries and so on for the bigger type of switchboards. Thus the keeping of spare parts has been very much simplified. Further construction details have been chosen as used for the stationary switchboards, and which have proved to possess good qualities, mechanical as well as electrical.

The lighter weight class includes one switchboard for 4 lines and another for 6 lines, which have 2 and 3 simultaneous conversation possibilities respectively. The heavier class is represented by a 20-line switchboard for 8 simultaneous conversations.

Design of the Switchboards for 4 and 6 Lines

These switchboards are intended for effecting connections between telephone sets on the local battery system with hand generator via single-wire as well as double-wire lines. Ordinary drop indicators are used as calling devices, and lever keys have been used for the switching. Transmission and signalling set is not included in the switchboards, which are intended to be combined with a field telephone set.

The mechanical construction of the switchboards is briefly the following: the various parts needed for one line are concentrated into a unit, the line aggregate. Four or six of these line units are then fitted along with certain common equipment on an inset. Finally this inset is placed in a strong case.

The *line unit* is shown Fig. 2. The mounting plate bent at right angles is fitted with calling and clearing drop, two keys and two contact clips for the connection of the line. The terminals are of a very sturdy construction with never-missing nuts covered with insulating material, and they are mounted on an insulating plate. The drop is used both as calling and clearing indicator. It is ironclad to prevent cross-talk between two line aggregates placed alongside one another, and it has a resistance of 1 000 ohm. It is highly sensitive to signalling currents, but at the same time its attenuation at voice frequencies is very low. The drop indicator is provided with alarm contact operated by the shutter. The lever keys are of the most modern design with the spring assemblies fitted on each side of a frame placed in the centre. The lever has a grip of insulating material. Each key has three positions, one normal position and two operating positions. Finally the parts of the line unit are connected by means of a cable so arranged that its other end can readily be connected to the bus bars of the switchboard.

The *inset* consists of a number of line units, in this case six, mounted on a common frame which also contains a number of bus bars, for the connection of the line units, and four terminals. These are mounted at the lower part of the frame on a plate of insulating material. The telephone set is connected to the two terminals on the left, and to those on the right a signalling device can be connected consisting of, say, a DCU bell and a battery.

Fig. 3 X 3545
6-line field telephone switchboard from Ericsson, Stockholm

The *case* Fig. 3, is made of best quality oak walnut-stained and cellulose lacquered. Both the lid and the front are fitted with hinges, and the whole case can be fastened by two snap locks. All corners exposed to damage are protected by metal, and the four bottom corners are fitted with rubber feet. A strong carrying strap of leather is fixed to the ends of the case by suitable fittings. The strap is adjustable and can readily be changed.

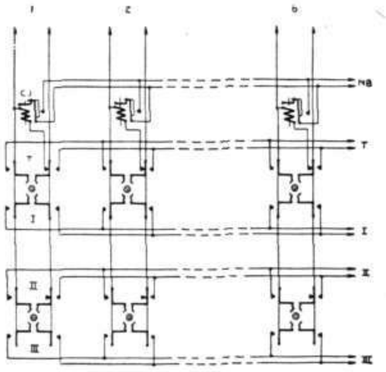


Fig. 4 X 3546
Circuit diagram for 6-line field telephone switchboard from Ericsson, Stockholm

Fig. 1 shows the 6-line switchboard opened. This switchboard has the following dimensions: height 235 mm, length 245 mm and width 165 mm; weight about 6.5 kg. For the 4-line switchboard the dimensions are: 235 mm, 185 mm and 165 mm; weight about 4.7 kg.

Operation of the 4-Line and the 6-Line Switchboards

The telephone lines served by the switchboards are connected to the terminals of the line units. If it is a single-wire line, it is connected to the rear terminal, while the front terminal is connected to earth. The telephone set and possibly an acoustic signalling device are then connected to the four terminals at the lower end, after which the whole is ready for use.

Fig. 4 shows the circuit diagram of these switchboards. The telephone lines are connected to the line units 1, 2 etc. The telephone set is connected at *T*, and at *NB* an acoustic signalling device can be connected.

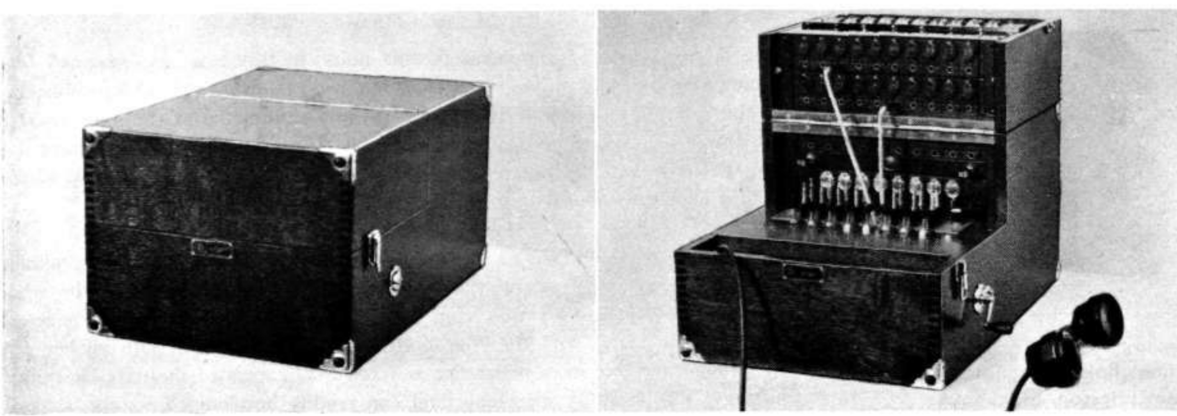
Operation is briefly as follows: an incoming ringing signal on line 1, for instance, operates the calling drop *CJ*. The call is answered at the telephone set by moving the key belonging to line 1 upwards, at the same time restoring the drop by hand. After receiving the order the key is restored, and then the line can be transferred to one of the three switching positions *I, II* or *III* by operating the corresponding key. Now the line ordered by the caller is connected to the telephone set, from which ringing signal is sent out by means of the generator. When the called line has answered, it is disconnected from the telephone set and switched over to the same switching position as the calling line. Then the two lines are in conversation connection with one another. During the whole call the drop indicator *CJ* is connected across each line, and when the call is finished the clearing signal from one line operates both drops, thus indicating the clearing. The connection is then cut off by restoring the two keys, after which the drops have to be restored by hand.

Calling on a number of lines in order to transmit information on them simultaneously is effected when all the lines in question are switched through to the telephone set by operating the respective keys. Then ringing signal is sent out, and, when all the called lines have answered, the information can be given from the telephone set of the switchboard or from any of the other lines connected.

Switchboard for 20 Lines

Fig. 5 shows a portable switchboard for 20 incoming lines and 8 simultaneous conversations. The calling devices consist of jacks combined with drops, and the switching cords used are in principle of the same pattern as for ordinary stationary switchboards. The switchboard is provided with complete transmis-

Fig. 5 X 7091
20-line field telephone switchboard from Ericsson, Stockholm



sion and signalling equipment consisting of hand microtelephone, hand generator, battery and so on. The dimensions of the switchboard closed are: height 260 mm, length 350 mm, width 500 mm; weight about 25 kg.

Field Telephone Switchboards from Elektrisk Bureau, Oslo

Of the series of portable switchboards designed by A/S Elektrisk Bureau, Oslo, the following deserve special mention: a 6-line switchboard with 3 simultaneous conversation facilities representing the lighter class, a 10-line and a 15-line switchboard representing the heavier class.

Design of the 6-line Switchboard

It is characteristic of this switchboard that press-button keys have been used as switching devices, and that special clearing indicators have been introduced. Transmission and signalling set is not included with the switchboard which is intended to be combined with an ordinary field telephone set.

The mechanical construction of the switchboard is briefly as follows: the parts needed for one line are fitted together to a line unit, which can readily be changed. Six of these line units are mounted, together with the common equipment on an inset. On this inset some equipment for the lines, such as terminals and fuses, is also mounted. Finally the inset is placed in a solid case of suitable dimensions.

The *line unit*, Fig. 7, consists of a straight mounting plate of light metal, on which a visual calling indicator, an operating key and three switching keys are fitted. The visual calling indicator is made as a star indicator with polarized armature set, making it highly sensitive to signalling currents. The resistance of the indicator is 4 000 ohm. It is fitted with alarm contact actuated by the operation of the indicator. The operating key is a press button key, which among other things is mechanically coupled to the calling indicator in such a manner that the indicator is restored when the button is pressed. The switching keys are of the same construction as the operating key. All the keys are so made that the button turns 90° when pressed. It is thus easy to see if a key is pressed or not when looking at the switch-

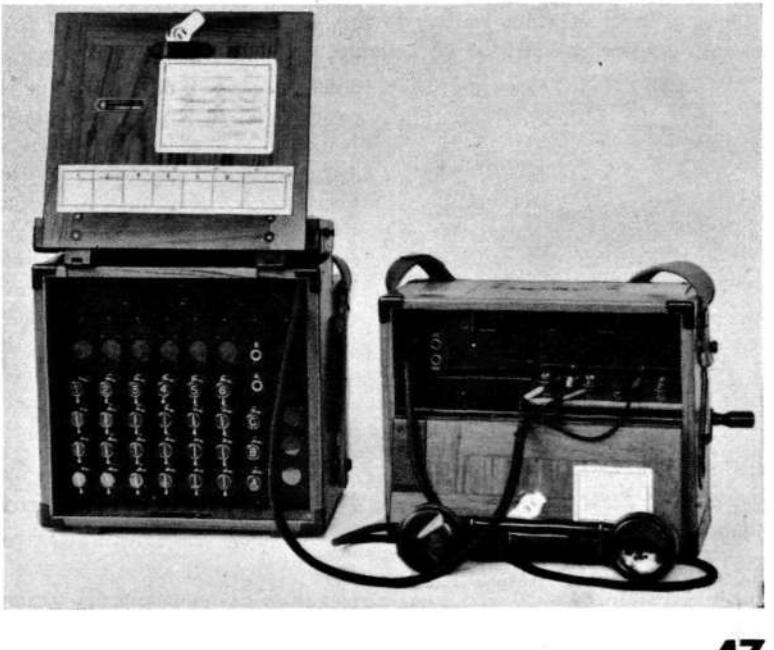


Fig. 6 X 5264
6-line field telephone switchboard and field telephone instrument from Elektrisk Bureau, Oslo

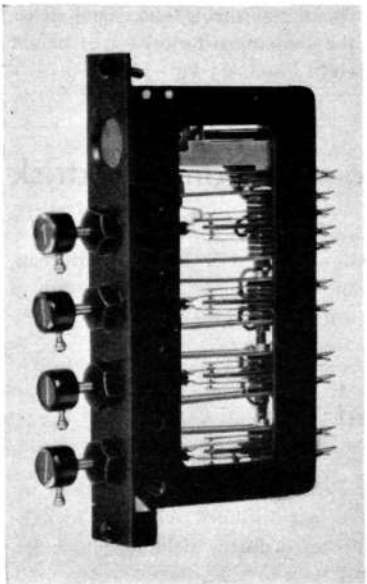


Fig. 7 X 3563
Line unit for 6-line field telephone switchboard from Elektrisk Bureau, Oslo

Fig. 8 X 3547
6-line field telephone switchboard from Elektrisk Bureau, Oslo

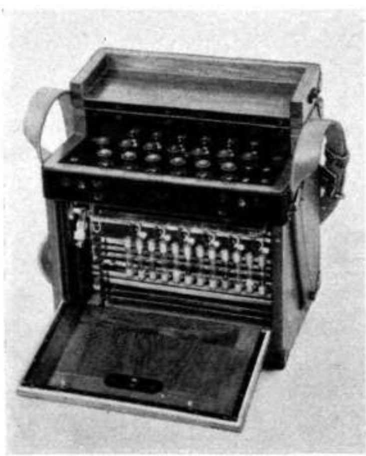


Fig. 9 X 3548
6-line field telephone switchboard from Elektrisk Bureau, Oslo
with back let down for changing rare-gas tubes

board from the front. The connection of the line unit to the line clips and to the bus bars fitted on the frame of the inset is effected by means of special spring fitted jacks.

The *inset* contains, in addition to the six line units, three visual clearing indicators, one for each switching position, and three listening keys coupled to the indicators in such a manner that these are restored by pressing the keys. The clearing indicator is of exactly the same design as the calling indicator, but is has a resistance of 1 200 ohm. In addition there are two connecting jacks at the front for the connection of two switching positions of two switchboards. For the connection of the telephone set there is a cord with four conductors, which during transportation can be kept in the box arranged at the top of the inset. In this box also are kept the connecting cords which are used for the connecting together of two switchboards.

At the rear of the top of the inset a block is mounted with terminals for the six line unit. This also contains a common earth terminal and individual earth press-buttons for each line arranged in such a way that one wire is put to earth when the button is turned 90°. At the immediate rear of the inset, see Fig. 9, six pairs of lightning arresters with changeable rare-gas tubes are to be seen and also the busbars earlier mentioned. At the right end a buzzer is also mounted giving an acoustic signal for calling and clearing.

The *case*, Fig. 8, is of first-quality cellulose-lacquered teak. The complete front consists of a lid which can be raised and fastened by means of a lock. The half of the top is cut off and provided with hinges thus forming a lid which covers the terminal. To facilitate changing of the rare-gas tubes part of the rear side can be lowered, see Fig. 9. All corners are rounded and protected by metal. The case is provided with a carrying strap fixed at the ends of the case.

Fig. 6 shows the complete switchboard opened and with the inset in place. The complete switchboard has the following dimensions: height 250 mm, length 270 mm, width 190 mm; weight about 9 kg.

Operation of the 6-Line Switchboard

The circuit diagram of the switchboard can be seen in Fig. 10. The telephone set is connected at *T* and *SB*.

Operation is briefly as follows: a call from one line operates the calling indicator. The call is answered at the telephone set by pressing the operating key, and by this the calling indicator is restored automatically. When the order is received, the calling line is transferred to one of the three switching positions *A*, *B* or *C* by restoring the operating key and pressing one of the switching keys. The wanted line is now switched on to the telephone set, and ringing signal is sent out. After getting answer the line is switched over to the same switching position as the calling line, and the conversation connection is established. When clearing comes from any of the lines at the end of a call, the clearing indicator of this switching position is operated. When pressing the listening key in question the clearing indicator is restored, and at the same time it is possible to make sure by listening in that the call really is finished. In such a case the conversation connection is cut off when the two switching keys are restored to normal. Circular calls can be established in the usual way either in the operating position or in one of the three switching positions.

10-Line and 15-Line Portable Switchboards

The portable switchboards with 10 or 15 lines made by Elektrisk Bureau are provided with quite a number of technical novelties. For instance a line unit, Fig. 11, of quite a new design has been used. This in principle is made

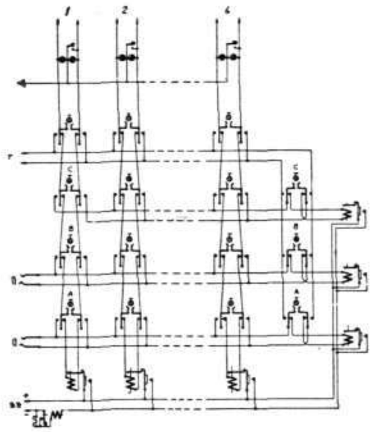


Fig. 10 X 3549
Circuit diagram for 6-line field telephone switchboard from Elektrisk Bureau, Oslo

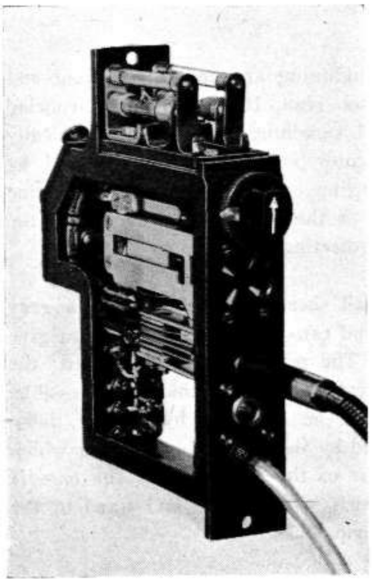


Fig. 11 X 3550
Line unit for 10 and 15-line field telephone switchboards from Elektrisk Bureau, Oslo

in such a manner that the line terminates in a connecting jack but also in a cord with connecting plug. The calling device is a polarised visual indicator of the same type as for the switchboard earlier described. The switchboards are provided with complete transmission and signalling equipment, and they are also fitted with a number of line transformers intended for use when calls are established over one single-wire and one double-wire line.

Fig. 12 shows a 15-line switchboard placed on a stand ready for use and also the same closed up and with the stand ready for transportation. The dimensions of the closed switchboard are: height 331 mm, length 495 mm, width 202 mm; weight inclusive of stand about 29 kg.

Field Telephone Switchboards from Ericsson, Colombes

Société des Telephones Ericsson, Colombes, has designed a number of new portable switchboards of a very simple and practical design. In the very careful design of these switchboards special attention has been paid to such qualities as simple installation and maintenance, working reliability and light and strong construction. The parts used are as far as possible of standard pattern.

The lighter weight class is represented by a 5-line switchboard not provided with transmission and signalling set. Of the heavier class there are a 15-line and a 20-line switchboard each fitted with transmission and signalling equipment.

Design of the 5-Line Switchboard

It is characteristic of this switchboard that the switching of the calls is effected by means of cords.

The mechanical construction is briefly as follows: all parts needed for one line are concentrated to a line unit, which can readily be changed. Five line units are fitted in a case, together with certain common equipment. The case is provided with a lid thus making all vital parts very accessible.

The *line unit*, Fig. 14, consists of a bent plate of light metal. On this plate terminals, a line protector, a calling and clearing drop indicator, a connecting jack and a cord with connecting plug are fitted. The terminals are mounted on a bakelite block placed at the rear of the line unit. The block is provided with grooves as guide for the connecting wires. The line protector consists

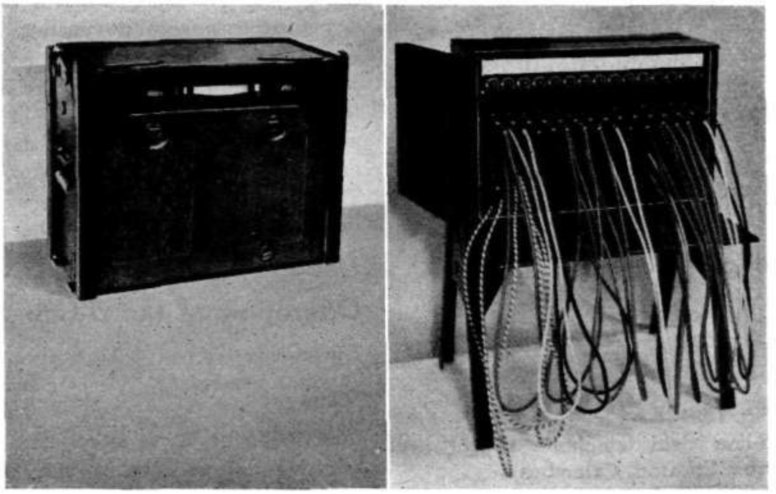


Fig. 12 X 5274
15-line field telephone switchboard from Elektrisk Bureau, Oslo
left, closed for transport, right, mounted on stand for use

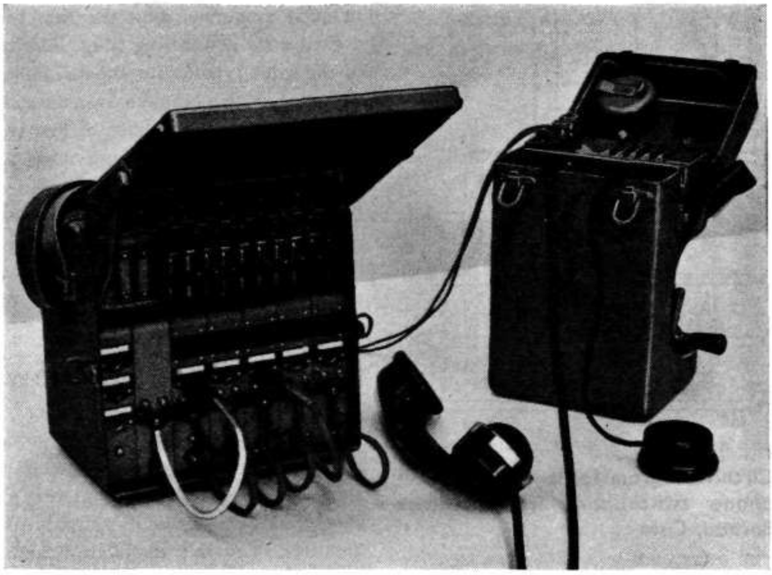


Fig. 13 X 5272
5-line field telephone switchboard and field telephone instrument from Ericsson, Colombes

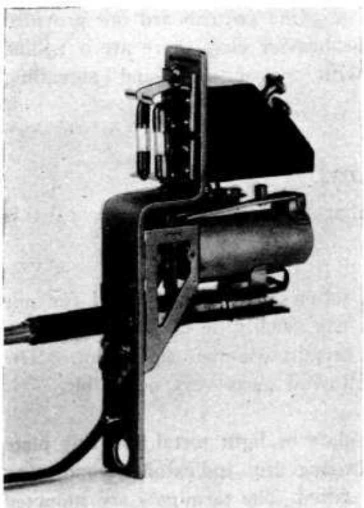


Fig. 14 X 3551
Line unit for field telephone switchboard from Ericsson, Colombes

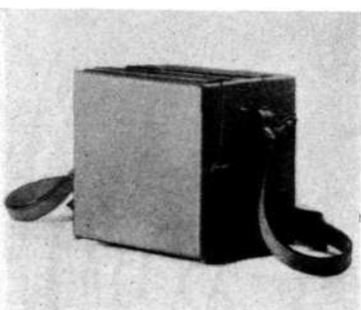


Fig. 15 X 3552
5-line field telephone switchboard from Ericsson, Colombes

of two fuses in glass tubes and a point lightning arrester. The calling and clearing indicator has a resistance of 1 500 ohm. It is completely ironclad to prevent cross-talk. Drop indicator and switching jack are mechanically coupled together. Thus an operated indicator is automatically restored by inserting a plug into the jack. The connecting cord is connected to the line aggregate via two terminals at the front of the plate. The free end of the cord is fitted with switching plug with protecting spiral.

The *case*, Fig. 15, is made from parkerised sheet steel lacquered in a grey colour. The front is mounted on hinges and can be opened in order to give access to the connecting cords and jacks. The rear also can be opened; the upper part can be raised thus making the terminals on the line unit accessible. Finally the interior of the switchboard can be inspected by turning down the lower of the rear. All hinges are covered by flexible leather packing which prevents water penetrating into the interior of the switchboard. The case is provided with a strong carrying strap which is adjustable and fixed to the sides. All lids are fastened by ordinary snap locks.

As can be seen from Fig. 13 the switchboard contains, in addition to the five line unit, an operating cord to which the telephone set can be connected, and three jacks intended for the switching of the calls when two or more switchboards are placed together. Therefore the jacks are connected to a multiplying jack placed towards the rear of the switchboard. They are also connected to a cord terminating in a plug. The linking together of two switchboards is effected by inserting the plug of one switchboard into the jack of the other one. The cord with plug is kept in a special box at the lower part of the switchboard. This box is also intended for holding the plugs of the connection cords during transportation.

The switchboard has the following dimensions: height: 205 mm, length 205 mm, width 165 mm; weight about 6.7 kg.

Operation of the 5-Line Switchboard

The circuit diagram of the switchboard is shown in Fig. 16. The incoming lines are connected to *1*, *2* etc., and the telephone set is connected at *T*.

Operation is briefly as follows: an incoming signal from one of the connected lines operates the drop indicator in question thus indicating a call to the

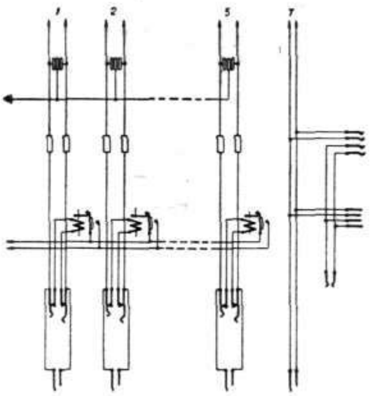


Fig. 16 X 3554

Circuit diagram for 5-line field telephone switchboard from Ericsson, Colombes

switchboard. The call is answered by inserting the plug of the operating cord into the jack. By doing this the calling drop is restored automatically. When the order is received the plug of the operating cord is transferred to the jack of the wanted line which is called by ringing from the generator of the telephone set. When the line answers, the operating cord is taken down, and instead the connecting cord of the caller is switched to the connecting jack of the called line, whereupon the conversation connection is established. The drop indicator of the calling line is connected during the whole conversation. When clearing comes at the end of the call from any of the lines, this operates the drop thus signalling the clearing. Restoring of the drop is effected by inserting the operating cord into the jack belonging to the line, and at the same time it is possible to make sure by listening in that the call is finished. If that is the case, the connection is cut off by taking down the connecting cord from the jack of the line.

Circular calls are switched in such a manner that the connecting cord of the first line is plugged into the jack of the second line. Then the cord of the second line is plugged into the jack of the third line and so on until all the lines concerned by the call are switched together.

15-Line and 20-Line Switchboards

The portable switchboards of the heavier weight class are made according to the same principles as the 5-line switchboard. The same line unit has been used, and the only difference is that complete transmission and signalling equipment has been mounted in the switchboard, consisting of hand microtelephone, hand generator and so on. The net weight of the 20-line switchboard is about 30 kg.

Single-Channel Carrier Telephone for Open-Wire Circuits

S. KRUSE & C. AURELL, TELEFONAKTIEBOLAGET L.M. ERICSSON, STOCKHOLM

Open-wire lines are still of great importance in telecommunication and, in order to make the best use of their possibilities, carrier systems are employed more and more in all parts of the world. Telefonaktiebolaget L.M. Ericsson, for many years working in the carrier field, has now designed new carrier systems applying the latest experience both with regard to principles and to mechanical design. As a result, carrier systems have been obtained with considerably improved transmission characteristics, low maintenance costs and reduced dimensions. This paper deals with one of the new systems, viz: the single channel carrier telephone system, Type ZL 400.

It has become more and more common to employ carrier systems for increasing the number of telephone communications on existing long distance lines. On lines of great length it is more economical to install a carrier system than to string new wires. Furthermore, the carrier systems may easily be adopted to varying traffic conditions and have often better transmission characteristics than a physical circuit. This is due to the fact that ordinary voice-frequency circuits are more exposed to disturbances and instability than a corresponding carrier channel, and the latter thus may be employed with advantage for great distances. This increases still further demands on the transmission characteristics of carrier systems, *i.e.*, on the width of the transmitted frequency band, the stability of the overall attenuation etc.

When the traffic intensity on a route requires additional circuits the question arises: which solution is the most economical, to string new physical lines or to provide for carrier channels. The cost of a new physical line and its maintenance amounts to a certain figure per kilometer. The corresponding cost of a carrier system is independent of the length of the line at least up to a line attenuation where a further increase of the line length will necessitate an intermediate carrier repeater. Over a certain distance the costs for stringing and maintenance of a new line and the costs for a carrier system and its maintenance will be equal. The carrier system will consequently be more advantageous for greater distances but for shorter distances a new line will give the best economic result. The critical distance depends of course on the relation between the costs of a new line and of a carrier system, which varies from country to country.

For obtaining one telephone channel in addition to the ordinary voice frequency communication on a line, a single-channel carrier-telephone system has to be employed. This system consists of two bays, one for each terminal office, which are easily moved from one place to another if desired and can be connected to the line without difficulty. The cost of a single-channel system is equal to the cost of a physical line about 50 km in length. This comparison holds good for fixed equipments but the single-channel system is also specially suitable for use on momentarily overloaded routes as for instance to a winter sports centre, a bathing resort etc. In this case the cost for a single-channel system must be compared with the total cost for all the lines on which it is succesively operated.

A special field where the single-channel system may be advantageously adopted is for the provision of a direct communication between the terminals of a railway telephone line used for operating selective-calling systems. In this case simple filters are installed at the intermediate way-stations, allowing of a direct carrier channel undisturbed by the selective calls between stations along the line.

The Ericsson single-channel systems, Type ZL 100 and ZL 200, have been designed to cooperate with the four-channel system, Type ZM 200, which was developed for twisted overhead lines. When transposed lines are used the carrier-frequency range must be limited upwards much more than is necessary when twisted lines are used. This is dealt with in an article in Ericsson Review No 4, 1935. Ericsson has designed a three-channel system for lines with flat transposition and in this connection also a new single-channel system, which is intended to cooperate with the new three-channel system.

General Characteristics

The single-channel system, Type ZL 400, shows many new features both with regard to material and mechanical design and to underlying principles. The result is a system with excellent transmission characteristics, low maintenance cost, reduced weight and small dimensions.

The system operates with suppressed carrier frequency and only the lower side-band is transmitted. The frequency allocation is shown in Fig. 1. For one direction the frequency band 3 500—5 900 c/s is used and for the other direction 6 900—9 300 c/s. The corresponding carrier frequencies are 6 200 c/s and 9 600 c/s. The highest frequency transmitted is consequently 9 300 c/s. When automatic level regulation is provided a pilot frequency is used for the upper band, which is a few hundred cycles per second higher. As the frequencies of this system are comparatively low, a certain number of intermediate cables in the line may be permitted. The effective width of the transmitted side-band is 300—2 700 c/s. The low-pass filter separating the voice-frequency channel has an upper cut-off frequecy of 2 900 c/s.

In the normal system, the output level of the side-band is 0.75 neper (6.5 db) above the level received at the office side. With regard to line noise, a level lower than — 1.75 neper (15 db) at the receiving end is not to be recommended. With these premises the maximum line attenuation is 2.5 neper (22 db). By means of an auxiliary output amplifier with filter the output level may be increased from 0.75 (6.5 db) to 2.0 neper (17 db). In this case the line attenuation may consequently amount to 3.75 neper (32 db). The additional output amplifier is used when a greater range is desired or when the single-channel system has to be operated on a line adjacent to another line carrying a three-channel system, in which case the levels of both systems should be alike in order to avoid cross-talk. The normal overall attenuation is 0.8 neper (7 db) but may be brought down to zero.

Signalling is accomplished by decreasing the carrier frequency by 500 c/s, which gives the same effect as if the carrier frequency were modulated with a fixed tone of 500 c/s. At the receiver this tone actuates a simplified voice-frequency signal receiver of Ericsson's normal design.

When the line attenuation is higher than what may be covered by the amplifications of the terminals, an intermediate carrier repeater, Type ZL

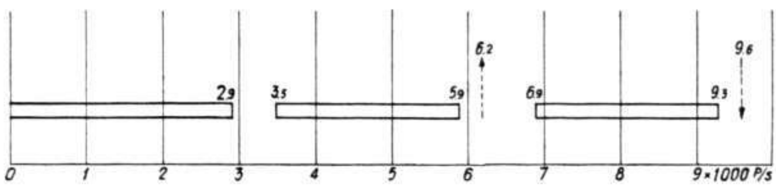


Fig. 1
Frequency allocation for single-channel system, Type ZL 400

X 5295

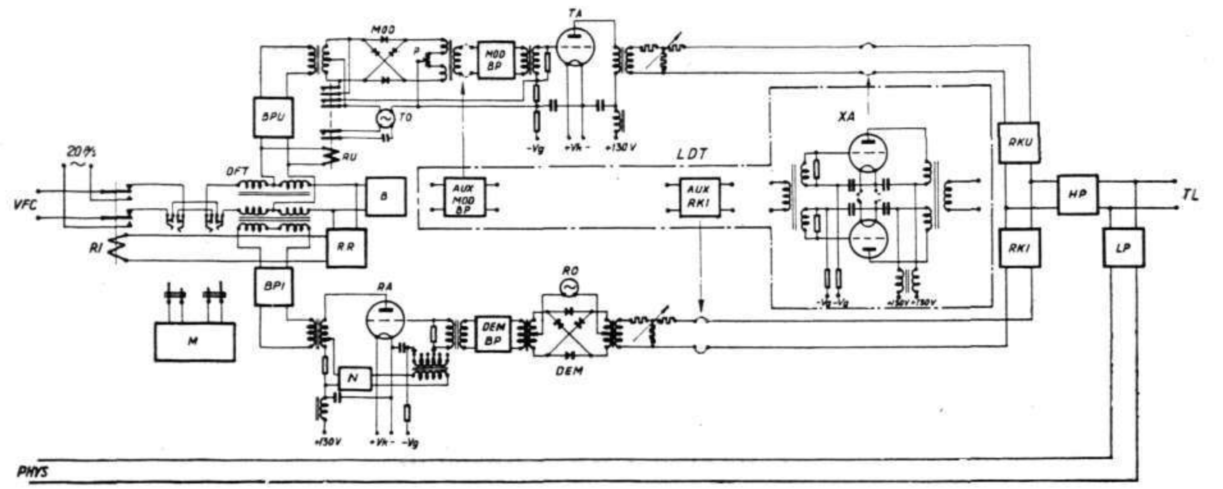


Fig. 2 X 7095

Circuit diagram for single-channel system, Type ZL 400

with and without auxiliary amplifier

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

450, has to be employed. This repeater is designed for an input level of — 1.75 neper (— 15 db) and an output level of + 2.0 neper (+ 17 db), the effective amplification thus being 3.75 neper (32 db). If required an automatic level-regulating device may be provided.

The system requires 24 V for the filaments and 130 V for the anodes. These voltages may be drawn from existing batteries in a repeater station. Where only AC mains are available the system may be equipped with a mains-supply set, which will be described in a following paper. Iron resistance lamps keeping the filament current constant in spite of varying 24 V are included. As modulators and demodulators, metal rectifiers are used which reduces the number of valves. Metal rectifiers are also much more stable as modulators and demodulators than are valves. A general comparison between the harmonic content in a communication channel with valves and one with metal rectifiers as modulators cannot be made but with a suitable dimensioning the rectifier harmonic content will become very low and mostly lower than what is usually tolerated for circuits with valve modulators and demodulators. Thus metal-rectifier modulators and demodulators are apparently to be preferred.

The considerably reduced dimensions of the new single channel system are mostly due to the use of dust-iron cores in coils and transformers. The low loss factors of these coils also render the transmission characteristics of the filters very good.

Terminal Equipment

The circuit diagram of the normal terminal equipment is shown in Fig. 2. The equipment is connected to the line *TL* by means of the line filters *LP* and *HP*, which separate the voice-frequency channel *PHYS* and the carrier channel. The low-pass filter *LP* passes frequencies between 0 and 2 900 c/s and suppresses any higher frequency while the high-pass filter *HP* suppresses all frequencies below 3 300 c/s and passes all higher frequencies. At the office side of the high-pass filter follows the carrier equipment proper. A carrier channel is in principle a four-wire circuit, different frequency bands being used for both directions. For the transformation of the outgoing and incoming circuits to a two-wire circuit, a differential transformer *DFT* is employed. The two-wire side *VFC* of this transformer thus forms the voice-frequency input to the carrier channel and is terminated in a jack in the trunk switch board. A line connected to this jack is balanced by the network *B*. The two four-wire circuits terminate in the carrier transmitter and receiver.

The voice-frequency currents are fed to the transmitter through a band-pass filter *BPU*. Then follows the modulator *MOD* with associated band-pass filter *MOD BP* only passing the lower side-band. The carrier frequency necessary for the modulation is generated in the transmitter oscillator *TO*. The carrier frequency is suppressed by balancing of the modulator. The side-band is amplified in the transmitter amplifier *TA* and fed into the transmitter directional filter *RKU*, where the side-band is further limited in order not to let through any disturbing currents to the receiver of the same terminal equipment. The side-band arriving from the other terminal station is passed by the highpass filter *HP* and the receiver directional filter *RKI* to the demodulator *DEM*. The carrier frequency necessary for demodulating purposes is generated in the receiver oscillator *RO*, producing a frequency which has to be equal to that of the transmitter within a certain limit of accuracy. The voice frequencies resulting from demodulation are passed by a band-pass filter *DEM BP* to the receiver amplifier *RA*, also containing a network correcting the amplitude distortion caused by the line. Finally, the receiver band-pass filter *BPI* is connected to the differential transformer. This filter has to be reciprocal to the transmitter band-pass filter *BPU* in order to obtain a characteristic impedance which is real and constant over the whole frequency range, measured from the terminals *VFC*, see Ericsson Review No 10—12, 1931.

The transmission of ring signals is accomplished in the following way: a ringing current arriving from circuit *VFC* actuates the relay *RU*, which decreases the transmitter oscillator frequency by 500 c/s. This frequency is fed directly into the transmitter amplifier *TA* and further to the line. At the receiving terminal the frequency is demodulated to 500 c/s and passed both to the two-wire circuit *VFC* and the balancing network *B*. In parallel to this latter is the signal receiver *RR* which has a great input impedance and hence is without any great influence upon the impedance of the balancing side. When the signal receiver is actuated by a current of pure 500 c/s the relay *RI* connects the circuit *VFC* to the local ringing current source. Currents not exactly of 500 c/s block the signal receiver in order not to allow false signals from speech currents which are always composed of several frequencies.

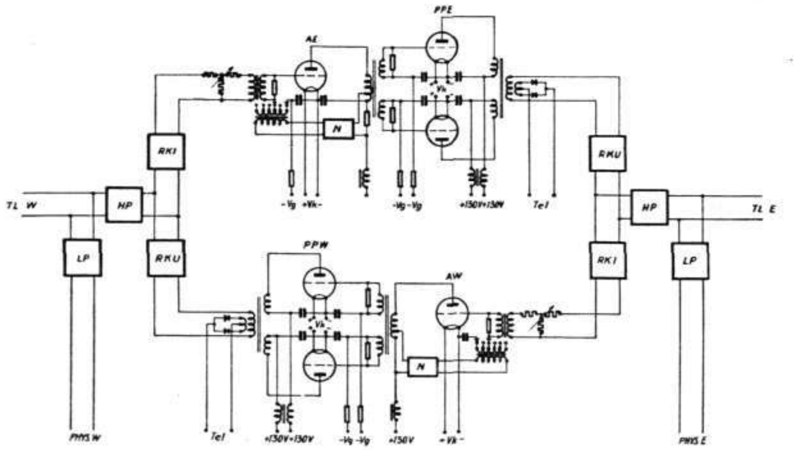
A supervisory device *M*, consisting of a hand set and keys, may be connected to the circuit *VFC* by means of a twin plug cord. By means of the supervisory device it is possible to call the operator of one's own station as well as the operator of the other terminal station or to listen-in without disturbing the conversation.

In addition to the devices shown in Fig. 2, some of which will be dealt with in more detail below, there are also current distribution equipment with switches and fuses for 24 and 130 V, iron-resistance lamps for the filament regulation, alarm relays indicating interruptions in the filament circuits, alarm bell and alarm lamps. Further there are jacks for the checking of filament voltage and anode current of each valve and of the high-frequency currents of the oscillators. A sufficient number of in- and out-jacks for all circuits are provided.

For the checking of valves there is a voltmeter and a milliammeter, by means of keys the latter may be combined with a metal rectifier to a level meter for measuring levels from —2 to 0 neper with an impedance of 600 ohm (overall attenuation measurement) and from 0 to +2.1 neper with high impedance compared to 600 ohm (level measurement). Zero-level corresponds to 6 mW in 600 ohm. The measuring current required for these measurements is obtained by means of a special key, which connects the carrier transmitter for the transmission of a constant ring signal. This signal is adjusted to correspond to the side-band of a voice-frequency input of 6 mW applied to the carrier channel through the circuit *VFC*. The output level may then be measured at the output terminals of the transmitter directional filter *RKU* and the overall attenuation at the terminals *VFC* in the other terminal station.

Fig. 3 x 5296
Circuit diagram for intermediate repeater, Type ZL 450

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



Sometimes it is necessary to increase the output level from 0.75 to 2.0 neper by means of an auxiliary amplifier *LDT*, consisting ot a push-pull amplifier *XA* to be inserted after the transmitter amplifier *TA*, see Fig. 2, and two auxiliary filters, one of which, *AUX MOD BP*, is added to the modulator filter and the other, *AUX RKI*, to the receiver directional filter *RKI*.

Intermediate Repeater

Two long distance lines, one west *TLW*, and one east *TLE*, are connected to the intermediate carrier repeater, Type ZL 450, Fig. 3. The lines are led in through line filters *LP* and *HP* by means of which the physical channel is separated and if necessary connected to an ordinary voice-frequency two-wire repeater. The carrier repeater proper consists of two high-frequency amplifiers, one for each direction. At the input side of each amplifier is an input directional filter *RKI* and at the output side there is an output directional filter *RKU*, both intended to prevent singing in the circuit formed by the two amplifier units.

Each amplifier contains a correcting network of the same design as in the terminal equipment. The intermediate repeater also contains current-distribution and alarm devices, test and measuring jacks like the terminal equipment. The measuring device is also the same. Further there is a means of listening-in on the output side of each amplifier unit, consisting of metal rectifiers and jacks for connection of a low-resistance telephone *TEL*.

Fig. 4 x 3585
Circuit diagram of rectifier modulator

Current Consumption

The valves used in this system are of Marconi-Osram manufacture with a filament current consumption of 0.15 A. Four filaments are connected in series together with an iron-resistance lamp, which keeps the filament current constant. The filaments are connected in parallel and fed by voltage of normally 24 V which may vary between 20 and 28 V. Also relays, alarm lamps and alarm bell are connected to 24 V. The anode voltage of the valves is taken from a 130 V source. Grid bias is obtained from different points on the filament series. Only for the receiver an additional voltage is necessary and it is produced by rectifying part of the receiver oscillator power. In the carrier repeater a special valve oscillator is provided for this purpose. Grid batteries are thus avoided. Signalling current of 16—60 c/s and 60—100 V may be taken from the station ringing machine or the AC mains, but if these current supplies should not be available the terminal equipment may be equipped with a pole changer operated by the 24 V source.

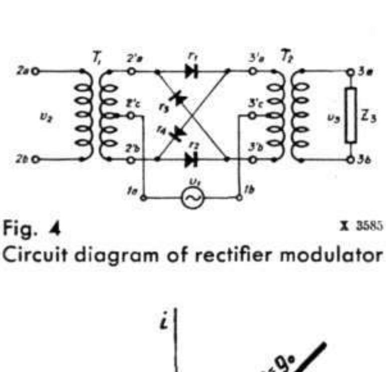


Fig. 5 x 3587
Current-tension curve for ideal rectifier

The current consumptions of the different equipments are:

	24 V A	130 V mA
normal terminal, Type ZL 410—416	0.15	25
terminal with auxiliary amplifier, Type ZL 420—426	0.30	50
intermediate repeater, Type ZL 450—456	0.30	70

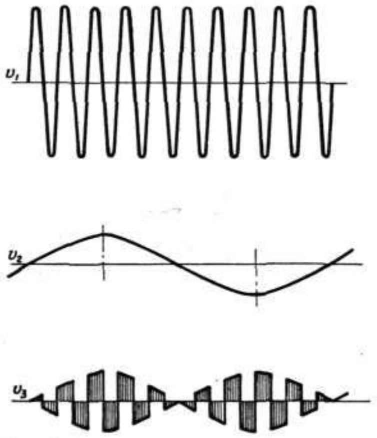


Fig. 6 X 3589

Modulation process in ideal rectifier modulator

v_1 carrier tension
v_2 modulating tension
v_3 modulated tension

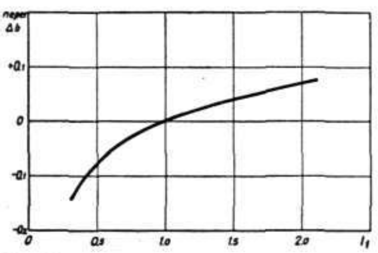


Fig. 7 X 3591

Overall attenuation $\triangle b$ in the modulator with variable input carrier current I_1 for single-channel system, Type ZL 400

normal carrier current $I_1 = 1$

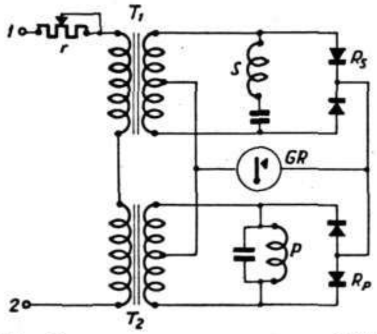


Fig. 8 X 3599

Circuit diagram for signal receiver

GR galvanometer relay
P parallel resonance circuit
r rheostat
Rp, Rs rectifiers
S series resonance circuit
T_1, T_2 transformers

**

Modulator and Demodulator

In their main principle the modulator and the demodulator are of the same design. Therefore only the modulator will be described here, the same description also applying to the demodulator. The circuit diagram of the modulator is shown in Fig. 4. The secondary windings of the transformers T_1 and T_2 connected to the rectifiers r_1—r_4 consist of two balanced halves. The carrier oscillator v_1 with the frequency f_1 is connected to the centre points *2'c* and *3'c*. The voltage modulating the carrier is called v_2 and of o frequency f_2. The voltage of the modulation products is called v_3.

In order to give a clear view of the principle of the modulator some simplifying assumptions will be made which, however, accord fairly well with practice. The rectifiers are thus supposed to be identical and ideal, *i.e.*, to have a characteristic according to Fig. 5, which means that the conductivity in the blocked direction is zero and in the opposite direction constant for all voltages v. The arrow shows the current flow. Further the carrier voltage v_1 is supposed to be purely sinusoïdal and to have very great amplitude, compared with the amplitude of the modulating voltage v_2 and of the voltage v_3.

When the voltage on the rectifier is positive curent flows through it. A small increase of the voltage causes a proportional increase in current, and decrease of the voltage causes a corresponding decrease in current. For small voltage alterations the rectifier thus acts as a conductor with constant conductivity in both directions. If the bias is negative, however, the rectifier will be blocked.

In order to simplify the description of the modulation we suppose that the frequency of the carrier voltage v_1 is very high compared with the voltage v_2, se Fig. 6. Considering Fig. 4 at a moment when the point *2'c* is positive compared with the point *3'c* we find that the rectifiers r_1 and r_2 are conductive and the rectifiers r_3 and r_4 blocking. If the polarity of v_2 is such that *2'a* is positive with regard to *2'b* the voltage v_2 will cause a current flowing from *3'a* to *3'b* through the primary winding of transformer T_2. When the carrier voltage v_1 is of opposite polarity the rectifiers r_3 and r_4 will be conductive and the rectifiers r_1 and r_2 blocking. With the same polarity of v_2 as before, there will flow a current from *3'b* to *3'a* through the primary winding of transformer T_2. The modulator thus serves as a commutator guided by the carrier voltage v_1 as shown in Fig. 6. The modulated voltage v_3 in the impedance Z_3 consists of consecutive elements with alternating polarity. The envelope of the positive as well as of the negative elements is of the same form as the curve v_2. An analysis of the curve v_3 shows a combination of voltages with the frequencies $f_1 \pm f_2$, $3f_1 \pm f_2$, $5f_1 \pm f_2$ etc. and the amplitudes of these voltages are proportional to $1 : \frac{1}{3} : \frac{1}{5}$ etc. By means of filters the unwanted frequencies $3f_1 + f_2$, $5f_1 + f_2$ and so on are suppressed.

It should be observed that v_3 does not contain any components with the frequencies f_1 and f_2, which are suppressed owing to the balance of the modulator bridge. The rectifiers, however, are not exactly equal, wherefore a small amount of carrier is to be found at the terminals *3a*, *3b*. To make possible a correct adjustment of the modulator balance a potentiometer P is inserted in the primary winding of transformer T_2, se Fig. 2. By means of this device the level of the leaking carrier may be reduced to 4 neper below the normal side-band level at I mW in the circuit *VEC*.

Two important properties of the rectifier modulator should be noticed, *viz.* that no cross modulation products of different frequencies in v_2 occur in v_3 and that the amplitude of the modulation product is independent of the carrier amplitude within wide limits. That this is the case with the ideal modulator is obvious from the previous analysis. Fig. 7 shows the result of practical measurements on the single-channel system, Type ZL 400. The

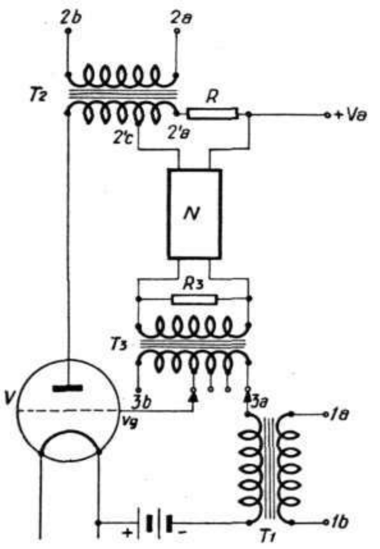


Fig. 9 X 3600

Diagram of correcting device

N phase-shifting network
R, R_3 resistances
T_1 receiver transformer
T_2 transmitter transformer
T_3 feed back transformer
V amplifier valve

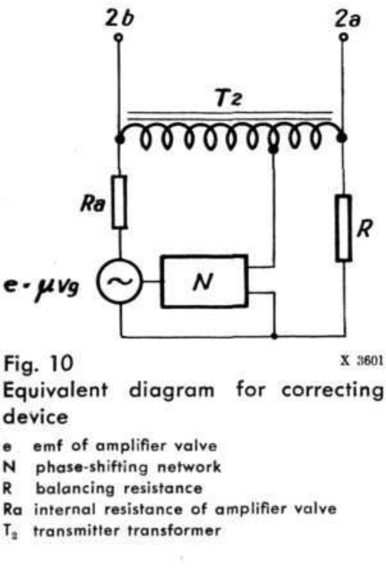


Fig. 10 X 3601

Equivalent diagram for correcting device

e emf of amplifier valve
N phase-shifting network
R balancing resistance
Ra internal resistance of amplifier valve
T_2 transmitter transformer

rectifier modulator is nearly independent of temperature and the overall attenuation of the system with auxiliary amplifier, Type ZL 420, varies by 0.005 neper/°C (0.044 db/°C) only.

Signal Receiver

The principle of the signal receiver is shown in Fig. 8. The arriving voice frequency ringing current of 500 c/s enters the receiver at the terminals *1* and *2*, between which two transformers T_1 and T_2 are connected in series. The secondary winding of transformer T_1 is terminated in a series resonance circuit *S* with a rectifier *Rs* in parallel, and the secondary of transformer T_2 in a parallel resonance circuit *P* and a rectifier *Rp*. Both circuits are tuned to 500 c/s. Between the centre points of the rectifiers on the one hand and the centre points of the secondaries of the transformers on the other a sensitive galvanometer relay *GR* is inserted. For all frequencies, except 500 c/s, there will be a certain voltage across the circuit *S*. This voltage is rectified in *Rs* and the current passes the relay *GR* in such a direction that the armature moves away from the contact. Across the circuit *P* a voltage will arise only for the signal frequency 500 c/s and after rectification causes a current of opposite direction in the relay *GR*. When the latter current becomes strong enough compared to the former, the relay makes contact and a current actuates an ordinary telephone relay which is sluggish in order to avoid false signals caused by momentary voltage shocks. The last-mentioned relay actuates a third relay which transmits 20 c/s ringing current on the circuit *VFC*. The strength of the received *VF* ringing current depends on the overall attenuation of the carrier channel and may be adjusted by means of the resistance *r*.

Correcting Network

Both in the terminal equipment and in the intermediate repeater a frequency correcting network has been provided in order to compensate for the amplitude distortion caused by the variation of the line attenuation with the frequency. The device adopted is based on the amplification in an amplifier being made dependent on the frequency by means of a phase-shifting feed-back network, Fig. 9. Part of the amplified voltage, *i.e.*, the voltage between the transformer terminals *2'a* and *2'c* plus the voltage drop in the resistance *R*, is fed back to the grid circuit through the phase-shifting network *N* and the transformer T_3. The phase-shifting in the network *N* has to pass a suitable interval, for instance 0—180°, when the frequency passes the range where the overall attenuation has to be corrected, for instance 0—3 000 c/s. At one end of the frequency range the feedback is then positive and at the other end negative. The curve for the amplification as a function of the frequency will consequently show a slope. The degree of feed-back is regulated through different tappings on the transformer T_3 by means of which the slope may be adjusted. If the connections *3a* and *3b* are shifted the curve will have a reversed slope. Fig. 11 gives overall attenuation curves for different tappings on transformer T_3.

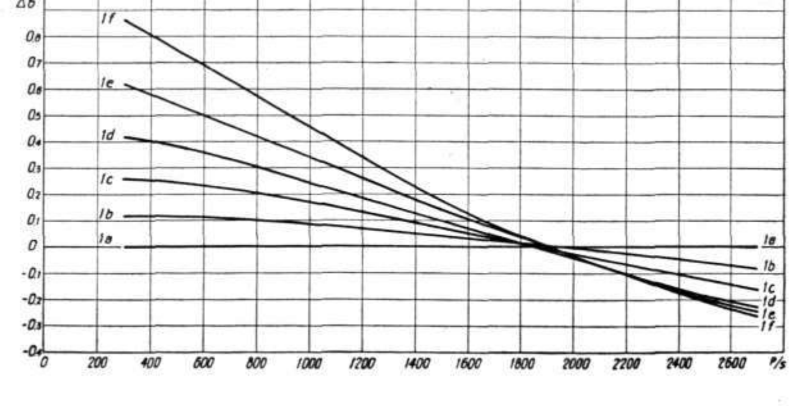


Fig. 11 X 5297

Overall attenuation △b for different correcting adjustments Ia — If for receiver's low-frequency amplifier

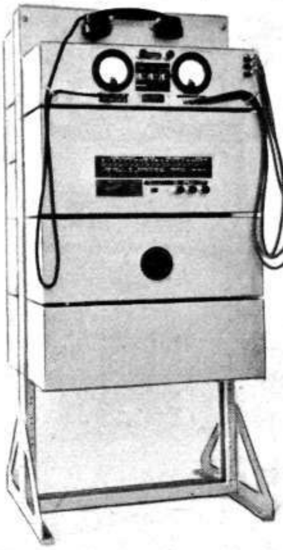


Fig. 12 X 3606
Terminal equipment, Type ZL 410
mounted on bay, without additional frame

The network N consists of a filter which lets the feed-back approach zero above the cut-off frequency. Consequently the amplification in this frequency range will be that of the amplifier proper.

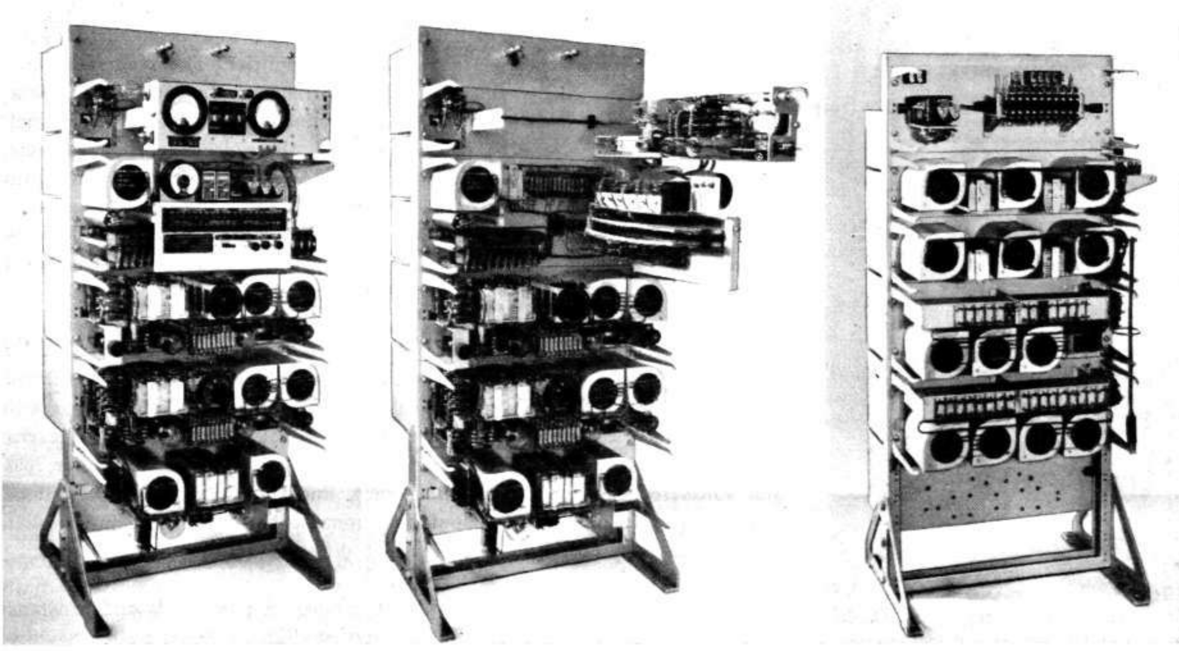
In order to avoid the load on the terminals *2a, 2b* reacting upon the feed-back and consequently also upon the slope of the amplification curve a bridge device is used, Fig. 10. For simplicity the transformer T_2 has been replaced by a coil. The load on the terminals *2a, 2b* is found over one diagonal in the bridge and the phase-shifting network N over the other. The left hand branch consists of the filament-anode path of the valve with the resistance Ra and the electromotive force $e = \mu \, vg$. The right hand branch is formed by the resistance R, which is proportional to Ra in the same ratio as the parts of the transformer winding. With the bridge balanced in this manner there will be no interaction between the loads on the diagonals.

Mechanical Assembly

The terminal equipment as well as the intermediate repeater equipment is mounted in a low frame of U-shaped iron. The bay is equipped with a foot and thus does not need any fastening, se Fig. 12. The total height is 1 121 and the width 495 mm. The depth is 416 mm. If desired the bay may be equipped with an additional frame in order to get the supervisory panel at a suitable height. The total height of the bay will then be 1 699 mm. In this case extra panels such as mains supply set and automatic level regulator may be mounted in the additional frame. Thanks to its compact design, the additional frame and the loose foot, the system may be adopted for different requirements. In case the additional frame does not hold anything but the mains-supply set the bay may easily be divided in order to facilitate transport.

Fig. 13 X 7096
Terminal equipment auxiliary amplifier, Type ZL 420
mounted on bay, without additional frame left, front with covers removed, middle, front with cover removed and bridges swung out, right rear covers removed

All integral elements are mounted on one side of 482.6 mm wide panels, mounted on both sides of the frame. The bay cabling is located between the front and rear panels and connects all panels with each other and the terminal strip at the top of the bay. All panels are equipped with removable sheet-iron covers. All jacks and instrument are on a level with and showing through openings in the tops of the covers. They are mounted on bridges,



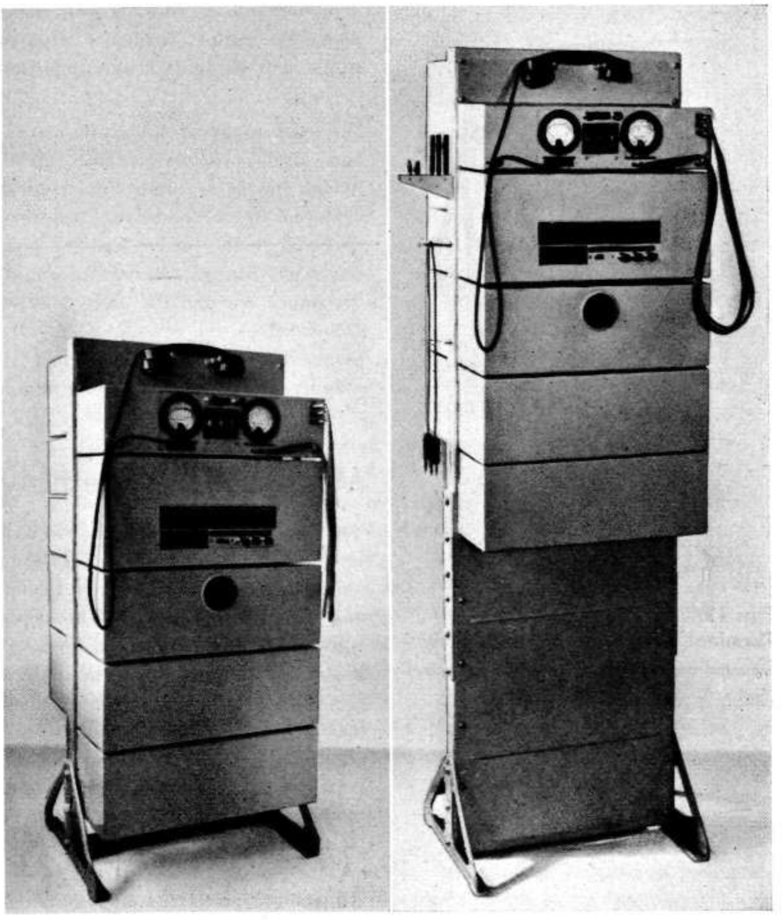


Fig. 14 X 5299
Terminal equipment with auxiliary amplifier, Type ZL 420
mounted on frame, left, without, and, right, with additional frame

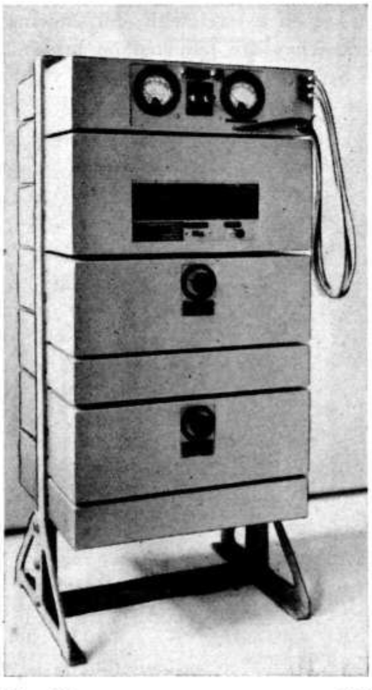


Fig. 15 X 3607
Intermediate repeater, Type ZL 450,
mounted on bay without additional frame

which may be swung out for inspection when the covers are removed, see Fig. 13. As to design of the integral elements and to the mounting, reference is made to Ericsson Review No 1, 1936.

Fig. 14 shows a terminal with auxiliary amplifier in a low frame. The front-side panels are from top to bottom: hand set panel, supervisory panel, current-distribution and signalling panel, oscillator and demodulator panel, oscillator and modulator panel and auxiliary amplifier. The rear side panels are: connecting panel, line-filter panel, voice frequency balancing filter panel, differential transformer with filters and directional filter panel. Some panels, *viz.*, the supervisory panel, the handset panel, the voice-frequency balancing filter, the auxiliary amplifier, the automatic level regulator and the mains supply set are in the nature of additional features to the carrier equipment proper and are thus not always required. The system may thus be delivered equipped in many ways, and panels not required are replaced by blank panels mostly with covers.

Fig. 15 shows an intermediate carrier repeater in a bay without additional frame. The front side panels are from top to bottom: measuring panel, current-distribution panel, amplifier panel west-to-east, output directional filter east, amplifier panel east-to-west and output directional filter, west. At the rear side the panels are: connecting panel, voice-frequency balancing filter, east and voice-frequency balancing filter, west, line filter, east, input directional filter, east, line filter, west, input directional filter, west. The intermediate repeater may also be delivered equipped in different ways.

Each bay is accompanied by a sufficient number of plug cords and resistance plugs for the purpose of connection and testing. Fig. 14 shows a shelf mounted

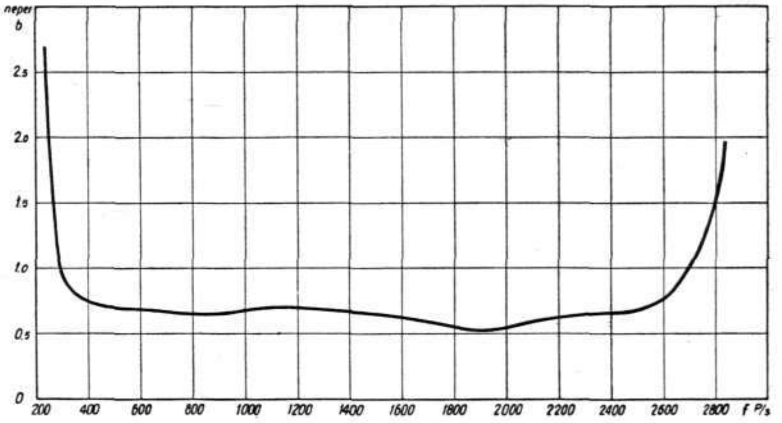


Fig. 16 X 5298
Characteristic overall-attenuation curve for single-channel system with auxiliary amplifier, Type ZL 420

on one side of the bay and intended to make spare fuses and resistance plugs easily accessible.

Transmission Characteristics

With regard to the fact that the noise level on open-wire circuits is often rather high, it is advisable to count on a range not higher than 2.5 neper (22 db) for the normal system, Type ZL 410—416, and 3.75 neper (33 db) for the system, Type ZL 420—426 with auxiliary amplifier. For open-wire lines with copper wires, iron cross-arms or an equivalent arrangement, 305 mm distance between the wires, 20 poles per km and under wet weather conditions, the above-mentioned ranges correspond to the following lengths provided that no cables are inserted in the line:

line		range, km	
mm	lbs/mile	Type ZL 410 $b = 2.5\ N$	Type ZL 420 $b = 3.75\ N$
2.5	150	330	500
2.84	200	380	570
3		400	600
3.5	300	450	670
4	400	510	750
4.5		550	820

The overall attenuation at 800 c/s, usually 0.8 neper, may be adjusted in steps of 0.2 or 0.1 neper by means of the receiver and the transmitter potentiometers with steps of 0.2 and 0.1 neper respectively.

The carrier-channel overall attenuation may vary because of variations in the 24 and 130 V supplies. The maximum variation of the overall attenuation is ± 0.1 neper if the filament voltage is altered by ± 4 V and the anode voltage by ± 5 V in both terminal stations simultaneously. The effective frequency band transmitted is 300—2 700 c/s. A characteristic overall attenuation curve is shown in Fig. 16. The harmonic content of the system has been dealt with above and a corresponding curve is given in Fig. 17. A cause of distortion may be a difference in frequency between the transmitter and the receiver carrier oscillators. The frequency variation of the transmitter oscillator caused by variations in anode and filament voltages and temperature is shown in Fig. 18 and the corresponding variations of the receiver in Fig. 19. The maximum frequency difference between transmitter and receiver to be expected under average conditions may be put at 10 c/s.

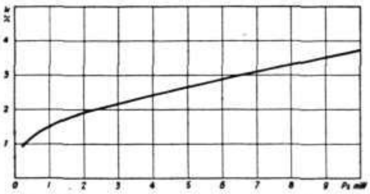


Fig. 17 X 3602
Non-linear distortion factor k as function of the voice-frequency input P_2

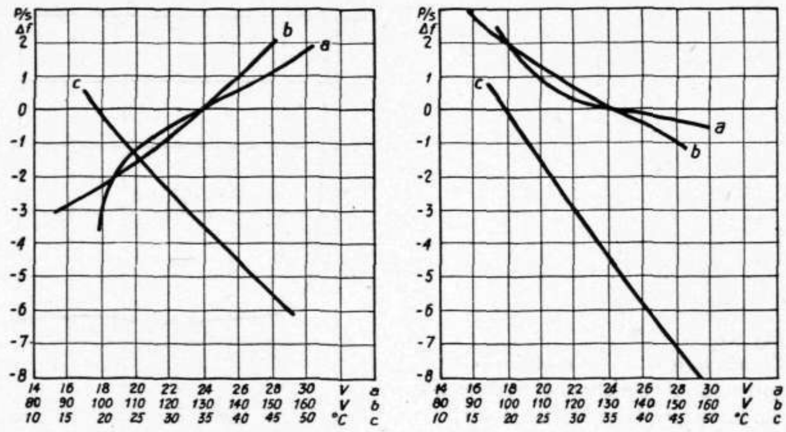
at 1000 c/s and 0.8 neper overall attenuation for whole circuit, incorporating single-channel system with auxiliary amplifier, Type ZL 420

The far-end cross-talk between lines depends to a great extent on the proper matching of the impedance of the terminating apparatus to the characteristic impedance of the line. The better the matching the lower the far-end cross-talk. The input impedance of the single-channel system, measured from

Fig. 18 et 19 X 3603 X 3604

Frequency variation of transmitter oscillator and receiver oscillator

a with 24 V tension
b with 130 V tension
c with temperature



the line terminals has been dimensioned with due regard to this requirement. The same applies to the impedance between the switchboard terminals *VFC* which is sufficiently constant and real for the good operation of the single-channel system in conjunction with a two-wire repeater or another carrier telephone system.

Connection to Trunk Lines

When installing carrier systems on open-wire lines it is necessary to ensure that disturbances between different carrier systems on adjacent lines on the same poles do not occur and that the physical channels are not affected. The first-mentioned problem is solved by selecting a suitable transmission direction with regard to the different frequency bands and by the retransposition of the lines if necessary. Thanks to the comparatively low frequencies of the system, Type ZL 400, it is usually easy to get the circuits sufficiently free from cross-talk. It is often possible to operate a single-channel system not only on the side circuits but also on the phantom circuit. The physical channel may be affected by the attenuation of the low-pass filters inserted. However, the attenuation of a low-pass filter is only 0.06 neper (0.5 db) between 0 and 2 400 c/s and is thus insignificant.

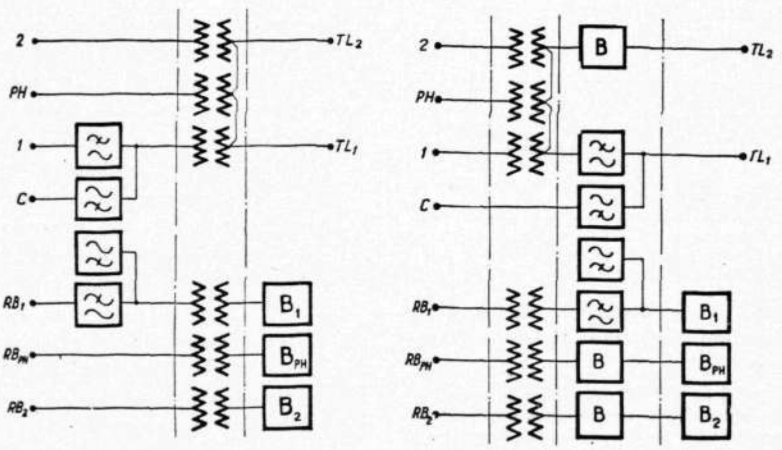
The single-channel system, Type ZL 400, may be connected either on the line side or on the office side of the line transformers. The latter connection is possible only if the attenuation of the line transformers is low up to 10 000 c/s, which is the case with most modern transformer types. An

Fig. 20 X 3612 X 3613

Connection of single-channel system to a quad

a inside line transformers
b outside line transformers

1 side circuit 1
2 side circuit 2
C carrier circuit
PH phantom circuit
B line balancing network
TL trunk line
RB repeater balance



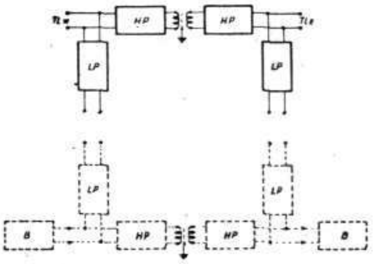


Fig. 21 X 3605

Diagram of by-pass

— line part HP high-pass filter

..... balance part LP low-pass filter

B balance TL trunk line

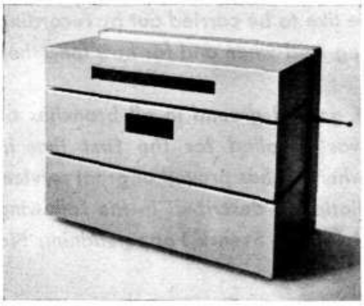


Fig. 22 X 3608

By-pass, Type ZL 612

advantage with this way of connection is that the transformer protects the line filter against voltage shocks on the line and that, if a quad is concerned, the balancing networks for voice frequency repeaters, both on the side circuit not carrying the single channel and on the phantom circuit, will be independent of the low-pass filter. If the single-channel system is connected to the line side of the line transformers of a quad, a phantom balancing network has to be inserted in the other side circuit, which compensates for branch unbalance in the phantom circuit caused by the low-pass filter. This phantom-branch balancing network has to be repeated in the voice-frequency balancing filter and, furthermore, the repeater on the phantom circuit has to be equipped with an extra network in addition to the phantom balancing network. Fig. 20 shows the two methods of connection.

By-Pass

In an intermediate station where the physical channel has to be made accessible for operation but the carrier channel shall be through-connected a by-pass equipment is used. The circuit diagram is shown in Fig. 21 and the appearance in Fig. 22. The by-pass consists of two normal line filter panels, the high-pass filters of which are interconnected by means of a screened transformer, and a jack and connection panel. The dimensions of the equipment shown in Fig. 22 are: height 400 mm, width 495 mm and depth 233 mm. In case a two-wire repeater is inserted in the physical channel a similar by-pass has to be connected to its balance side. The height in this case is increased to 666 mm. The attenuation of the high-pass part is 0.07 neper (0.6 db). The by-pass equipment is mounted in a frame of U-shaped iron intended to be fastened to a wall.

Utilisation of the Centralograph in a Pulp and Paper Mill

E. PRYMUS, RUŽOMBERSKÁ TOVÁRNA NA CELLULOSA A PAPÍR A.S., RUŽOMBEROK

With the object of facilitating control of operations in industrial establishments, a number of recording apparatus have been introduced for measuring and recording the various data required for satisfactory supervision of operations. One of these is the Ericsson centralograph, which enables continuous supervision of 30 machines or the like to be carried out by recording the times and the periods they are running and when and for how long they are idle.

The Ericsson centralograph has rapidly gained ground in all branches of industry, and in 1935 the apparatus was installed for the first time in a Czechoslovakian pulp and paper mill where it has proved of great service. The experience derived from this installation is described in the following article, reproduced with the kind permission of Svensk Papperstidning No 10, 1936.

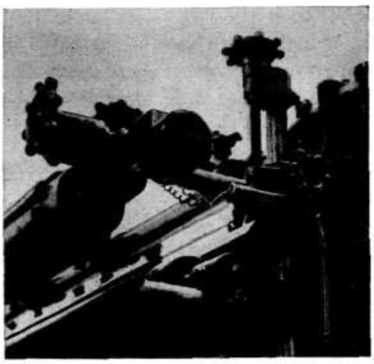


Fig. 1 X 3592
Contact apparatus
mounted on a cutter

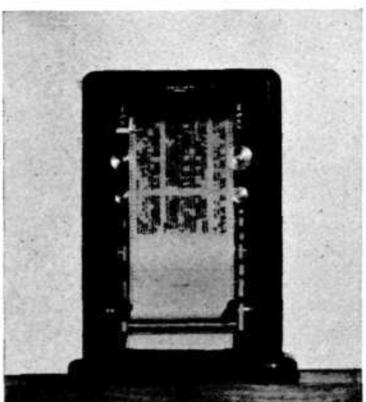


Fig. 2 X 3593
Central apparatus with relay cabinet

Supervision of Production

The pulp and paper mill at Ružomberok produces pulp from pine. To begin with there was no control or supervision of the manufacturing processes. They were allowed to proceed as they would, with the result that while there was congestion in some sections of the mill, in others on the other hand there was no work to be done. Briefly, work proceeded without any plan and the efficiency was poor. It was not until some time later that steps were taken to organise operations; planning of the work was introduced, with careful supervision of the processes of production, and a number of other fundamental improvements. The planning of the work is now carried out by an independent operations office, which constantly supervises the manufacturing processes in all their phases.

In this organisation the Ericsson centralograph has been introduced as the controlling organ for the managing director. By means of the centralograph it is possible to follow the whole operation in its principal processes and at the same time supervise the work of the operations office. The diagram of the centralograph gives an accurate picture of the times and the periods the machines supervised have been running, how long they were idle and when this occurred, how often stoppages took place, the speed at which the machines have been working, etc. Each trouble or defect which occasions a stoppage or interruption of the production process in its main sections can be observed immediately by the managing director, who can see to it that steps are taken to remedy the trouble. After this first control has been carried out by means of the centralograph diagram it goes on to the operations office where it is submitted to careful investigation and care taken that all defects observed and irregularities are remedied.

The principle of the Ericsson centralograph is based on the transmission of electrical impulses from the machine supervised to the central apparatus which registers the impulses received on a running diagram. The electrical impulses are emitted by special contact apparatus, Fig. 1, which are mounted on the supervised machine and connected with same by a rotating shaft or roller. The contact apparatus consists of a contact and a gear-box in which the speed of the machine shaft is geared down so that the contact is closed at suitable intervals. The contacts for all the machines supervised are connected by a special cable network over a relay set to the central apparatus, Fig. 2, each contact having its own relay. Each impulse emitted by a contact apparatus energises the corresponding relay, whereupon a stamp in the central apparatus marks the impulse through an inked ribbon on the diagram paper. The central apparatus has 30 stamps enabling 30 different machines to be supervised by one central apparatus. The installation is driven by 6 V DC from a battery. The diagram paper is driven by a synchronous motor directly connected to the 220 V, 50 c/s, mains, see Fig. 3. In cases where current failure frequently arises or when DC only is available it is, however, advisable to arrange for the drive of the centralograph paper to be by battery. The central apparatus and the relay cabinet are mounted in the managing director's office. From there the main cable, 32×0.5 mm, goes out to a main terminal distributor where the circuits from all the contact apparatus meet. The battery with automatic charging rectifier is mounted in a room whence current under 6 V tension is conveyed to the relay cabinet and thence to the whole centralograph network.

When ordering a centralograph it is necessary to work out a plan for the most suitable fitting of the contact apparatus and the central apparatus as well as the cable network. As a basis for this planning there must be a control plan, showing accurately the most important phases of the manufacturing process, which are to be supervised by the centralograph; after that it can be decided whether a single centralograph for 30 machines will suffice or whether several centralographs may be necessary. From this control plan are selected the most important machines or manufacturing groups which must be submitted in direct operation to an investigation, in order to determine whether they can conveniently be controlled or supervised by the centralograph and to decide how the contact apparatus are to be mounted.

Supervision by means of the centralograph is simplest to arrange when it is a question of parts rotating regularly. When such a machine part has been found it is necessary to fix maximum, normal and minimum speeds and likewise the direction of rotation. The greatest attention must be devoted to this matter, as these data are decisive for the calculation of the gearing of the contact apparatus. The contact apparatus can be conveniently mounted at the front of the machine part selected, *e. g.*, a shaft, journal, roller, eccentric or the like, indeed any horizontal part. The contact apparatus is mounted by boring a hole in the rotating shaft and screwing in a clutch, which latter is then connected to the contact apparatus by means of a spiral spring which transmits the rotating movement of the machine part to the contact apparatus. This apparatus is mounted on a support or on one of the bearings of the machine, see Fig. 1. Those contact apparatus which are mounted in very exposed positions as is often the case in paper machines for instance, should be protected against jars or other influences by a strong guard. A light tight fitting protecting hood is usually sufficient shield against dripping water, lye or wood dust. Great care should be taken to ensure efficient tightness in the contact-apparatus hood, as this not only prevents damage but also saves much trouble in operation, due to the penetration of water or other liquid to the contact. With some machines it may happen that there is no journal available for mounting the contact apparatus. In such case a special transmission shaft may be arranged for transmitting the movement of the machine to the contact apparatus via a belt. In the installation here referred this was the case, for example, with the circulation pump in the digester house where the shaft of the motor was coupled to the pump at one side and completely built in at the other. Here the rotation had to be transmitted from the coupling by a belt to a belt pulley mounted on a transmission shaft.

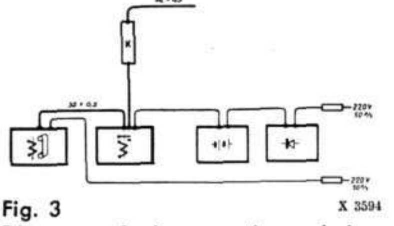


Fig. 3 X 3594
Diagram of the centralograph installation

It is only when all questions concerning the mounting of the various contacts on the machines have been settled that it is possible to work out a scheme for the cable network, Fig. 4. For a large installation, therefore, an accurate situation plan is exceedingly valuable. The lay-out of the cables and the taking of measurements for the different lengths are best done on the spot. The

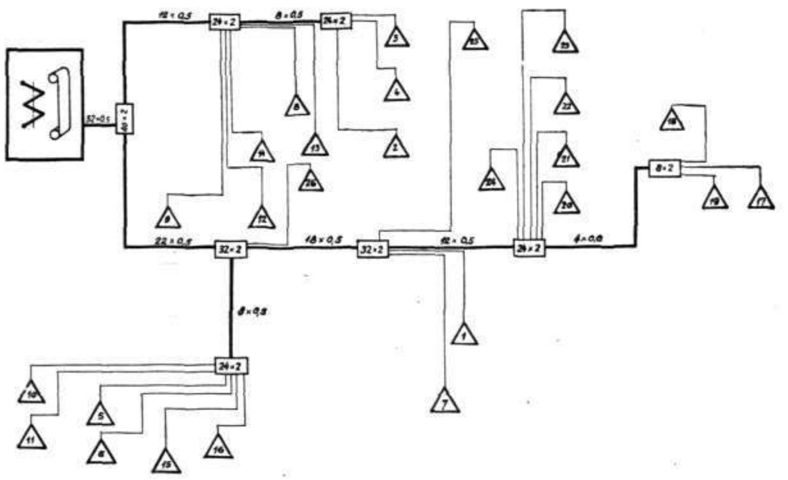


Fig. 4 X 5294
Lay-out of the cable network of the centralograph installation

various lengths of cable are marked direct on the network plan and the method of laying the different sections of cable are sketched for guidance when installing. The various contact apparatus are connected over a two-wire lead cable. The cables from contacts close together are laid the shortest way to a terminal distributor where they are combined in a four-wire cable which leads to the next terminal distributor. The contact apparatus are connected with the central apparatus by one wire only, the other wire being connected to a common return circuit. The cables are drawn in armoured piping which is laid in trenches in the floor or the walls and emerge in ordinary boxes about 2 m above the floor. From there the cable runs along the wall, to which it is fixed by clamps to wooden plugs fixed in the wall. All the combined cables are then united at the main terminal distributor from which a 32-wire cable goes to the relay-cabinet terminal distributor. This cable contains the 30 wires for the different contact apparatus with a common return circuit.

In the pulp and paper mill the following stages of manufacture are supervised by the centralograph, the contact apparatus being connected to the following machines:

1. wood conveyor to the chipper, driving shaft 160 r/m, contact 17,
2. chipping machine, main driving shaft, 178 r/m, contacts 18, 19,
3. digester, transmission shaft, driven by belt from the main shaft of the lye pump, 1 450 r/m, contacts 20, 21, 22, 23, 24,
4. pre-bleacher, back shaft of the cell filter, 210 r/m, contact 25,
5. water-extracting machine, driving shaft, 45 r/m, contact 26,
6. pulp dryer, conducting-roll at end of machine, 35 r/m, contacts 1, 2,
7. grinder, main shaft, 95 r/m, contact 7,
8. paper machine, conducting-roll driving paper web at end of machine, 18—200 r/m, contacts 3, 4, 5, 6,
9. calender, lower steel roll, 25—200 r/m, contacts 8, 9, 10, 11 (the contact apparatus could not be fixed to the conducting roll or any of the upper rolls),
10. cutter, conducting roll in middle of machine, 70—150 r/m, contacts 12, 13, 14,
11. edge runner, gear transmission shaft, 95 r/m, contacts 15, 16.

The majority of the shafts and rolls to which the contact apparatus are fixed only rotate when the machine in question is producing.

The Diagram and its Use

The impulses sent out by the various contact apparatus are recorded in the central apparatus on a moving paper strip forming a diagram. The diagram paper moves at a speed of 0.5 mm/min and is divided into 30 numbered columns each 4 mm wide, one for each of the machines supervised. The

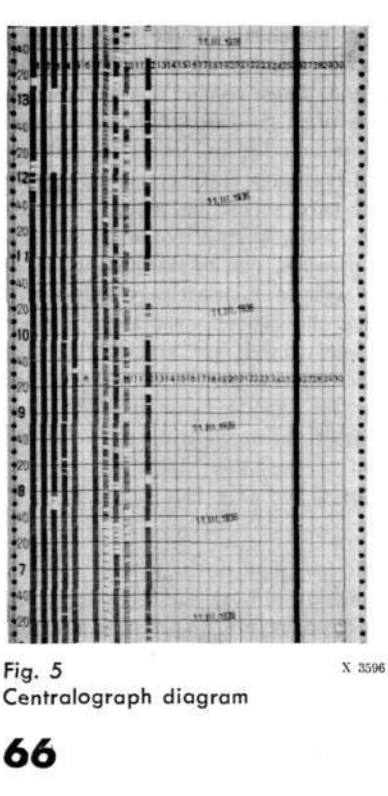


Fig. 5 X 3596
Centralograph diagram

paper is inserted into the central apparatus in the form of a roll 50 m long, sufficient for 70 days. A diagram for 24 h working day is 0.72 m long.

Fig. 5 shows an actual centralograph diagram for the pulp mill, made during the first shift, from 6 a.m. to 2 p.m., on March 11th, 1936, as per plan on Fig. 4. To simplify the diagram contacts 13—25 were disconnected; contacts 27—30 are free. The diagram shows that pulp dryer I, contact 1, was working the whole of the 8 hours. In that period it was idle four times, for 24 m altogether. The effective working time of the machine was thus 7 h 36 m, *i.e.*, 96 %. Working time amounting to 24 m was lost by stoppages. The diagram gives only the productive work of the machine, *i.e.*, the time during which pulp was being dried. Pulp dryer II, contact 2, was working without interruption for the whole 8 hours. Its effective working time was therefore 8 h, *i.e.*, 100 %. Paper machine III, contact 3, was in operation for 8 h. During the shift it was stopped twice, for a short period from 7.45 to 7.56, *i.e.*, 11 m, and for a longer time 12.05—1.10 p.m. Investigation showed that the first stoppage was due to breaking of the paper and the other to replacenemt of a felt. Previous diagrams had fixed the time for replacing felts as always about 40 m. In this case the works manager had to point out that the replacement had taken more than an hour. The actual effective time was thus 6 h 44 m, *i.e.*, 84 %. Paper machine IV, contact 4, was working 8 h, during which seven interruptions of production took place, which did not exceed 2 m, however. These short stoppages were obviously due to breaking of paper and called for no special remark. The effective production time was thus 8 h, or 100 %. Paper machine V, contact 5, was working 8 h and the diagram shows that only three stoppages occurred, two of them short and the other of 4 m duration. All were due to breakage of the paper. The actual production time was thus 8 h, or 100 %. Paper machine VI, contact 6, was out of action during the whole shift. For all the machines referred to, contacts 1—6, the diagram thus shows the actual effective production, time *i. e.*, the time during which the machines were producing paper or pulp.

The grinder, contact 7, was working uninterruptedly during the whole shift and its production time was thus 8 h, *i.e.*, 100 %. Calender I, contact 8, was working during the whole shift. It was mainly used for calendering diagram paper. It appears from the diagram that the machine was running idle from 6 to 7.40 a.m. Enquiry showed that the third roll was being repaired during this time. For this work 1 h 40 m was taken, as is indicated by the diagram. It was found, however, that 2 h 30 m had been credited for this work and this error was easily discovered by the aid of the diagram. Throughout the shift the calender had 18 stoppages, by which 2 h 40 m, or 34 % of the productive time was lost. Between 7.40 a.m. and 2 p.m. the utilisation of the machine noticeably improved, namely 84 %. Calender II, contact 9, was working the whole of the 8 hours. It is used for calendering of tissue paper. The productive time amounts to 5 h 36 m, *i.e.*, 70 %. Throughout the shift the calender had 25 stoppages in all, due partly to breaking of the paper and partly to changing the rolls of paper. Tending of this machine is rather difficult so that the workmen are fairly tired at the end of the shift. This is clearly apparent on the diagram by lengthening of the time taken to change the rolls of paper. Calender III, contact 10, was in operation all the eight hours. The thinnest tissue paper is calendered on this calender. During the shift there occurred 23 stoppages, some of them fairly long, for example, one from 7.20 to 7.45 and one from 1.26 to 1.48. The effective time amounted to 4 h 37 m, or 58 %. The very poor utilisation of this calender was found to be caused by bad organisation of the work and the works manager was called upon to remedy the matter. Calender IV, contact 11, was not working. Cutter I, contact 12, was working throughout the eight hours. During this time it had 20 stoppages, some of which were extremely long, for example, one from 9.56 to 10.48. It was ascertained that this stoppage of 52 m was due to negligence on the part of the foreman,

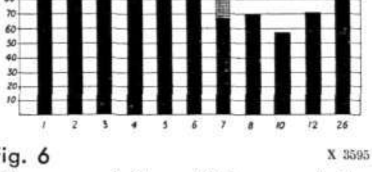


Fig. 6 X 3595
Diagram of the efficiency of the machines for productive work

The actual production time of the machine was 5 h 42 m, or 71 %. The water extracting machine, contact 26, worked uninterruptedly during the whole of the eight hours. Its effective production time was thus 8 h, or 100 %. If the particulars provided by an analysis of the diagram are considered as a whole, we obtain an image which exactly corresponds to reality and gives a clear picture of the utilisation of the machines for productive work during the first shift, see Fig. 6. Experience has shown that with the aid of the Ericsson centralograph, the following details can be determined and supervised:

1. production time of the machine supervised,
2. time lost by the machine supervised,
3. comparative speed of the machine supervised,
4. exact time work began,
5. exact time work finished,
6. exact time taken for certain regularly recurring replacements and repairs,
7. how often the paper or the pulp breaks,
8. that the proper time for changing from one work to another is not exceeded,
9. that the machine is satisfactorily utilised,
10. that the machine does not unnecessarily run idle,
11. workers' unproductive time at the machine,
12. number and duration of stoppages,
13. suitability of the organisation of work,
14. proper carrying through of plannings,
15. that manufacture is not over-much split up (on account of too frequently occurring changes),
16. that the management devotes attention to the running,
17. that the means of production are in good order,
18. that organisation of operations is satisfactory,
19. the time required for the various stages in an uninterrupted process of production,
20. that stoppages on change-over between the different stages are not over-long,
21. that there is not intentionally undue slowness in working,
22. correctness of wages, as shown by the diagram times,
23. how long the parts requiring regular replacement take to wear out.

All these particulars can naturally only be derived from the diagram by a careful analysis and systematic investigation of the causes for the occurrences recorded.

It can be seen that, for control of operations in a well-managed pulp and paper mill, the centralograph is an invaluable help which can give much valuable information. There are many possibilities for utilising the particulars recorded by the centralograph and these are limited solely by the interest of the management for perfect economy. Where there exists no interest in progress and no striving after improvement and perfection, then the centralograph is of no utility, since it is not the machine but the spirit which is decisive.

The centralograph may be employed in almost any factory. The possibilities of use are extremely varying and governed by many circumstances. To sum up, it may be said that the centralograph constitutes an exceedingly good control device which brings to light faults in the plan of work and points out faults in the organisation, thus indicating the way to achieve economies. For a well organised factory the centralograph is a reliable supervision device which helps to ensure uninterrupted running.

Press-Button Electrical Interlocking Apparatus

A. JOHANNESSON, LINE ENGINEER, VARBERG-BORÅS-HERRLJUNGA RAILWAY

As a step towards rationalisation on the Varberg-Borås-Herrljunga Railway the administration decided in 1933 to introduce safety point and signal installations at a number of the intermediate stations. The question arose how these smaller installations could be made as electrical switching plants similar to the practice followed for some time with the larger stations. In collaboration with L.M. Ericssons Signalaktiebolag, therefore, it was decided that an experimental installation should be put in at Tofta station on the railway in question. The installation was carried out by the railway company's own staff, to plans and specifications drawn up by Signalbolaget and in May 1934 it was ready for service. The installation has thus been in operation for about two years and during the whole time has functioned with complete satisfaction. Later seven more similar installations were put in, the last three being taken into operation during the summer of 1935.

Two tracks are laid down at the stations, see Fig. 1, the switching being made by electrical point machines, operated either centrally or locally. The catch-points and scotch blocks as also the points leading to the sidings in the tracks are for local operation, but are locked from the operating board. The entrance signals are made as daylight signals showing a green light for the main track and two green lights for entrance to sidings.

The interlocking apparatus, Fig. 2, consists of a metal cabinet, 90×32×22 cm, convenient for placing on the front of the station building, see Fig. 3. To prevent the operating board being tampered with by unauthorised persons, it is provided with a wooden case the wall of which is hinged for raising and is fitted with a glass panel and a lock. The operating board is provided with switches for operating the point machines, the interlockings and the signals, together with control lamps indicating the positions of the signals and for showing the positions of the centrally operated points and interlockings. In addition there are two control locks, one a track lock to cut off current to the operating devices of the point machines and the scotch blocks before a signal can be set at »clear», the other for suspending the inter-dependence of entrance signals to allow of unsupervised shunting.

The light signals are fed normally from the lighting mains over a transformer, feeding the lamps at 12 V. As a reserve for the light signals there is a 34 Ah battery, charged automatically from the mains over a metal rectifier. In case of failure of the lighting mains the reserve battery is connected in by a switch on the operating board.

A signal is set at »clear» by throwing the corresponding switch on the operating board. The »clear» signal then shown is determined by the position

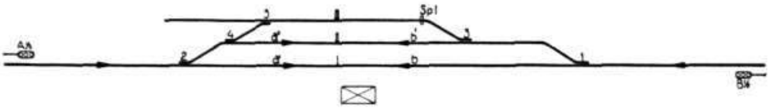


Fig. 1 X 5287

Track diagram for meeting-station on a single-track line

1, 2 centrally and locally operated point
3, 4, 5 locally operated and centrally barred points
$A^1/_2$, $B^1/_2$ entrance signals
a^1, a^2, b^1, b^2 tracks

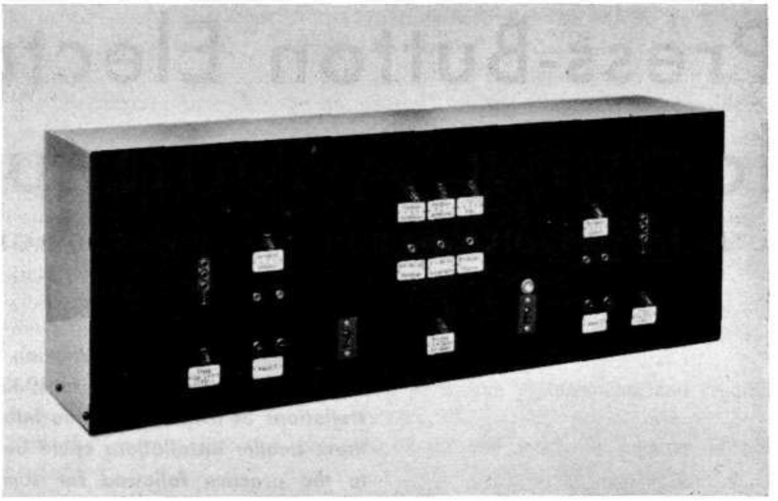


Fig. 2
Switching gear

X 5288

of the entrance points. »Clear» signal for the main track cannot be given unless the track is clear for through running. »Clear» signal to sidings may be given irrespective of the position of the points for departure at the other side of the station.

The point machine drives, Fig. 4, are operated by means of relays actuated by press buttons on the operating board, one for the normal position of each set of points and one for switched position. Freedom to switch these points locally is given by throwing a switch in the operating board, whereupon a flash lamp lights up at the local position indicating that local switching can be done. Both point-operating devices are fed direct from the lighting mains. When current is cut off the point machines are operated manually by hand levers. Supervisory current for the motor points is always fed direct from the battery. To prevent alteration of the centrally switched points when rolling stock is on or just coming to them, there is immediately before each point a track circuit connected to a relay. Over contacts on this relay the current is conveyed to the drives of the point machines.

The interlockings are operated by 136 V DC delivered from the lighting mains over a dry rectifier. On current being cut off the interlockings are operated by the corresponding armatures being pressed down by hand. The supervisory current for the interlockings is normally fed over the metal rectifier, thus having a tension of 136 V, reduced to 24 V via a resistance, this being the tension for which the relays belonging to it are constructed. On failure of the lighting mains the supervisory current is obtained from the reserve battery by throwing a switch on the operating board, by which the series resistance is shunted.

Fig. 3
Switching apparatus
mounted on the station building wall

X 3577

Special combinations of relays provide that when one of the signals has been set at »clear» for the main track, either a passing train must have entered and left the track thus set, or a train from the opposite direction must have been shunted on to a siding, before it is possible to have »clear» signal in the opposite direction on the main track. Should the order of running for any reason be changed after »clear» signal has been set for the main track, or if the train departs from the station without the insulated track section at the station's other end being passed, the interdependence can be cancelled by switching an emergency contact in the station-master's office. When the station staff is on duty the key intended for unattended running is taken from the operating board and kept in a locked key-cabinet in the station-master's office. The master key for the track locking is in charge of the train dispatcher. When the station

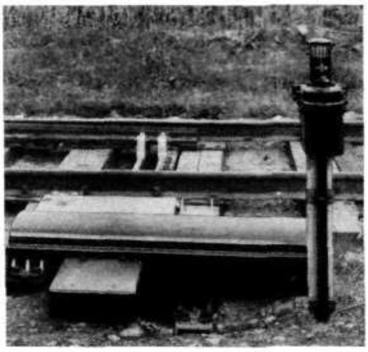


Fig. 4 X 3579
Point machine with local switch

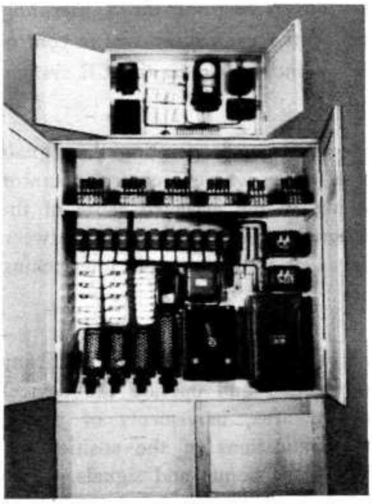


Fig. 5 X 3578
Instrument cabinet
above, cabinet for meter and fuses
below, cabinet for relays, rectifier, resistances, etc.

is not attended the first-named key is placed on the operating board. The master key for track locking is then locked in the key-cabinet. An emergency switch is placed in this cabinet. As the main signals are not to be locked in »clear» position there is a switch placed outside the case of the operating board, by means of which the main signals can at any moment be restored to »stop».

The cabinet for relays, rectifier, resistances and other electrical equipment, Fig. 5, is located at a convenient spot in the office or the parcels room. As this cabinet should be kept locked and sealed by the signal inspector, the instrument board for meters and fuses is placed where it is easily accessible for reading the meters and changing fuses.

The cost of installation of an interlocking system as described above is about the same as for a mechanical installation of the same extent. The advantages with the electrical installation are mainly that the *station is much easier to operate* and *maintenance costs are minimum*. At places where point switchings are few or where the points and the stop-blocks are situated in immediate proximity to the switchgear, the cost of installation can be reduced by replacing the electrical locking by a control lock, the key for which is placed on the operating board, where it is locked by means of the master key before »clear» signal can be given.

Press-button electrical interlocking apparatus has since been delivered by Signalbolaget to a number of privately-owned railways in Sweden and also installed at one railway station in Portugal. This last installation, Fig. 6, controls some thirty points. A further installation of this kind is being supplied in Portugal. In other countries also the press-button electrical interlocking apparatus has begun to receive attention. At Dayton in the USA for instance an installation of this kind and rather large in extent has been supplied by an American firm.

Fig. 6 X 5289
Press-button electrical interlocking apparatus at Ermezinde, Portugal
above, track diagram; below, point switches, track switches and signal switches; on table, telephone switchboard

Centralised Traffic Control

H. MONTELL, L.M. ERICSSONS SIGNALAKTIEBOLAG, STOCKHOLM

Automatic equipment on railways has in recent years become more and more extensive, both for ensuring safety in traffic and reducing the cost of operation; for many years level crossings and such places have been protected by warning signals, and use has been made of automatic line blocking, etc. The strong competition which railways have to meet from motor transport has compelled railway authorities to direct more and more attention to measures which, while reducing operating costs, do not in any way neglect the demand for safety. A factor in these efforts to bring down operating costs while maintaining safety is provided by the centralised traffic control developed by L.M. Ericssons Signalaktiebolag and known as the CTL system.

The CTL system provides for ordering the tracks and operating the signals for the control of train traffic from a central office where a control operator is stationed, without the addition of blocking in the accepted sense of the term, *i. e.,* an interlocking of points and signals and of the signals between themselves. This interlocking is carried on as at present by the interlocking plant and the automatic line blocking.

With the CTL system the control operator can get into connection with any desired station along the controlled track section and operate the devices for regulation of traffic within that station area, movements of points, signals, etc. The control operator receives indications of the positions of trains along the line as also of the setting of the points and signals, on an illuminated diagram which has small lamps which light up and go out on the stretch of track there reproduced. At the central office a responsible control operator is stationed. It is his duty to operate and control the traffic on the line concerned. This is done from a central control board by operation of control switches mounted on the board, each switch when turned actuating the various devices in the CTL unit connected with it. Combined with the control switches are order lamps which indicate the last order dispatched. The control operator can follow on the illuminated diagram all train movements on the tracks, check the positions of the points, the setting of signals, etc. Immediately there is any change in a train's position, etc. indication of same immediately goes in to the control operator. If required, the installation can be supplemented by an apparatus which automatically records the times during which trains occupy the different sections.

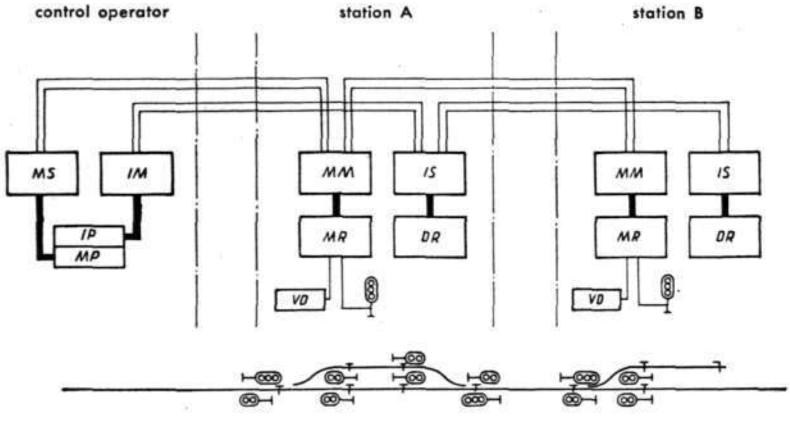
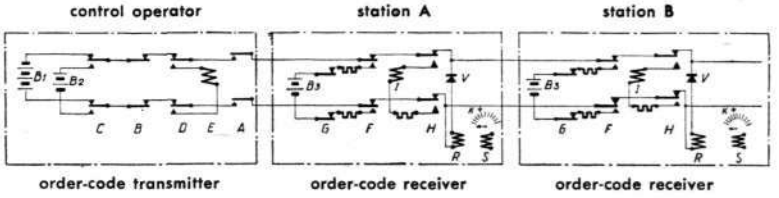


Fig. 1 X 5284
Diagram for centralised traffic control, CTL system
DR operating relays
IM indication-code receiver
P illuminated diagram
IS indication-code transmitter
MM order-codereceiver
MP order panel
MR operating relays
MS order-code transmitter
VD point machine



X 5285

Fig. 2
Order circuit diagram

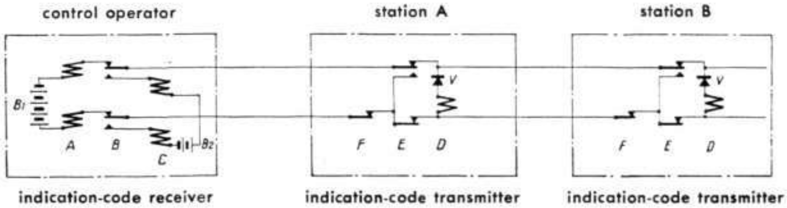
Ordinary telephone lines — overhead or cable — are used for the transmission of signals. Along the line two wires are required for order giving and two for indication, only four wires in all. The system is built up of constructive parts such as are employed by Telefonaktiebolaget L. M. Ericsson in their different automatic telephone systems. The devices used have all proved their reliability and safety in actual practice. To a great extent therefore this system constitutes an application to railway signalling of the knowledge and experience already gained in automatic telephony.

Under normal circumstances, *i. e.*, when employing ordinary telephone cable for the transmission of signals, it should be quite possible to operate up to 20 CTL units distributed over a distance of 30 km from the central office. By special measures, such as raising the operating tension or improving line resistance and leakage resistance, it is possible to extend the above distance considerably.

To control a station with only one siding normally requires only one CTL unit, while for larger railway stations with a number of tracks and points several CTL units are required to handle traffic; to operate crossing gates along the line, for example, one CTL unit is required at each level crossing. Fig. 1 is a diagram of an installation on the CTL system. Two railway stations are controlled from the central office. At the central office there is a control board consisting of an order panel and an indication board, an order-code transmitter and an indication-code receiver. At the stations order-code receivers and indications-code transmitters are mounted. The former are connected to operating relays for the point machines, signals, etc. The indication-code transmitters are connected to track relays, point-indication relays and other devices whose position is to be shown on the track diagram.

Order Circuit

The circuit for order-code transmission is shown on Fig. 2. When an order is to be transmitted, the circuit is connected to the order-code transmitter over contacts *A*. The circuit receives tension and all the relays *R* along the circuit are energised. Over contacts *B* a number of impulses corresponding to the number of the wanted CTL unit is transmitted. The relays *R* receive the impulses transmitted and energise the selectors *S* in such a way that these move forward as many steps as the number of impulses transmitted. The contact positions on the different selectors are so arranged that contact-making occurs for different numbers of impulses at the different stations. After the completion of the impulse series there is a switching over in the order-code transmitter, whereupon the impulse receiving relay *E* is connected over the contacts *D* to the circuit. The order-code receiver whose selector stopped at the marked contact position is connected to the circuit. All



X 5286

Fig. 3
Indication circuit diagram

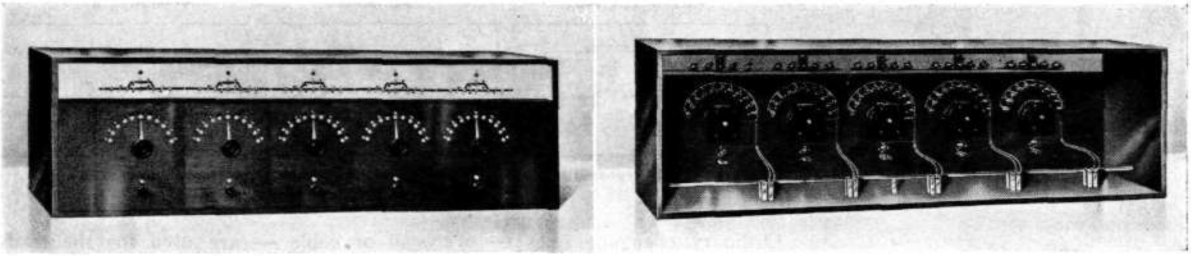


Fig. 4 X 7094
Central order board for centralised traffic control

other code receivers are disconnected. The impulse contacts G are connected to the circuit over contacts F. A control series of impulses is transmitted to the order-code transmitter and is received by relay E. The electric rectifiers V are connected in series with the relays R. These rectifiers prevent the relays R from being energised by the various series of impulses. When the transmitted and received impulse series agree it is an indication that the right station is connected. The contacts C have prepared for connection of battery B_2 in place of battery B_1. When the control impulse series is finished, battery B_3 is disconnected from the order-code receiver and the impulse-receiving relay I is connected over contacts H. Relay E is disconnected from the order-code transmitter and instead of it battery B_2 is connected in the circuit. A number of impulses is transmitted over contact B and received by relay I. The size of the impulse series over contacts B indicates what change is required at the station. When the impulse series has been received, a switching takes place both on the order-code transmitter and on the order-code receiver, whereupon a control impulse series, not shown on the diagram, is again sent. When this control series has been transmitted the order for the required signal or point movement may be sent. If the control impulse series received agrees with the order impulse series transmitted then an order lamp corresponding to the order lights up, and both transmitter and receiver are restored to original positions ready to deal with a new order. Should the order and control series transmitted not agree, then the order lamp does not light up, but an alarm signal is received, both audible and visible. The visible signal indicates the CTL unit to which the defective order has gone and facilitates fault finding.

Indication Circuit

The line connection of the indication circuit is seen on Fig. 3. When the system is idle all the relays D along the circuit are attracted by current from battery B_1. Relay A, which has a very low resistance as compared with relays D, does not attract for the supervisory current flowing through these latter relays. If there occurs a change which is to be communicated to the central office, the indication-code transmitter for the apparatus affected by the change comes into operation, provided that the circuit is not busy with another indication, *i. e.*, provided relay D is energised. If the circuit is free when the change occurs, the current to relays D, for that transmitter and those lying behind it, is cut off and the relays are de-energised. At the same time the relays D of transmitters in front are short-circuited and call is made to the indication-code receiver by relay A which then connects instead the impulse-receiver relay C to the circuit over the contacts B. Relay C is connected to battery B_2 so that the current in the circuit becomes the reverse of the normal supervisory current. From the indication-code transmitter there is transmitted over contact F a number of impulses corresponding to the transmitter's number, and these are received by impulse receiving relay C and recorded. Thereupon the indication-code transmitter tests the position of all apparatus connected to it and transmits information about same to the indication-code receiver. The markings on the track diagram change to agree with the incoming indications. After that the indication-code transmitter

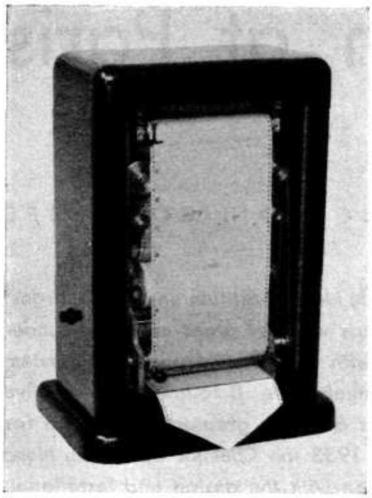


Fig. 5 X 3334
Apparatus for automatic train recording

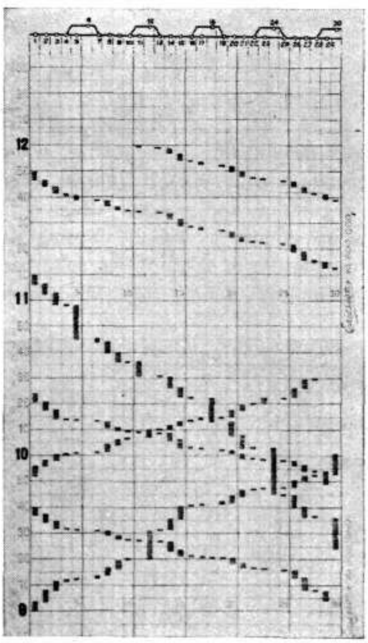


Fig. 6 X 3576
Train movements record

and the indication-code receiver are restored to original position and all the relays *D* are again energised. The devices are then once more ready to record a new change of position along the line.

Central Order Board

The central board consists of an order panel and a track diagram, see Fig. 4. Numbers of order switches, press buttons and lamps are mounted on the order panel. For each order unit there is a switch with the requisite order lamps, a fault lamp and a starting switch. A number of switchings can be carried out by the order switches and each switching represents a change required at the unit concerned. The order lamps at the order switches indicate the switchings last made. The starting key below each order switch is used to start the transmission of an order code. The fault lamp indicates that an incomplete or defective order-code transmission has taken place and facilitates the localising of the fault. The order panel is moreover provided with two lamps, one of which lights when order-code transmission is going on and the other when indication-code is coming in. To economise current there is a switch to cut off current to all signal lamps on the central board during that part of the day when supervision is not required. Another switch is used to clear the blocking of the order-code transmitter arising in conjunction with the lighting up of a fault lamp. The audible signals obtained in connection with fault signal are also stopped by this press button.

On the track diagram there is a miniature lay-out of the track stretch which is operated from the central order board. All the important track sections and other devices along the line which require supervision are marked on the diagram by small lamps. The lamps indicate whether rolling stock is on the track sections concerned, as also the position of the apparatus they represent.

The relays, selectors and condensers required for order-code transmission and indicating-code receiving are mounted on a steel rack which is enclosed in a frame and provided with lockable apertures which close dust-tight to the frame. The order-code receiver and the indicating-code transmitter are made as separate units. Each unit consists of a relay rack in a wood cabinet with lock, which is fixed on the wall. The relay rack in the cabinet can be swung out, making both back and front easily accessible. Both central order board and relay rack are delivered ready connected up and tested, so that only local connections require to be made.

Power supply required for these devices consists of 24 V batteries. A current feed of about 100 V is employed, both for the selection of the stations when transmitting order-code and for supervisory current on the indication circuit.

Automatic Train Recording

An important accessory to the system described above is the automatic train movement recorder. For this a special apparatus, Fig. 5, is used, which registers on a paper strip running at a fixed speed how long a train occupies the different track sections. This automatic record of the movements of trains is of great utility to the control operator. If delay occurs it is immediately apparent on the diagram, see Fig. 6, and the control operator can take any measures necessary.

Dispatching Installation at Paris Gare du Nord

G. FRYDBERG, SOCIÉTÉ DES TÉLÉPHONES ERICSSON, COLOMBES

The lines of the French Chemins de Fer du Nord constitute one of the largest railway systems in France. It connects Paris with the great mining and industrial regions of Northern France and with the Channel ports. The system also serves suburbs of several million inhabitants. It follows that effective supervision at the Gare du Nord in Paris is of the greatest importance for the regular operation of the services. In 1933 the Chemins de Fer du Nord entrusted Société des Téléphones Ericsson with the design and installation at the Gare du Nord of a dispatching system with the object of operating and, by immediate notification in case of faults, supervising the movements of trains through a special office in telephone communication with stations, signal cabins and locomotive sheds. The installation was put into operation in May 1934.

The dispatching system, Fig. 1, comprises four station lines and four signal-cabin lines. Each of these eight lines consists of two conductors to which telephone instruments are connected in parallel; in no case is earth used as return conductor. During the periods of the day when traffic is small the circuits of the dispatching system are utilised by the accounting department of the railway. This has an instrument at la Chapelle-Triage and another at le Bourget-Triage on the Paris-Mitry line.

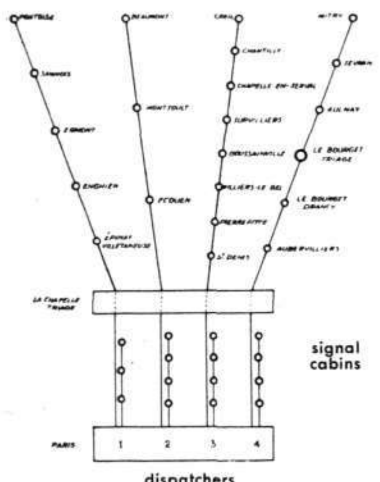


Fig 1. X 3580
Diagram of the Gare du Nord dispatching system

Operation

The dispatching system is worked in two different ways: *regulation,* when the dispatchers do not listen-in at the instruments continuously; *control* when they are listening-in without break. For regulation a dispatcher deals with several lines, usually all four. He marks up minute by minute a diagram of the situation at the platform tracks at the Paris station. At suburban stations and the signalcabins the responsible employee must call the dispatcher

Fig. 2 X 5290
Dispatching office at Gare du Nord

Fig. 3 X 3614
Central apparatus for dispatcher

immediately anything unusual occurs, *e. g.*, a fault or something causing same, delays of more than three minutes, alterations in the movements of trains or locomotives, defects in the shunting devices, briefly, anything that may affect the regular handling of traffic. Train regulation is normally in operation from 6 a.m. to 9 a.m. and from 5 p.m. to 8 p.m. on weekdays, and from 6 a.m. to 9 a.m. and from 11 a.m. to 2 p.m. on Saturdays. In addition to these times the chief dispatcher at Paris may put regulation into operation at other times. In that case he sends out a general call to all the instruments connected to the line he wishes to supervise. When all these have answered he declares »regulation in operation until further notice». The responsible employees then make arrangements for advising the dispatcher of any troubles. Should anything occur outside the hours of operation the employee who notices the incident should advise the dispatcher of same over the telephone instrument of the system. The dispatcher then decides whether it is necessary to put train regulation into operation.

Fig. 4 X 3581
Central apparatus for special dispatcher

Control is put into operation in case of serious interruption on a line and Paris then allots a special dispatcher to that line. The same thing is done when traffic is particularly heavy, such as the eves of holidays, the days following holidays, race days, etc. Two, three or four such special dispatchers may work in collaboration. The dispatcher in Paris marks up a diagram of the actual traffic over that line for one direction or the other or for both directions, according to the circumstance. Independent of this another employee makes a diagram of the situation at the Gare du Nord station tracks. To put train control into operation a general call is sent out from the Gare du Nord and when all instruments have answered notice is given »line .... will work under control in .... direction». From that moment an employee at each station communicates over the dispatching system telephone each passage, arrival or departure of a train. The same applies to the signal-cabin staffs.

In addition to this telephoning of traffic on certain lines, the responsible employees at the stations must advise the dispatcher at Paris of all unusual happenings, as in the case of regulation. When control is in operation the dispatcher is continuously connected and the station and signal-box staffs have no need to ring up by the magneto when taking up the receiver. Use of the magneto is only necessary if the dispatcher does not reply.

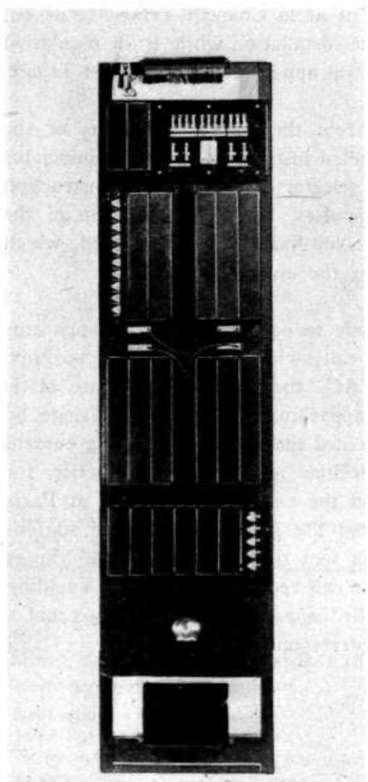


Fig. 5 X 3582
Relay rack

Construction

Fig. 2 shows the interior of the dispatching office. The four desks corresponding to the four stations and the four signal-cabin lines may be seen on the illustration. On the central apparatus, Fig. 3, may be seen, to the right, the buttons for calling stations and signal cabins in the suburbs. The black button at the bottom right hand corner is used for general call. To the left are the switches for connecting up the four station lines and the four signal-cabin lines. These switches each have a position for connecting up the lines to the three other apparatus, see Fig. 4. Over each switch are two call lamps connected in parallel, one acting as reserve. The row farthest left contains a switch which joins up the four signal-cabin lines so that they can be operated simultaneously. This row contains in addition at the top a key for testing the reserve signal current delivered by a converter. The accounting-department central apparatus at la Chapelle-Triage is arranged in the same way as that at the Paris station.

Relays and other devices are mounted on a rack, Fig. 5. The four relay sets in the middle form the four impulse emitters, one for each regulation station. Below that is a call relay set, and at the bottom, protected by a cover, the converter which supplies reserve for the ringing current. At the top of the rack there are fuses and connecting terminal.

Fig. 6 X 3584
Central apparatus for twenty positions

Fig. 7 X 3583
Central apparatus for two positions

The central apparatus at le Bourget-Triage, Fig. 6, is fitted with a dial with twenty positions, with a magneto as reserve current supply. The apparatus at the other stations, Fig. 7, contains two switches for call by magneto to one of the other two central apparatus. On the upper part of the apparatus there are a bell with cover, a lamp and an annunciator. The selector and other devices are mounted inside the apparatus on a frame which can be swung out.

Functioning

The dispatching apparatus at Paris calls the stations and the signal cabins by selective call and with current from the 120 V, 50 c/s, mains. In case of failure of the mains a converter comes automatically into work. This converter is fed by the 24 V battery in the telephone installation at the Gare du Nord and likewise delivers 120 V, 50 c/s. The dispatcher in Paris may call each station or signal cabin individually, or send out a general call over two or more lines simultaneously. To call a station or signal cabin the dispatcher presses the corresponding call button for an instant, after pulling down the switch corresponding to the called instrument's line. The impulse emitter then sends out the corresponding number of impulses, following which current is fed for about 6 s, during which time a bell rings and a lamp lights at the called instrument. The disc of the annunciator falls at the same time so that the called employee can see there has been a call even if he did not hear the bell. When the bell rings the dispatcher hears answering tone. The dispatcher may, if desired, prolong the call by keeping the call button pressed until the called employee replies whereupon the answering tone ceases. This is of particular utility in case of general call: cessation of answering tone then indicates that all instruments have answered. The impulse emitters are fed in the same way as the converter by the 24 V battery in the telephone installation at the Gare du Nord.

The apparatus of the accounting department at la Chapelle-Triage sends out calls in the same way, but may not use the installation while train regulation is in progress. The same applies to the central apparatus at le Bourget-Triage.

Call from the train dispatcher or also from the central apparatus of the accounting department is signalled at the called instrument by bell, annunciator and lamp. These devices are operated by a selector of very strong construction which is governed by the call current impulses. By the lighting up of the lamp the call is indicated even if the receiver has not been replaced, which interrupts the ringing current and restores the annunciator disc.

From a station or signal cabin call is made to one of the central apparatus by turning the magneto after putting the call switch into the right position. The dispatcher at Paris is called by AC, the central apparatus at le Chapelle-Triage by DC and the central apparatus at le Bourget-Triage by DC but of opposite polarity. It should be noted that the 30 V ringing current from the stations cannot actuate the selectors as these only function for selective call at 120 V. On the other hand the call receiving relay at Paris is actuated only by generator current from the instruments at the stations or signal cabins. The 120 V AC which is sent out for selective call causes the energizing of a relay which cuts out the call receiving relay, thus avoiding false call. The call is indicated on the called apparatus by two lamps and a buzzer. Answer is made by moving the corresponding switch.

Automatic Exchanges Interconnected by Carrier Channels

C. W. RIISE, A/S ELEKTRISK BUREAU, OSLO

The telephone net work of the Oslo Electricity Works comprises, in addition to the administration building and different power plants within the city, a number of large transformer and power stations outside its boundaries. Between these stations telephone connections on the rural automatic system of Elektrisk Bureau are employed and it should be specially noticed that a carrier-telephone channel operated on the high-tension lines has been installed between the power station in Solbergfoss and the plants in Oslo.

Soon after the new rural automatic system of Elektrisk Bureau was put on the market the question of modernising the telephone net work belonging to Oslo Electricity Works came up for consideration. As this system was specially suited for the purpose, especially because of the possibility of interrupting a local conversation, the Electricity Works of Oslo adopted it for the automatisation of its telephone network. Automatic exchanges have already been installed inside the town as well as in the transformer station at Smestad, 5 km from Oslo, and in the power station at Mörkfoss-Solbergfoss, about 40 km from Oslo. The circuits between the stations inside Oslo and between these and Smestad are two-wire.

From the Töien transformer station to the power station at Mörkfoss-Solbergfoss the Electricity Works had a carrier channel operated on the high-tension circuits. The question arose whether this channel could be used for communications between the district station in Solbergfoss and the stations in Oslo. This war arranged as seen from the circuit diagram, Fig. 2, by introducing relay repeaters ahead of the carrier equipment at each end of the power line. The carrier receivers are constantly in service, while the transmitters are started only when required. The time elapsing between the start of the transmitter and the moment when the carrier is really transmitted varies from about 0.5 to 1.5 s, and moreover the receiver only indicates that the carrier transmitter at the other end of the line really transmits.

The district system of Elektrisk Bureau works with different calling and answering signals as may be seen from Fig. 1. Thus the circuit is closed for a local calling signal and with a long-distance call a trunk impulse is transmitted over the channel immediately after the closing of the circuit. When a channel is engaged the corresponding channel group-selector transmits a back signal to the master register, which indicates that the station number requires to be repeated. If the call concerns an exchange with a number of 100-line groups and with one station number only the second channel group-selector transmits two back signals to the register. This results in the transmission of the hundred figure and the directing of the call to the proper hundred group. When a final selector is engaged it transmits three back signals to the register, indicating that the ten and unit figures may be transmitted. When the called subscriber replies, the back signal is led to the calling cord circuit.

To provide for the above-mentioned trunk impulse and other circumstances, the carrier equipment is governed by the relay repeaters, which signal between themselves and fix the moment for the different operations.

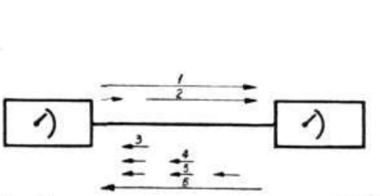


Fig. 1 X 3597

Calling and answering signals in the district system

1 local signal
2 trunk signal
3 answering signal to first channel group-selector
4 answering signal to second channel group-selector
5 answering signal to final selector
6 answering signal to subscriber

Operation

For a *local call from Töien* this station calls Solbergfoss by starting the transmitter, thus transmitting carrier frequency. When the carrier frequency is received at Solbergfoss this station answers with a new carrier frequency and at the same time the channel final selector *KLV* shows engaged. When the carrier is received in Töien this station responds with an impulse on the carrier to Solbergfoss. At the moment the impulse starts, *viz.*, when the carrier to Solbergfoss is interrupted, the selector *KLV* in Solbergfoss automatic exchange emits a call and the carrier to Töien is interrupted. When the impulse stops, *viz.*, when the carrier to Solbergfoss starts again, the selector *KLV* at Solbergfoss is ready to receive a trunk impulse. When the selector at Solbergfoss answers with three back signals, the carrier is started three times, which means that three carrier impulses are transmitted to Töien. The answering impulses are repeated in Töien and sent through the channel to the master register. The register transmits forward impulses through the channels to the selector *KLV* in Solbergfoss, which is set at the desired subscriber's number.

If the subscriber is not engaged a ring signal is transmitted on the line but if the subscriber is engaged locally Solbergfoss transmits a series of answering impulses to Töien. After the fourth impulse Töien interrupts the carrier to Solbergfoss, which cuts off answering signals and is after a moment ready to receive call signals. Töien interrupts the circuit from the local selector KGV_{lok} in the secondary station and KGV_{lok} disconnects the communication with Töien. The calling subscriber in Oslo receives engaged signals.

For a *call from Solbergfoss* this station calls Töien by means of transmitting carrier. When the carrier is received in Töien the circuit is connected to the local channel group-selector *KGV* in the secondary station. The selector gives an answering impulse to the repeater in Töien which starts the carrier

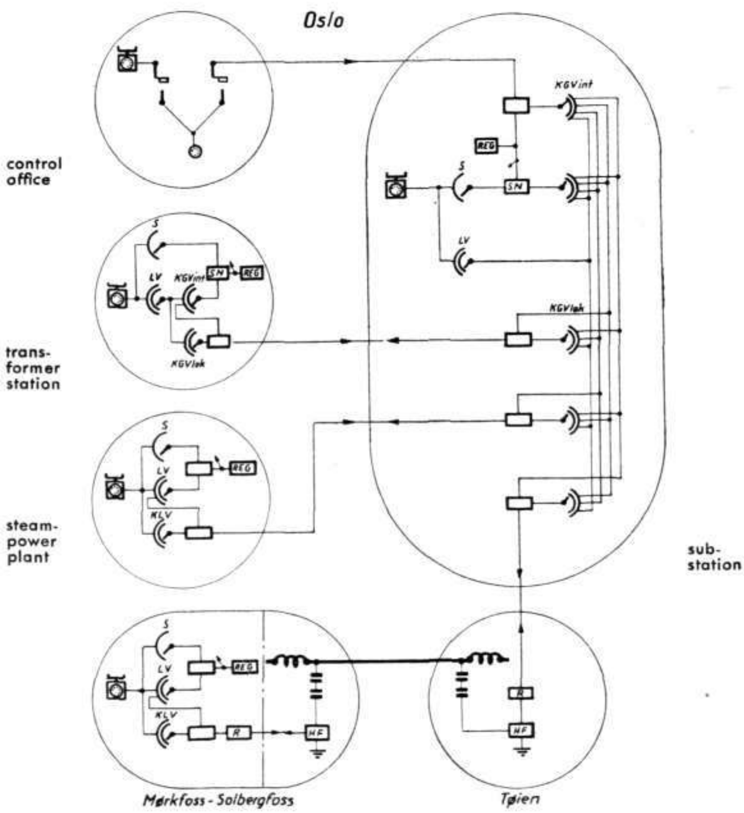


Fig. 2 X 1506

Circuit diagram of Oslo Electricity Works central network

HF	high frequency repeater
KGV_{int}	trunk channel group-selector
KGV_{lok}	*local channel group-selector*
KLV	channel final selector
LV	final selector
R	relay repeater
REG	register
S	call finder
SN	cord circuit

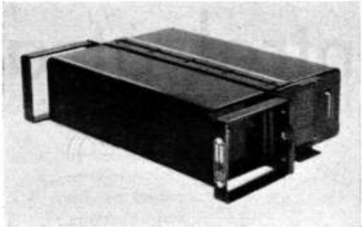


Fig. 3
Relay repeater

X 3598

to Solbergfoss. When the carrier is received at this station an impulse in the carrier to Töien is transmitted. When the carrier from Solbergfoss is interrupted, *viz.* when the impulse starts, the answering carrier to Solbergfoss is interrupted. This answering carrier is repeated by the repeater and led to the master register in Solbergfoss, where the register transmits station number impulses to Töien. These impulses are repeated by the repeater and led to the local selector, which is set to engage a new device, selector *KGV* or *LV*, which replies, and so on.

If the line or subscriber in Oslo is engaged the circuit to Töien is interrupted and the repeater transmits a series of answering impulses to Solbergfoss. After the fourth answering impulse the communication is disconnected from Solbergfoss, the repeater in Solbergfoss disconnects the calling cord circuit and the calling subscriber receives engaged signal.

On *trunk disconnection of a call to Solbergfoss* the trunk channel group-selector listens in on the channel to Töien. Warning is given that the connection will be interrupted and thereafter the repeater in Töien is released by means of interruption of the circuit. The carrier to Solbergfoss ceases and the repeater in Solbergfoss releases the channel final selector *KLV*. When the selector KGV_{int} engages the repeater in Töien anew it will indicate trunk engagement and transmit carrier to Solbergfoss. This station answers when the repeater has come to rest. The connection is put through as a local with the exception that the selector *KLV* in Solbergfoss and the repeater in Töien will indicate trunk engagement.

If the called subscriber is not engaged the trunk exchange calls his number, but if the number is engaged locally the trunk exchange can interrupt the connection by means of a ring signal.

On *trunk disconnection of a call from Solbergfoss* the selector KGV_{int} in the sub-station interrupts the circuit to the repeater in Töien, which sends a series of answering impulses to Solbergfoss, this station stopping the carrier to Töien after the fourth answering impulse. Töien stops the answering impulses when the carrier from Solbergfoss ceases and does not close the circuit to the secondary station until the repeater has come to rest and is ready to receive the trunk impulse from the selector KGV_{int}. The connection is put through in the same way as described above for calls from Töien.

The carrier connection satisfies all demands that may be put on a rural automatic system. One requirement was that all exchanges should belong to the same number series. A subscriber in Solbergfoss can thus call any subscriber belonging to the telephone net work of Oslo Electricity Works simply by dialling the number of the subscriber in question. If a circuit or a subscriber's line is found engaged during the process of connection the part of the connection already put through will be released and the caller receives engaged signal from his line equipment. Trunk disconnection of local connections may always take place. The trunk equipment of the control office can thus interrupt any connection within the local net work of the Oslo Electricity Works, including connections through the carrier channel to Solbergfoss or inside the Solbergfoss station. This demonstrates the great adaptability of the system employed and opens up wide possibilites for automatisation.

Automatic Breaker Control at a Power Station

N. SUNDEVALL, ERICSSON SALES COMPANY, STOCKHOLM

Interruptions at power stations often result in the breakers automatically coming into operation one after the other at short intervals. When investigating the causes of the fault it is important to know what order the breakers operated and the intervals between them.

Telefonaktiebolaget L.M. Ericsson has supplied to the recently opened Malfors power station of the Swedish Royal Board of Waterfalls a time-recording installation with the aid of which it is possible to determine exactly the times and the order in which the breakers operate. The installation will also be employed to check that the staff correctly carry out orders regarding connections.

The installation consists of a recording apparatus with relay set, Fig. 1, and a master clock. The recording apparatus contains thirty stamps and a paper strip driven by impulses from a master clock. Divisions of time are indicated by horizontal lines and the strip moves normally at the rate of 60 mm/h. On automatic operation of breakers the strip is connected up for a speed of 1 800 mm/h. The strip is divided vertically into thirty columns, one for each stamp. Each of the stamps, which are actuated by their individual electro-magnets, is connected to a contact on a breaker. The relay set consists of a combination of relays for transmission of impulses from the master clock to the driving mechanism of the recording apparatus, switching from normal to high speed, etc. The master clock is a precision clock with seconds' pendulum and contacts for half-minutes and for seconds. The clock is also employed for driving the frequency-control installation of the power station.

Fig. 1
Recording apparatus
on wall, relay set

X 3609

Connection of the automatic breakers to the recording apparatus is made in such a way that the movement of the diagram strip is switched from low to high speed immediately a breaker operates. To indicate that the apparatus has changed over to high speed the thirtieth hammer is connected to mark in the last column so long as the paper is moving at the high speed. There is also fitted to the recorder a synchronous clock with second hand but not self-starting. This clock is connected over a break relay in the relay set and is deprived of current at the moment the recorder changes over from low to high speed, the clock then stopping and indicating the exact time the fault arose. As the recording apparatus marks intervals of a second during the time of interruption, it is easy to tell to a second the moment the fault arises and the moment it is corrected.

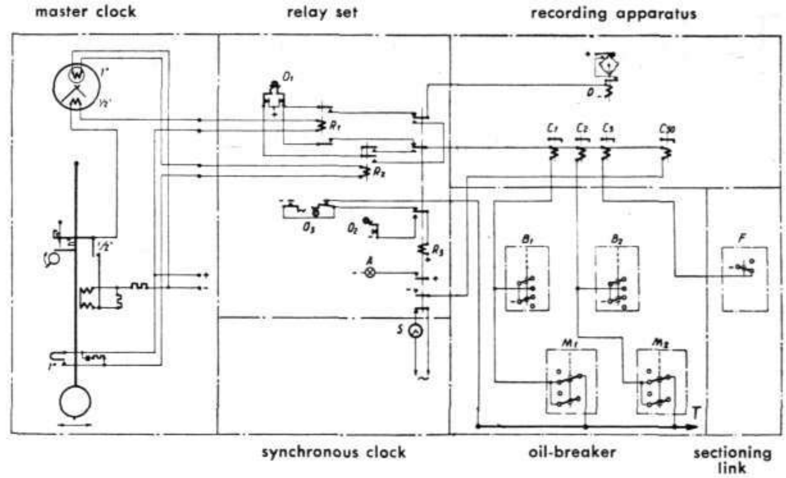
The principle of the installation is shown by the diagram of Fig. 2. At normal speed the driving mechanism D of the recording apparatus receives an impulse every half minute from the master clock, whereupon it is attracted and then moves forward a number of steps over a self-driving contact. The number of steps is fixed by a break contact which is influenced by a cam disc connected to the shaft of the driving mechanism. At the same time the stamps C, which are connected to the disconnected sectioning link and breaker, are energised. These stamps receive their minus tension over a contact in the breaker B or the sectioning link F. Plus tension is received over realy $R\,1$ which attracts for half minute impulses from the master clock.

On automatic breaking, a circuit for alarm relays is connected to minus tension over contacts in the breaker B and the operating switch M. The connecting relay $R3$ in the relay set is connected to alarm circuit; it attracts and

Fig. 2 X 5300

Circuit diagram of automatic breaker-control installation

- A alarm lamp
- B_1, P_2 oil-breakers
- $C_1 - C_{30}$ stamps
- D driving mechanism
- F sectioning link
- M_1, M_2 operating switches
- 0_1 disconnecting switch
- 0_2 restoring switch
- 0_3 testing switch
- R_1 half-minute impulse relay
- R_2 seconds impulse relay
- R_3 connecting relay
- S synchronous clock
- T circuit for the alarm relay



is self-held. The stamp *C* is connected direct from the contact in the breaker. When relay *R3* attracts, the alarm lamp lights up and the synchronous clock stops. The driving mechanism is connected over to second-impulses and the stamps are connected for marking in seconds over relay *R2*. The thirtieth stamp marks the diagram paper to indicate that it is moved by second-impulse.

The diagram, Fig. 3, shows the process during the time the breakers operate. The breaker no 11 has functioned. The diagram paper which, up to the operation of the breaker, was moving under half minute impulses marks the time as 17.45. The synchronous clock, disconnected when the break occurred, stopped at 17.45.14. This time is marked on the diagram in the column next to the thirtieth column. Following the first marking in this column each mark corresponds to 1 s; the distance between each horizontal line corresponds to 5 s. One second later, breaker 5 operated and in one second more breaker 15. By counting the markings in the respective columns it is found that breaker 11 was disconnected for 110 s, *i. e.*, from 17.45.14 to 17.47.04, breaker 5 for 89 s, *i. e.*, from 17.45.15 to 17.46.44, and breaker 15 for 128 s, *i. e.*, from 17.45.16 to 17.47.24.

Restoring is carried out in three stages, the two first in conjunction with the working of the breakers and the third especially for the recording installation. First the operating switch *M* is moved, by which minus tension is disconnected from the circuit for the alarm relays. The stamping for the forward movement of the paper continues uninterrupted since relay *R3* is self held. Then the breaker is switched in whereupon the stamping for the breaker in question ceases. Switch *O2* is then pressed in, which releases relay *R3* and the installation returns to normal speed of paper; the alarm lamp *A* goes out and the thirtieth stamp ceases to stamp. This return to normal speed may also be made before the breaker is switched in. Finally the synchronous clock is reset to correct time and started and the diagram paper shows the correct time.

By means of switch *O3* the relay *R3* can be connected direct to the minus pole and the installation tested for the higher speed; if it is desired to record accurately the process in a connection known in advance, this switch can also be used to connect up the higher speed in anticipation. The switch is set at middle position when it is desired to operate a breaker by hand and in that case the recording of the time can only be made to within half a minute. By using switch *O1* the stamping can be altogether disconnected.

The arrangement of the recording apparatus for two different speeds has the advantage of giving a small consumption of paper with a short and clear diagram. With normal operation the stamping intervals of 30 s are quite sufficient and the 1 s stampings on interruptions give all necessary time indications. The recording apparatus works with typewriter ribbons and the reversing of the ribbons is automatic. Thus all trouble in feeding ink and keeping pens clean is avoided. The attention required by the apparatus is confined to insertion of a new roll of paper about once a month.

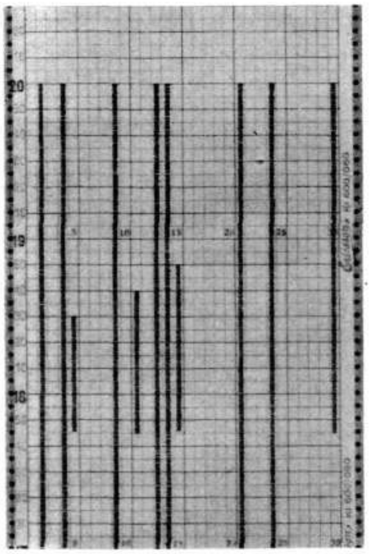


Fig 3 X 3610

Diagram of operation of breakers

Telecommunication Installation at the Eastman Dental Institute in Stockholm

J. ERICSSON, TELEFONAKTIEBOLAGET L.M. ERICSSON, STOCKHOLM

On 15th December, 1930, the City Council of Stockholm decided to accept the offer which had been made by the late Mr George Eastman to place at the disposal of the City a donation amounting to $ 1 000 000 for the building of a dental institute on lines laid down by the donor. The institute was officially opened on April 25th, 1936.
The equipment of the institution is of the most modern design and included in same are a number of telephone installations, of which a short description is given below.

Fig. 1 X 3586
Telephone switchboard

For internal communication there is an automatic private branch exchange with about thirty instruments connected to it, located in various parts of the building. The private branch exchange is located in a room specially arranged for the purpose in the basement and is provided with arrangements for operation in conjunction with the public telephone system. For this outside communication there are four outgoing and six incoming lines. Outgoing traffic is completely automatic while incoming traffic is handled by an operator. The operator's desk, Fig. 1, is located immediately to the right of the entrance, thus permitting a combination of telephone exchange and inquiry office for visitors.

To maintain uniform time throughout the building there is an electric clock installation. The installation which consists of some ten secondary clocks, Fig. 2, connected to a master clock in the basement, is driven from an accumulator.

At the entrance of the institute there is a hall telephone board, comprising loud-speaker and microphone together with a number of labelled press-buttons, by means of which a visitor can communicate direct with persons living on

Fig. 2 X 5292
Hall and conference room
with electric clock

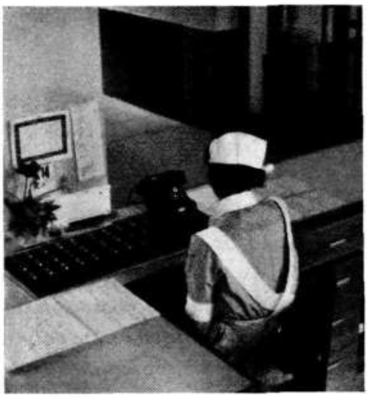


Fig. 3 X 3590
Waiting room
with illuminated signals

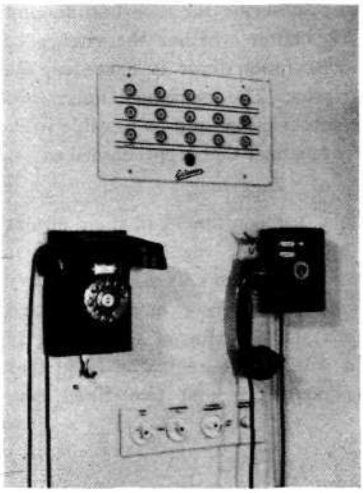


Fig. 4 X 3588
Nurses' room
with illuminated signal board, public telephone and hall telephone

the premises or on duty there. The hall telephone is also connected with an electric door catch, so that the door may be opened from the room called to let the caller enter.

To facilitate handling of patients in the tooth-stopping hall, containing twenty dental chairs, a system of illuminated signals has been arranged by means of which a dentist as soon as he is free attracts the attention of the nurse on duty in the waiting room. The chairs are numbered and when the button at one chair is pressed the corresponding number lights up on the nurse's indication board, Fig. 3, and she can therefore direct a waiting patient to the free chair. Restoring of the signals is independent for each number and is done by the nurse immediately after she has marked the number of the chair on the patient's card.

There is also a button on the chair for calling nurses, the signal going to the nurses' room where it shows on a lamp board, at the corresponding number, thus indicating the chair from which the call has come. These signals also are restored independently.

There are a number of in-patient wards on the second floor and a system of illuminated signals has also been installed there. The operation of the system is such that when a patient calls a nurse a lamp lights up over the door at the same time as a light shows in the nurses' room, Fig. 4. The nurse has then only to observe the door over which a lamp is lit to know whence the call came. If required a buzzer can also be connected in the nurses' room which sounds intermittently so long as the calling signal is not restored. Restoring of the signal can only be done in the ward from which it came.

In the in-patient section there is, in addition, a program distributing wireless with connections to each ward, see Fig. 5. The connecting plug and the volume regulating device are combined on a common panel with the light-switch, the connecting plug and press-button for the illuminated calling signal, the power-contact for connecting vacuum cleaner and the like. This arrangement gives an agreeable appearance while ensuring a practical placing of the various contacts.

In the office of the director of the institute an engaged-signal installation is mounted, by means of which the director may indicate at will whether he wishes to receive visitors or not.

Fig. 5 X 5203
Ward
with wireless program distributor

Power Regulator

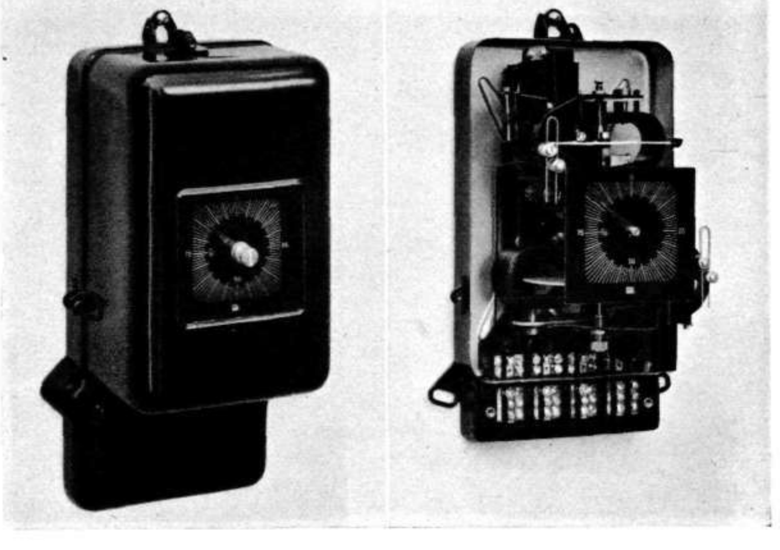
A. GARTNÄS, TELEFONAKTIEBOLAGET L. M. ERICSSON, STOCKHOLM

In order to utilize with full efficiency the electrical energy subscribed for by a consumer, the load must be kept constant and as near the subscribed power as possible.
The Ericsson power regulator has been designed to enable consumers of electrical energy to utilize in a rational way the power subscribed for, to ensure that the power consumed follows as nearly as possible the subscription limit.

The aim of the electricity companies is to maintain a constant load on their generators. With this object in view, their rates are made up in such a way that it lies in the interest of the subscribers to keep the load constant. Generally the rates are such that the consumer may subscribe for a certain amount of power and pay a basic price for this, no matter whether the energy be consumed or not; if, however, the fixed subscription limit is exceeded, the consumer must pay a considerably higher price. The consumer must thus maintain the load as constant and as near the subscription limit as possible without exceeding it, in order to utilize in an efficient manner the output subscribed for.

The Ericsson power regulator is intended to assist consumers in their efforts towards rational utilization of subscribed energy. The regulator, Fig. 1, is made for single-phase as well as three-phase AC. It consists of an ordinary single-phase or three-phase kWh meter, without metering mechanism, and the rotation of the rotor disc is opposed by a spiral spring *a*, see Fig. 2, in the same manner as the balance-wheel of a watch. The regulator is further provided with three contacts, one moving contact *b* and two fixed contacts *c* and *d*.

The moving contact is mounted on the rotor disc and oscillates between the two fixed contacts. It is pressed against left fixed contact *c*, the minimum contact, when the load is inferior to the subscription limit; when the load exceeds the subscription limit, it is pressed against the right contact *d*, the maximum contact. When the load just equals the subscription limit, it does not make contact with either maximum or minimum contact.



X 5301

Fig. 1
Power regulator

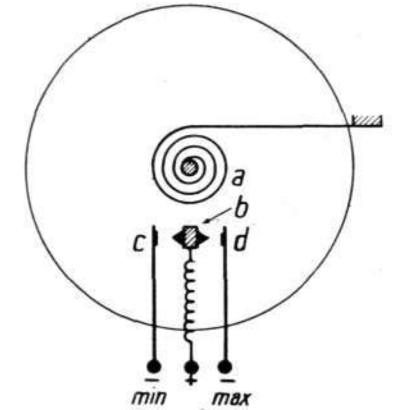


Fig. 2
Sketch showing functioning of power regulator

According as the load is below or above the subscription limit, a current is closed through the minimum or maximum contact. This current actuates regulating devices which increase or decrease the load of the installation, depending on which of the contacts is closed. The regulating devices may be designed in such a way that the load is increased or decreased in small steps with or without delayed action between each step to ensure uniform regulating. To prevent the moving contact following incidental variations in the load, the delayed-action relay, *e. g.*, thermic relay, may be connected in series. The small oscillations produced when the contacts in the regulator are closed are damped by two permanent magnets. Through a little aperture on the front of the meter, it is possible to see whether the maximum or the minimum contact is closed.

The regulator may be set for different subscription limits by means of the dial of the regulator, see Fig. 1, the point of which moves along the scale. According as the dial is turned, the spiral spring is tightened or loosened, and the subscription limit is adjusted to the right figure. A diagram supplied with the regulator shows the subscription limit as a function of the number of divisions on the scale.

The power regulator is particularly useful in installations where it is possible without inconvenience to vary the load of some of the apparatus, as e. g. electric heaters, pumps with water tanks, grinding machines in paper mills, etc.

Ericsson Technics No 2, 1936

H. Sterky: Frequency Division—a new Circuit for the Generation of Subharmonic Frequencies

Constantly increasing demand for synchronizing devices in telecommunication technics has involved extended use of devices for the production of harmonics and subharmonics of an input master frequency. This article describes a new circuit for a subharmonic generator by which frequency division can be obtained. The principle of feed back is applied in a new way to a valve circuit having a non-linear response characteristic. The conditions for optimum output power are deduced and the advantages of the new circuit are discussed.

Ericsson Technics No 3, 1936

C. Palm: Calcul exact de la perte dans les groupes de circuits échelonnés

When a method similar to that used by Erlang for determining the proprieties of a group of non graded circuits is applied to a group of graded circuits, one obtains for the computation of the loss a system of linear equations of generally very high degree. In the present article the general principles of the use of this method are laid down and the basis of the theory is developed for gradings in general. Further, the simple type of grading is examined more in detail and the simple cases which can be established directly are computed; the determinants found during the solution of the equation system are treated briefly. Finally, it is shown how the equation system can be simplified by introducing a rational function determined by a partial differential equation. The properties of the system thus simplified are investigated and a few examples of the numerical computations are given.

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CONTENTS

On the cover: Wireless Receiver with Built-in Gramophone

Economic Considerations on Cable Carrier-Telephone Systems

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

Efforts made in recent years to apply carrier technics — formerly practised only on overhead lines — to cable circuits also have led to a number of schemes for new systems. It is hardly possible so survey the facilities at hand when planning new telephone cables without comparing in a general way the different systems from an economic point of view. However, it is clear to all that such a comparison involves considerable difficulties: a great number of variable factors besides local and contingent circumstances will affect the costs. Therefore, if a general view of the problem is desired, the demand on exactness of result must be reduced. The summary and general investigation reviewed below must consequently be looked upon only as indications of alternatives which should be considered for a more detailed calculation.

Different Kinds of Cable Carrier Systems

This article will not describe the systems suggested or installed, as these may be supposed to be known in a general way, thanks to descriptions in the technical press. From an economic point of view, however, three different systems may be distinguished.

Systems for Loaded Cables of Normal Type but with Increased Cut-Off Frequency

With these systems there is an advantage on the costs of circuits as a certain increase of the cut-off frequency may be accomplished without any great increase in costs for loading coils and repeaters, these comparatively constant costs thus being split up over a greater number of channels. This, in turn, is due to the fact that the cut-off frequency — especially on four-wire circuits for great distances — must be kept rather high in any case because of the building-up time and because a cable as well as a four-wire

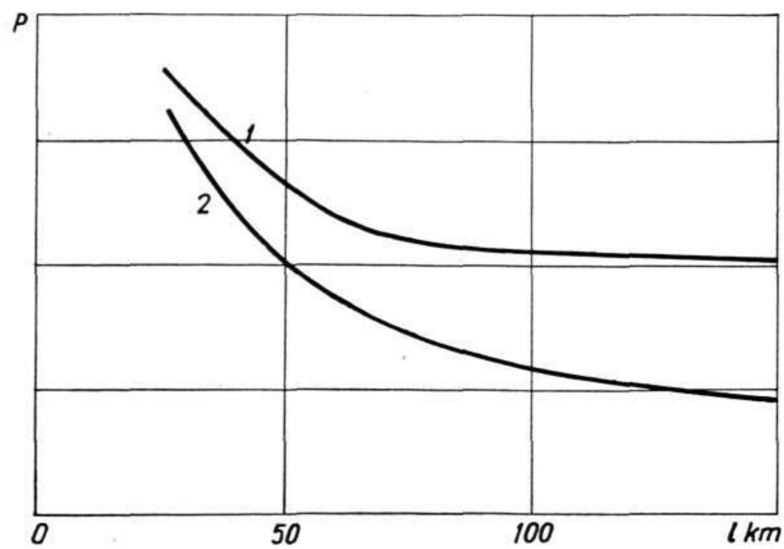


Fig. 1 X 5312
Cost as function of the mean distance l at constant number of circuits = 100
1 four-wire circuits
2 carrier channels

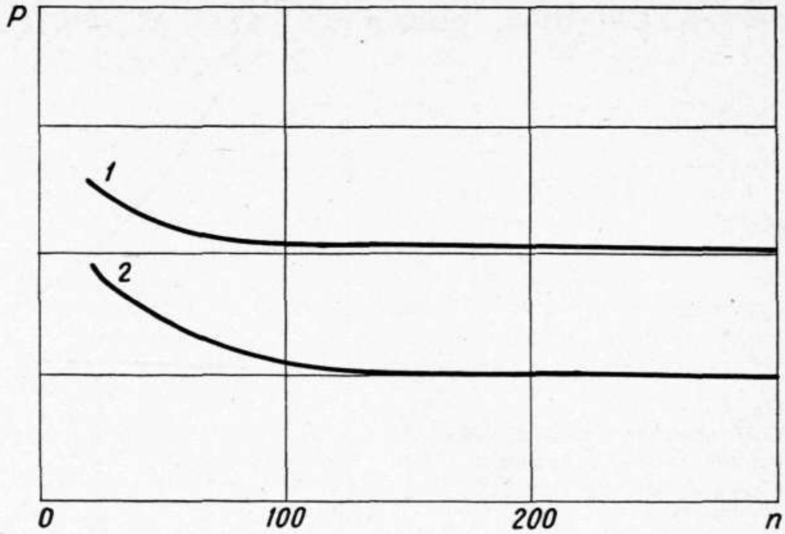


Fig. 2 X 5313
Cost as function of the number of circuits at constant mean distance $l = 100$ km
1 four-wire circuits
2 carrier channels

repeater without any great modification may transmit a frequency range greater than the ordinary voice frequency band. As in this case it is the question of utilizing existing margins on four-wire circuits, it is expected that systems of this kind will be limited to *single channel systems on four-wire circuits, i.e.,* to four-wire systems operating an audio frequency band and a carrier-frequency band both in the same direction. The two-band system, where the two bands on the same pair are used for transmission in opposite directions, necessitates special repeaters and filters in the intermediate stations and is consequently out of the question for general purposes.

Systems for Unloaded Cables of Normal Type with Several Pairs

In these systems the omission of the loading constitutes a further economy. The technical and economic limit of the useful frequency range is not quite defined in this case. If cables and repeater stations of normal type are considered, cross-talk and section attenuation will limit the number of channels to about 10 to 20. If a great number of channels is used the repeater and circuit costs will increase but on the other hand these costs are spread over a greater number of channels. Consequently systems of this kind, while differing somewhat in the numbers of channels, will not show any considerable difference as to costs. The number of channels is, therefore, fixed with a view to practical design. The calculations which follow have been based on a twelve-channel system.

Systems for Wide-Band Cables, e. g., of Coaxial Type

In these systems the cross-talk difficulties are eliminated, only one physical circuit being used for each direction and carrying all the channels. The costs for this circuit and the repeaters will increase considerably but are split up over a very great number of channels.

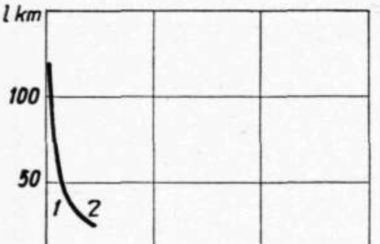


Fig. 3 X 3645
Limit of cost for *n* circuits in cross-section and mean distance *l* per circuit
1 four-wire circuits
2 carrier channels

Chief Variables of the Cost Comparison

From an economic point of view the terminal costs of all the above systems — as of any carrier system — are greater than those of ordinary voice-frequency systems. Therefore, they will be justified economically, only when the distance to be covered reaches a certain limit, where the gain in circuit costs outweighs the additional costs for terminal equipments. The *mean length* of the cable circuits is thus one of the variable factors governing the

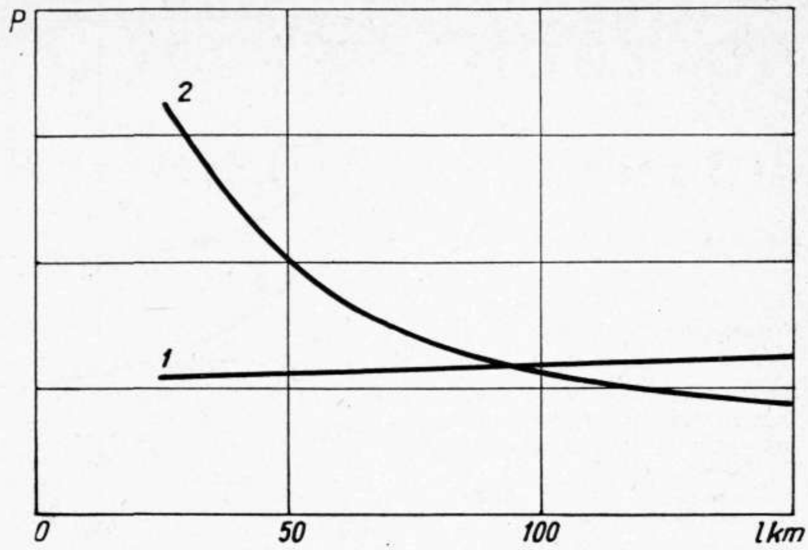


Fig. 4 X 5314
Cost as function of mean distance l at constant number of circuits $n = 100$
1 two-wire circuits
2 carrier channels

economy of the different systems. The other variable factor of importance is the *number of channels* and on this point the three kinds of systems will differ considerably. In the second and even more in the third group of systems the circuits are brought together to large bundles and consequently they will turn out to be economical only when the number of circuits exceeds certain limits.

For a summary comparison it is sufficient to consider the costs per circuit kilometer for different systems as a function of these two variable factors. Certain costs, which are relatively independent of the type of system but vary with other factors, may be left out of this comparison. When judging the results of such a calculation it is necessary to have due regard also to the difference in quality of the circuits obtained with one system or the other. Carrier channels are always of the four-wire type and have shorter building-up and propagation time than ordinary lightly loaded four-wire circuits. The demands on circuits suitable for long distance communication have increased with the development of international telephony and, besides, a circuit short in itself must nowadays very often be of a quality allowing the circuit to be used as a link in a long distance channel. This must be duly taken into consideration especially when carrier channels and ordinary two-wire circuits are compared.

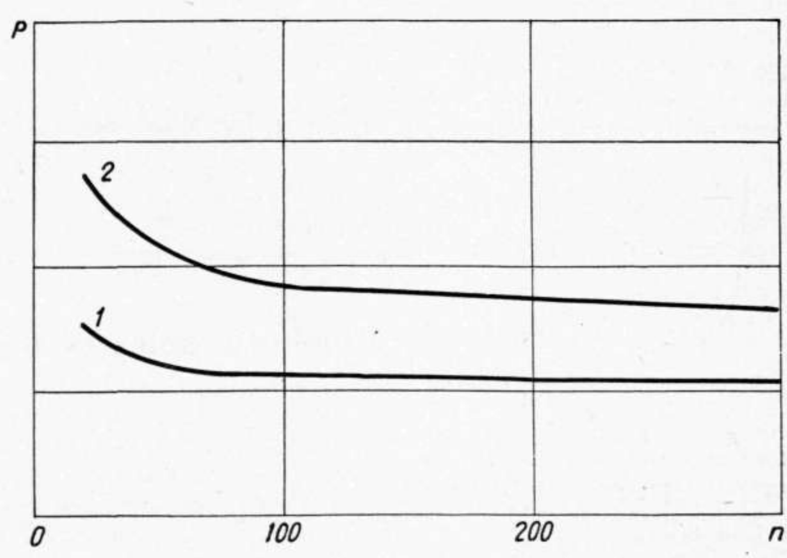


Fig. 5 X 5315
Cost as function of the number of circuits n at constant mean distance $l = 50$ km
1 two-wire circuits
2 carrier channels

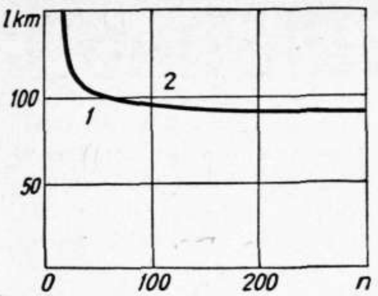


Fig. 6 X 3646

Limit of cost for *n* circuits in cross-section and mean distance *l* per circuit

1 two-wire circuits
2 carrier channels

Carrier Systems Compared with Voice-Frequency Systems

If at first cables with one kind of circuits only are compared it will be found that, when *high-grade four-wire circuits* intended for long distance operation are required, carrier channels will be less expensive than ordinary four-wire circuits already at short mean distances and small bundles, see Fig. 1 and 2. In order to illustrate in a simple way the ranges for which one system or the other is the more advantageous a diagram showing the relation between mean distance and number of channels for systems of equal costs is given in Fig. 3. It has to be observed that the curves have been derived from general cost formulae, which are accurate only within a certain range — at short mean distances and small numbers of channels especially, the accuracy is not very great. On the other hand, if *ordinary two-wire circuits* are acceptable as regards quality, comparison of costs will not turn out to the advantage of the carrier systems. If also in this case a twelve-channel system is allowed to represent carrier systems, the curves will show a character according to Fig. 4 and 5. The mean distance in Fig. 5 has been selected lower than in Fig. 2 in order to correspond more closely to cases of practical interest for two-wire systems. The diagram for equal costs, Fig. 6, shows that the two-wire circuits are the less expensive within the ranges most important in practice. From Fig. 4 may be gathered also that the difference in costs is considerable for short mean distances.

Without entering into similar comparisons with other kinds of carrier systems, which point in the same direction, it is possible to draw the conclusion that carrier systems will probably be predominant in long distance traffic but that they cannot compete with two-wire circuits on short distances in the present state of technics. There seems to be an economic limit at about 100 km; how far down this limit may be moved, if account is taken of the quality of the circuits, is difficult to decide. It is possible, therefore, that in future one will have to calculate either on mixed cables or on separate long-distance cables designed for carrier systems and short-distance cables with loaded two-wire circuits.

Comparison of Carrier Systems of Different Kinds

When comparing carrier systems of different kinds, both ordinary cables and mixed cables with carrier channels combined with loaded two-wire circuits have to be considered. In both cases, however, the results will be

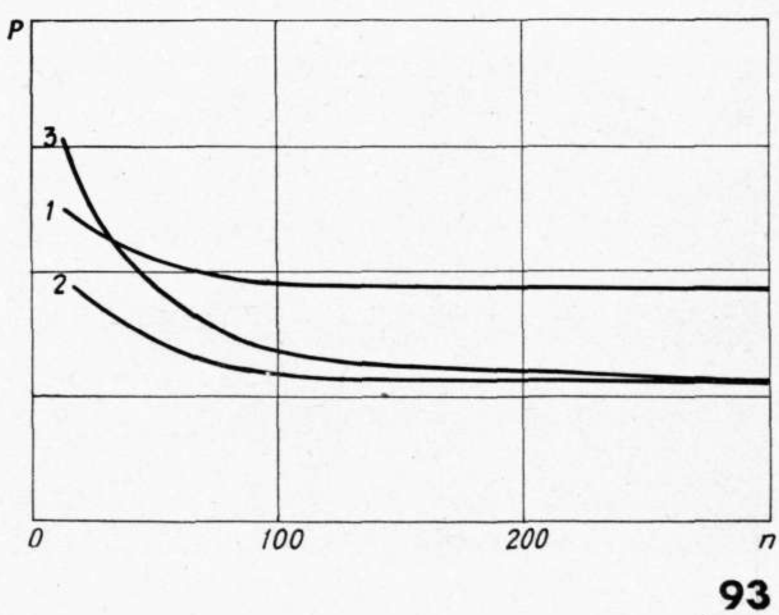


Fig. 7 X 5316

Cost for different kinds of carrier systems as function of the number of circuits *n* at constant mean distance $l = 100$ km

1 single-channel system on loaded cables
2 twelve-channel system on unloaded cables
3 wide-band system

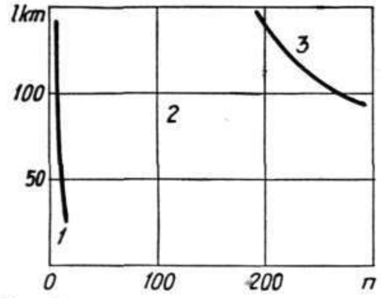


Fig. 8 X 3647

Limit of cost for *n* circuits in cross-section and mean distance *l* per circuit

1 single-channel system on loaded cables
2 twelve-channel system on unloaded cables
3 wide-band system

similar; it is chiefly the number of high-grade channels that counts, the mean length being of less importance.

When trying to fix the economic limits for the different systems a difficulty will be encountered, *i.e.*, the technical details — especially for the wide-band systems — are not yet sufficiently known to allow a satisfactory comparison of the costs. The curves of Fig. 7, relating to a short mean distance, 100 km, can therefore only be regarded as approximate. However, the tendency displayed in Fig. 8 is obvious. Systems of the first kind, *i.e.*, systems operated over loaded circuits, are advantageous only when the number of channels is very small, less than 10—20, while wide-band systems are advantageous only if the number of channels is greater than 200—300; carrier systems for unloaded multi-pair cables are suitable for the remaining range. Thus it seems as if carrier systems for *loaded cables* would be chiefly of importance as a transitory form and for providing a few high-grade channels in mixed cables mainly serving short distance traffic.

Whether in the future multi-pair cables or wide-band cables will predominate for traffic on distances greater than 100 km is, however, difficult to judge. It is possible that the wide-band cables may win in the long run owing to their suitability for television transmission and perhaps also because of greater possibilities of reductions in cost thanks to technical progress. On the other hand the technics of multi-pair carrier cables is more closely related to present practice and corresponds better to the volume of traffic to be met with to-day and in the near future.

Centralised Traffic Regulation in Large Towns

C. JENSEN, DANSK SIGNAL INDUSTRI A/S, AND N. FORCHHAMMER, L.M. ERICSSON A/S, COPENHAGEN

Dansk Signal Industri A/S has designed for the Borough of Frederiksberg, a densely populated section of Greater Copenhagen, a system for centralised synchronous traffic regulation of the main thoroughfares of the borough. The system, which was installed at the same time as a fire and police alarm plant on the Ericsson system, described in the Ericsson Review No 3, 1934, has now been in operation for two years and has given entire satisfaction, both to the police and to the public.

Application

A continually increasing number of large towns are adopting light signals for traffic regulation at busy street crossings. In most cases three colours are used, green for »go», red for »stop», and yellow for »clear the crossing» as intermediate signal between the main signals.

While in most places these installations have been adopted as auxiliaries for the traffic policeman at the street crossing, at other places a further step forward has been made by the introduction of installations with automatic operation. In such case there is no need for a constable to be stationed at the street, or where there is one he can devote his whole attention to the traffic on the streets and take action in special circumstances, while the regular change of the colours goes on automatically.

This system, however, has a rather serious drawback when crossings along a main thoroughfare are equipped with automatic installations. It often happens that a whole line of cars given free passage at one crossing meets with a red light at the next crossing. The system of Dansk Signal Industri described below goes the whole way, all signals along a main thoroughfare or in a selected section of the town are subject to a common central control. This is also fully automatic in operation and the individual signals are arranged in relation to each other on the basis of a plan for speed of

Fig. 1 X 5310
Street crossing with four-sided traffic signals (to left and in centre) and control box (to right)

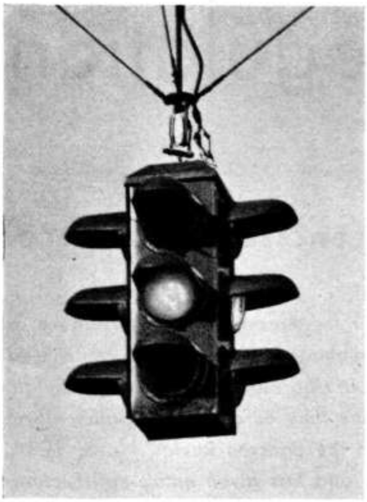


Fig. 2 X 3633
Traffic signal for suspension at street crossing

Fig. 3 X 3634
Control box for traffic regulation
in upper part of box are fitted police telephone and fire and police alarm

traffic, *e.g.*, on the basis of a speed of 30 or 40 km/h for motor vehicles and about 15 km/h for tramcars, cycles and horsed vehicles. With this system drivers soon learn to accommodate their speeds to the arrangements of the signals, so that traffic in the regulated thoroughfares proceeds in regular waves.

Main Principles

A centralised installation of the type referred to must be flexible. It must be possible to vary the setting according to the experience gained with operation of the installation. It must take into account the various kinds of traffic in the different streets, and the variations in traffic at different times of the day or in different weathers. The following definite requirements may be stated:

1. when the remote control of a group of signals is in operation, all the signals in the group shall follow one another at a *synchronous* rate, fixed by the remote control;
2. whenever the remote control is switched off or fails then the individual signals must continue to change automatically at a regular *individual* rate;
3. there must be manual operation of each signal from an operating box at the street crossing by means of a special lever, so that a traffic constable can operate the signal, no matter whether the signal at the moment is working at synchronous or individual rate;
4. when the remote control resumes operation after a stoppage and also after manual operation, the signals shall in the space of a few cycles resume their synchronous rate;
5. alteration of the cycle of remote control should be possible by means of a simple device in the installation central, without affecting operation;
6. the individual speed of the signals, and the relation between the intervals fixed for »red», »green» and »yellow» must be variable in simple control boxes, so that each individual signal may be set to suit special conditions at the crossing concerned.

Traffic Signals

Centralised regulation on the lines laid down above has been carried out in Frederiksberg Borough for 22 street crossings in all. At each crossing a traffic signal, Fig. 2, is suspended immediately above the crossing; in special instances more than one signal may be used, possibly two- or three-sided, as shown in Fig. 1. These signals may also be supplemented or entirely replaced by stand signals. These last are easier to see from close to, while the suspended type have the advantage that they can be seen from a great distance. The traffic signal is made of aluminium throughout without using a heavy system of lens, and in this way the weight of the four-sided signal is brought down to about 40 kg. As regards the luminous output, by special shaping of the reflectors and the placing of the lamps there has been attained the very clearest signal light, which thus in unfavourable conditions is plainly to be seen both from a distance and near to. The height of the signal exclusive of suspension is 1 090 mm, width including shades 890 mm and the diameter of the light opening is 200 mm.

Regulating Machine

At each crossing a control box, Fig. 3, is set up, from which the traffic signals are controlled. In addition to the traffic-regulating machine there is room for a telephone, and the necessary switches and fuses, as well as fire and police communicating devices, are built in. Above the box there is fitted a cylindrical lens which repeats the yellow light shown on the traffic signal. This serves to notify vehicles which have come to a standstill too near to the crossing for the driver to see the change of lights on the signal. The mechanism itself takes up so little space that it can easily be fitted in existing boxes for fire and police alarm or in telephone-boxes; Fig. 4 shows

Fig. 4 X 3253
Combined alarm box and telephone cabin
incorporating traffic-regulating machine

a combined alarm box and telephone box in Frederiksberg, in which the traffic regulating machine is fitted below the fire and police communicating devices.
The traffic regulating machine, Fig. 5, is distinguished by precision of running and reliability of remote control, combined with great possibilities of adjustment and small bulk. The measurements of the device with remote-control relays and including case are: height 500 mm, width 230 mm, depth 240 mm. The main features of the machine are the contact mechanism, seen uppermost on the figure, the operating devices with motor fitted behind the contact mechanism and separated from it, and the operating relays which are seen below on the figure.

The contact mechanism which lights and extinguishes the separate lamp groups, is driven by a set of toothed discs. By the rotation of these discs in relation to each other it is possible to vary at will the relation between the times the various lamps light up. The connection of the contacts is such that on each change of colour two lamp groups burn in series for an instant. This special connection saves the contacts as they never have to break the full intensity of the lighting current; moreover the life of the lamps is considerably prolonged by this gradual change-over, as it attenuates the shock on connecting the current. In the Frederiksberg installation the change of colour is done in this way in a fraction of a second; the contact mechanism can also be adapted to systems which require the yellow light to burn for a short while along with the main colours to indicate transition.

The motor drives a shaft carrying the control discs, over a friction clutch and gear and gearwheels. The speed of the motor may be adjusted by a regulator, so that the intervals between signals, *i.e.*, the time for a complete cycle green-yellow-red-yellow, may be varied from about 40 to 60 s. There is a lever which is normally locked up in the operating box; by attaching it to the shaft the traffic constable can operate the signal manually by pulling it sharply to a certain position or retaining it. During manual operation the motor continues to run, as the friction clutch slips.

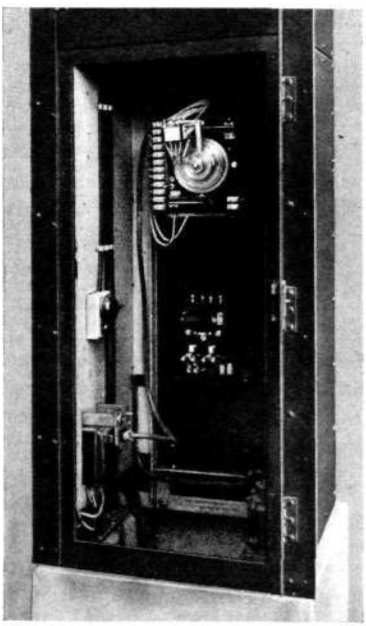


Fig. 5 X 3635
Traffic-regulating machine
mounted in box; above machine with contact mechanism, below relays for central control, to left switch for immediate replacement of machine

Remote Control

The remote control for a complete group of signals works over two wires, *e.g.*, a pair in a telephone cable. By means of the control-impulse sender described below, these wires receive tension, the polarity of which is shifted once in every half cycle. In each machine there are two relays, R_1 and R_2, connected to the remote-control circuits. The relay coils are connected in series and shunted by rectifiers connected in opposite direction, see the diagram Fig. 6; the relays therefore attract alternatively for positive and negative polarity. The motor of the machine is set for an individual cycle which is somewhat shorter than the shortest synchronous cycle desired.

The remote control functions in such a way that the motor in each of the main thoroughfares is stopped as long as remote control is maintained; this is done by means of contacts on the two relays and by two synchronising contacts driven by a disc. When it is required to cut off remote control, the control impulses are interrupted, with the result that both relays fall, whereupon the motor runs freely at its individual speed. Fig. 6 shows in simplified form the working of the remote control. The only thing that occurs on alteration of the distance control cycle (longer or shorter positive and negative impulses) is that the cutting off of the motor is somewhat lengthened or shortened; regulation is thus exceptionally simple and reliable.

After a period of manual operation the motor continues running at its higher speed and in subsequent cycles it is not stopped by control impulses until it has reverted to its normal speed. It may happen that manual intervention has lasted so long that the contact mechanism leads the control

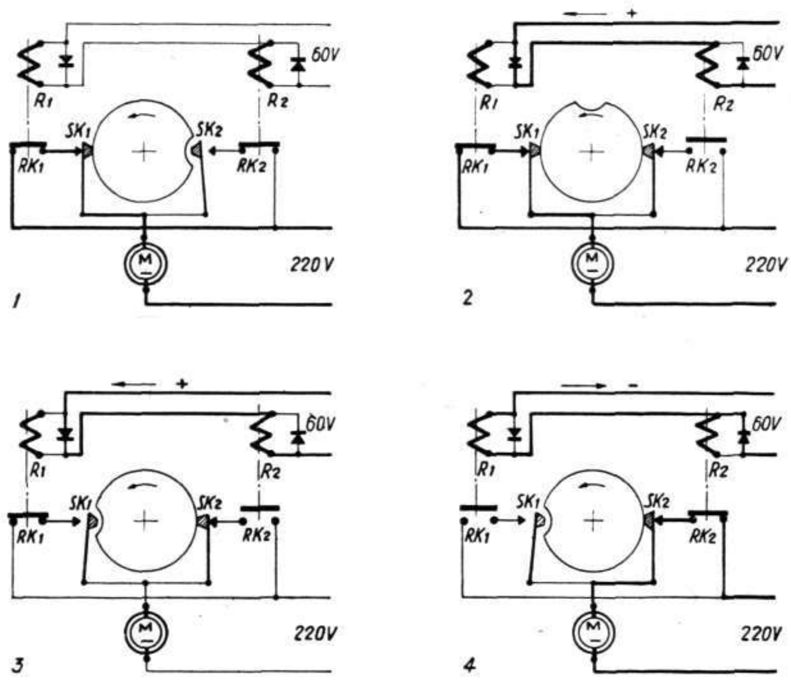


Fig. 6 X 3311

Working of traffic-regulating machine
with and without remote control

1 working at individual rate without remote-control impulses; the motor can always obtain current either over contacts *RK1* and *SK1* or over *RK2* and *SK2*
2 a remote-control positive impulse is sent out; motor *M* continues to run, but contact *RK2* is broken
3 motor *M* has run through a half cycle, while a half remote-control cycle is not completed; the motor stops therefore the instant contact *SK1* is broken
4 after half a remote-control cycle the polarity shifts, relay *R2* falls, while relay *R1* attracts; the machine again receives current over contact *RK2*, and runs until the same process is repeated at the next half cycle

impulses; in such case the colour change stops at the first main colour and the signal is soon running at the same speed as the others.

As may be seen from Fig. 6, the machine can also without further adjustment be used for automatic regulation without central control, simply by omitting the two relays. From Fig. 5 it may be observed that in such case the machine takes up still less space, and can be mounted on a pole or the like, in a watertight case measuring 500×280×250 mm. This simplified form is used in installations where the signals are controlled by street contacts or the like. In special circumstances where purely manual operation suffices, an operating device of the utmost simplicity can be employed.

Control-Impulse Sender

From the above it will be seen that it is possible over a single pair to control from a distance any desired number of signals by means of alternating plus and minus impulses. These impulses are sent out by a special impulse sender. It consists of an accurate contact mechanism, which may be regulated for cycles of from about 40 to 70 s. The impulse current may be taken from a 48 or 60 V accumulator.

It is often advisable to divide up the signals of a large installation into smaller groups. These groups may be distributed, according to circumstances, over several control-impulse senders, so that they may work with different synchronous districts, while single groups may in such case be disconnected from the remote control and left to their own individual automatic regulation.

All switches and regulators are combined on a common operating board, Fig. 7, set up at the central for the installation. The groups may be distributed as desired over the control impulse senders by means of switches. Each control impulse sender has its own switch; besides the »off» and »on» position these have a third position, »reserve», by means of which a common reserve sender may be connected up in case of need. On the board there are in addition regulating dials for the impulse senders, voltmeter, supervisory lamps and fuses.

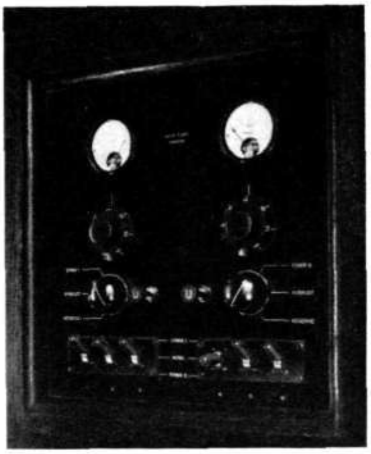


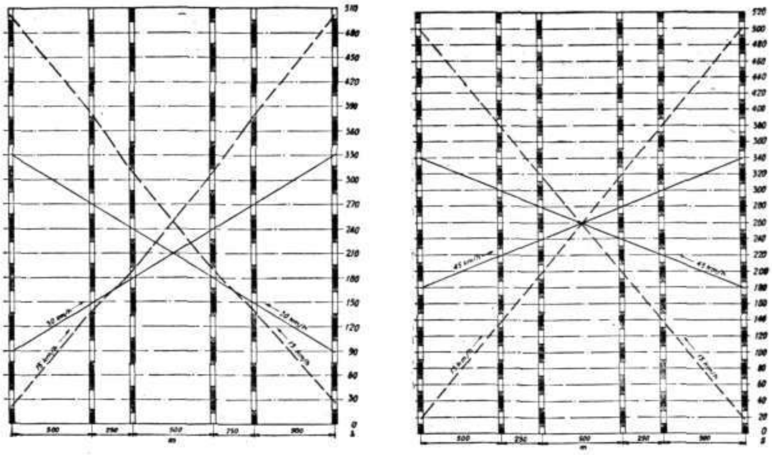
Fig. 7 X 3636

Operating board for remote-control
above voltmeter, middle regulating dials and switches for control-impulse sender, below switch for distributing 6 signal groups over two impulse senders

Fig. 8 X 3637 X 3638

Traffic plan of main street with side streets at regular intervals

left, with 60 s cycle for heavy traffic (corresponding to 30 km/h for motor vehicles and 15 km/h for trams, bicycles and horsed vehicles), right, with 40 s cycle for lighter traffic (corresponding to 45 km/h for motor vehicles and 15 km/h for trams, bicycles and horsed vehicles)



Each impulse sender is provided with an emergency stop which automatically disconnects the remote control should the alternation of the control impulses for one reason or another — fault in instruments or in operation — become 10 or 15 s delayed. Following such disconnection the signals of the group concerned continue to change colour at their individual speed, and the transition time is so short, that the fault is scarcely apparent to drivers.

Traffic Diagram

The basis for planning a traffic regulation installation consists of a number of statistical data derived from traffic census and random checks. On this basis it is decided which main thoroughfares and which street crossings shall be subjected to regulation. The choice of cycles for light signal changes is within certain limits linked up with the average speed it is calculated on maintaining; the regulation possibilities of the apparatus ensure that these figures may be modified later to conform with actual experience.

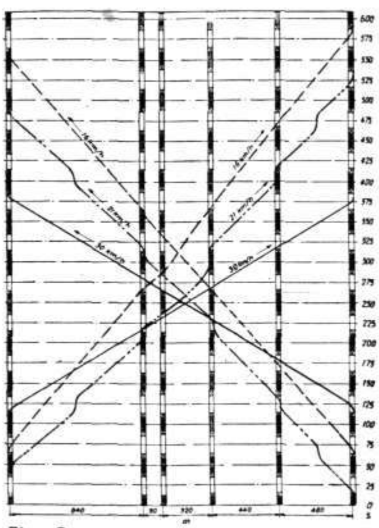


Fig. 9 X 3639

Traffic plan of main street with side streets at irregular intervals

50 s cycle (corresponding to 30 km/h for motor vehicles and 16 km/h for bicycles and horsed vehicles, trams being reckoned separately at 21 km/h with normal waits at stops)

When considering the details it is an advantage to make use of a kind of speed plan of traffic, drawn up in much the same way as those commonly employed on railways but naturally of a more diagrammatic nature. At the left of Fig. 8 will be seen such a speed plan for a main street with six crossings at 250 or 500 m intervals. For each crossing the colour changing of the signal is shown by black for red light for main street, black and white for yellow light and white for green light indicating that traffic can proceed along the main street. To give traffic in the main street a precedence over the side streets, the »go» period for the main street is set at 28 s, »stop» period at 24 s, and yellow at 2×4 s, the total cycle being 60 s. The continuous transverse lines on the plan indicate the higher speed (30 km/h) corresponding to motor traffic, the broken lines being the »secondary» speed (14.5—15.5 km/h) representing tram and bicycle traffic. At times when traffic is less the cycle of lights may be changed to 40 s, see right-hand side of Fig. 8. The higher speed is then raised to 45 km/h (motor traffic), while the other traffic now runs on a »tertiary» speed line, still showing about 15 km/h. Fig. 9 shows the conditions existing with less regular distances between cross streets; it can be seen that in such circumstances also it is possible to adapt the system to the requirements of traffic.

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Frequency-Control Equipments

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

Frequency control has in recent years become indispensable to power stations for many reasons, including the increased employment of synchronous motors for clocks and other instruments, making it a necessity for the power supplier to deliver current with a constant mean frequency. It is, moreover, a remarkably good accessory for frequency signalling between one power station and another. The system of frequency control worked out by Telefonaktiebolaget L.M. Ericsson contains a number of technical novelties and is already extensively used by power stations in several countries.

For a network to be known as frequency controlled the power station must run its generators so that the difference between the official standard time and »synchronous time», *i.e.*, the time indicated by a clock connected to the network, does not exceed a certain figure inferior to, *e.g.*, 30 s. This does not mean that the frequency at all moments remains constant, which is impossible as the load is varying all the time, but only that the mean value, *e.g.*, over 24 hours, is constant. Frequency control installations, therefore, consist in principle of a synchronous clock, driven from the AC network, a precision clock which gives as accurately as possible the official standard time, and a difference clock in which the times indicated by the other two clocks are compared. The power station must then keep the difference in indicated times within the limits stipulated.

The simplest method of keeping the mean frequency correct is to regulate it manually with the aid of the frequency control equipment. Automatic regulation is also conceivable but has not up to now been used. At the stations where the control is exercised there is always experienced staff available and in addition the manual regulation is more flexible if it is done with care; moreover it allows of greater facilities for employing frequency control for signal purposes.

The Ericsson frequency control installations are intended for use with manual regulation. In addition to the precision clock, the synchronous clock and the difference clock, the system includes also a time-correction device for the precision clock. However accurate this precision clock may be, yet it requires

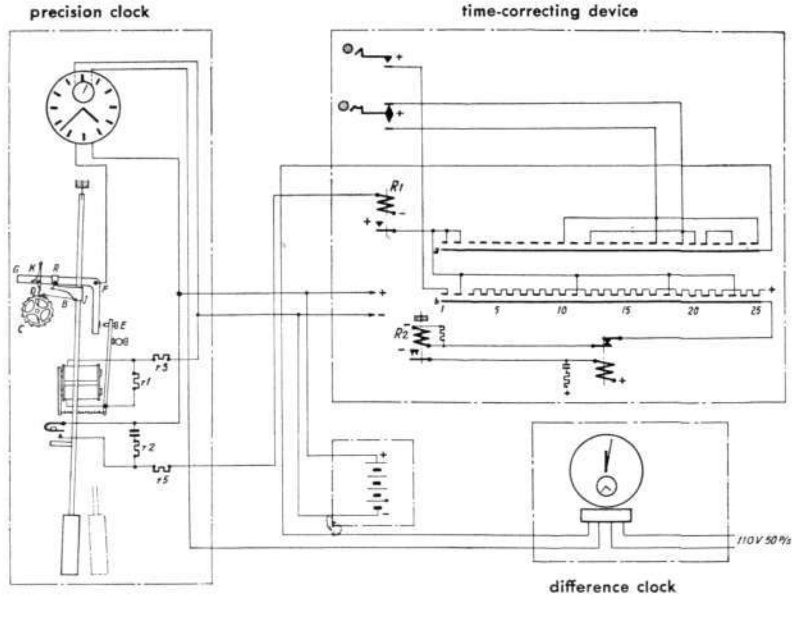

Fig. 1 X 5317
Diagram for frequency-control installation

to be adjusted from time to time to agree exactly with the official standard time, this being usually done by checking it with the wireless time signals. The time correcting device then corrects the time indicated in the whole system.

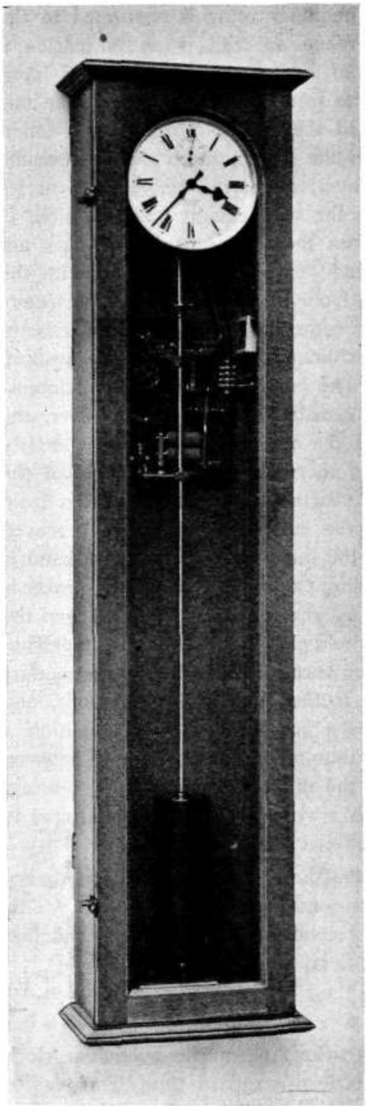

Fig. 2
Precision clock

X 3649

Precision Clock

The precision clock consists of a pendulum clock, the pendulum having 1 s oscillation time. The pendulum rod is made of a special alloy with extremely low coefficient of dilatation, thus ensuring great accuracy in the clock's running. The pendulum is of the free swinging type, *i.e.*, the influence on it due to the moving parts which affect or are affected by the pendulum is reduced to a minimum. The clock has two contact devices, one for emitting impulses each half minute and one for emitting each second. The former is built in with the mechanism which provides the energy necessary for the pendulum's movement. On the pendulum rod, see Fig. 1, a device *J* is attached. On this rests a hook of piano-wire, faced with agate at the bent end, which as the pendulum moves engages with the teeth of a count-wheel *C* and turns this $^1/_{15}$ of a revolution each time the pendulum swings to the right. Wheel *C* is provided with vane *D* which once in each revolution acts on the releasing catch *K* for the gravity-lever *G* pivoting at the point *F*. Thus each half minute this gravity-lever is released and, the lefthand part of the lever being heavier than the right, it falls down, *i.e.*, counter-clockwise. With this the roll *R* fixed to the gravity-lever glides against the level part of *J*, and in this way through its weight provides the necessary supplement to the movement energy of the pendulum. When the pendulum swings to the right, the gravity-lever *G* is unloaded by making contact with the screw *E*. At the same a current for the electro-magnet *A* is closed, whereupon this attracts its armature and returns gravity-lever *G* to rest. At the same time a half minute impulse is sent out, which we shall deal with later in connection with the diagram for the whole installation. The contact emitting the second impulses consists of a spring group enclosed in a glass tube. The spring group is provided with a small iron armature. When the pendulum passes middle position, the spring group is influenced by a magnet attached to the pendulum rod, so that the contact is closed during about 100 ms.

The precision clock is built in to a case of oak and is designed for mounting on a wall, see Fig. 2. In the upper part of the case a secondary clock is fitted, the second hand of which is driven by second impulses and the minute hand by half-minute impulses from the precision clock. The hour hand's movement is governed by the minute hand in the usual way.

Difference Clock

The difference clock contains a synchronous clock consisting of a synchronous motor of normal Ericsson design. The difference clock directly indicates the difference between synchronous time and official standard time. The difference clock, Fig. 3, is designed for mounting on an instrument panel and has a dial 300 mm in diameter. The difference hand, *i.e.*, the hand showing direct the variation between official standard time and synchronous time, is pivoted at the centre of the clock and concentric with this is another which is connected to the difference hand over an ordinary hour gear and thus makes $^1/_{12}$ revolution for each revolution of the difference hand.

On Fig. 4, showing the rear of the clock, may be seen in the middle the difference mechanism, where the variation between the synchronous time and the official standard time is marked by electrical means. This device, illustrated in Fig. 5, consists in the main of a coil *B* of the same size and shape as the stator winding on an ordinary synchronous motor. The coil is encircled by a ring *A* of soft iron which is clamped between two shields *S* of the same material. In each of these shields one of two shafts are borne, centered in line with the centre of the coil; each shaft holds a two-pole rotor *R*. One rotor is somewhat larger in diameter than the other and projects over it. The outer rotor is driven by a toothed gear in the synchronous motor and the gear is so selected that the rotor makes half a revolution per

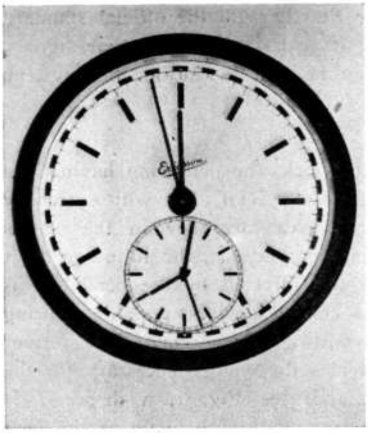

Fig. 3 X 3650
Difference clock

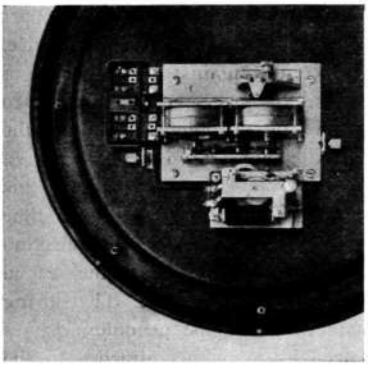

Fig. 4 X 3651
Mechanism of difference clock
left to right, terminals, synchronous motor and difference mechanism; below, second-impulse mechanism

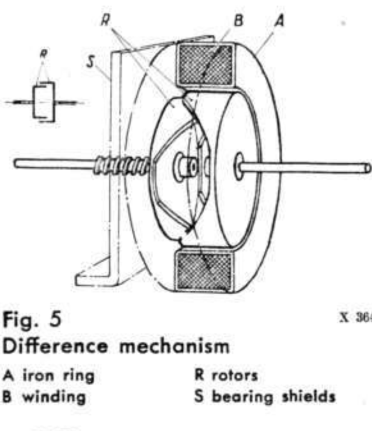

Fig. 5 X 3648
Difference mechanism
A iron ring **R rotors**
B winding **S bearing shields**

second with exactly 50 c/s in the AC. The inner rotor is connected to the difference hand through a helical gear. When the coil is under tension a magnetic field is formed in the direction of its centre line. The field lines, however, inside the coil tend to follow the iron and thus go from the one shield to the other through the shafts and the rotors. Through the action of the magnetic field thus set up between the rotors, these seek to become parallel to each other. The outer rotor which rotates the whole time carries the inner rotor with it in its movement if the coil remains under tension. If the coil is receiving short current impulses then the inner rotor does not follow the rotating movement, but only tends to put itself parallel with the other at each impulse. The impulses come from the pendulum clock at intervals of 1 s; during this time the outer rotor, at a frequency of exactly 50 c/s, rotates half a revolution, and thus at each impulse takes up the same position magnetically in relation to the inner rotor. The inner rotor therefore maintains its position and the difference hand will remain still. Should, however, the frequency be below the proper figure then the outer rotor does not complete a half revolution in a second, and instead there remains, on arrival of the current impulse, a certain angle which is proportional to the deviation from frequency. At the emission of the impulse the inner rotor therefore is moved this angle backwards, at the conclusion of the impulse. The difference hand is thereupon turned backwards to a corresponding extent. If the frequency exceeds 50 c/s, the outer rotor rotates more than $^1/_2$ revolution in a second, and the inner rotor then moves forward correspondingly. If the coil is receiving continuous second impulses, the inner rotor turns in an angle corresponding to the deviation from normal frequency. It thus totals the deviations, and the difference hand which is geared to the rotor gives by its position a direct indication of the total deviation and thus of the total difference between synchronous time and standard time. On the difference clock it is therefore possible by direct reading to see how much a synchronous clock connected to the network is fast or slow in relation to official standard time.

On the lower part of the difference clock dial there is in addition an ordinary clock dial with hands, driven from a second-impulse mechanism. This impulse mechanism in its turn is driven by second impulses from the pendulum clock and the hands therefore show the official standard time.

Time-Correcting Device

The time-correcting device is used for occasions when the pendulum clock becomes fast or slow in relation to the official standard time. This device then corrects the standard-time indications in the whole system. Because of the design of the difference clock this cannot be done by simply excluding or adding a second-impulse, but such a correction in the system must be extended over several seconds. The time correcting device is therefore so designed that an impulse is added or taken away in 4 s.

The apparatus, Fig. 6, consists of a selector and two relays, with a press-button starting switch and a switch for positive and negative correction. The parts of the apparatus are built together in a sheet-metal case. The process of operation is as follows: assuming that the pendulum clock is going somewhat too slow in relation to official standard time and that 1 s difference between the time shown by the precision clock and standard time has arisen. In order to correct this difference, the switch is pushed up to positive position and the device is set in motion by pressing the starting button. This prepares for a speeding up of the impulses; when the next impulse comes in from the pendulum clock, the time-correcting device comes automatically into operation, and from then sends out impulses at 0.8 s intervals. Thus after 4 s five impulses have gone out into the system and the difference clock has been put back one second. Should the pendulum clock on the other hand be fast then after some time correction takes place in the opposite sense. In that case the switch is pushed down to minus position and the starting button pressed. In the same way as before impulses are now sent out, but only three in 4 s. This is done by one impulse being lengthened so that it and the next impulse merge in one long impulse lasting 1 s. As regards the

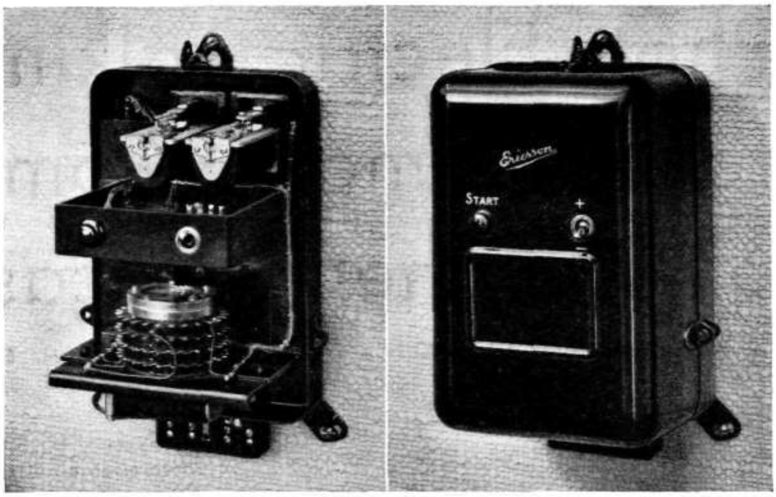

Fig. 6
Time-correcting device

x 5318

difference clock this means that the inner rotor accompanies the outer for half a revolution and draws the difference pointer one second to the negative side.

Diagram for the Installation

Fig. 1 shows a principle diagram for the installation. It contains two current circuits, one for half-minute impulses and one for second impulses. The half-minute impulses are obtained in conjunction with the current supply to the pendulum through gravity lever G on its contact with screw E closing a circuit. In this circuit is connected the impulse mechanism of the pendulum for half-minute impulses and in addition secondary clocks with mechanism for half-minute impulses may be connected. Second impulses come from the pendulum clock's second-contact. These impulses drive this clock's second-impulse mechanism direct and the relay R_1 in the time-correcting device. This relay repeats the impulses and sends them out over the selector's contact system to the clock. When the system is adjusting itself the selector functions and sends out impulses as described above.

A contact device may be embodied in the difference clock, to connect a signal circuit at certain figures of difference between synchronous time and official standard time. This saves the operating staff from constantly watching the difference clock, and leaves them more free to attend to other duties.

A number of difference clocks may be connected to one installation. It is often desired to have in various parts of the power station information regarding the deviation in time of a synchronous clock connected to the network, and the officials may have difference clocks in their rooms so that they can supervise the working staff.
A suitable power supply for the installation is a 24 V Nife accumulator with 20 Ah capacity. Preferably it is charged continuously from the AC mains over a dry rectifier, Type RH 30 152, with 0.25 Ah rated output.

Operating Results

The Ericsson frequency-control system differs from former systems in the special difference indicating device. In difference clocks driven by planet gear the difference pointer is driven continuously forward by the synchronous motor, to be abruptly jerked back when the impulse comes. This gives the design a very limited life. In the Ericsson system, on the other hand, the movement each second of the difference pointer is insignificant, occurring only when deviation in frequency arises; in this way wear is minimised and more accurate reading is possible. The pendulum clock has certain exceptionally good working features. Its running accuracy in most cases has kept within ± 1 s/month, which must be regarded as exceedingly satisfactory.

Photo-Electric Talking Machine for Automatic Communication of Weather Forecasts

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

In Ericsson Review No 2, 1934, a description was given of the first models of the Ericsson photo-electric talking machines, viz., the time-giving machine and the talking machine for 1 s and 20 s communications. Ericsson now has developed a new talking machine specially designed for giving weather forecasts to telephone subscribers. In this way Ericsson has furnished telephone administrations with a fresh means of popularising the telephone.

It is common knowledge that, when other topics of conversation are lacking, people talk about the weather, and mankind in general is exceedingly dependent on weather conditions as well as on the time. Because of this, time signals and weather reports were included in wireless broadcasting at an early stage. These items of the programmes must, however, of necessity be confined to certain times of the day, when perhaps the listener does not require them or has not the opportunity to listen in to them, so that they do not entirely fill the want. The public gets better service if it has the facility of receiving the desired information at any time of the day. Such a facility is available when telephone exchanges are equipped with apparatus for sending out time signals and weather forecasts. Experience with such apparatus installed up to now has shown that, despite regular broadcast by wireless, the numbers of calls to these apparatus are exceedingly high. Thus the number of calls to the time-signalling machine in Stockholm amounts in round figures to 18 000 each weekday for about 125 000 subscribers. The figure for Warsaw is about 30 000 for 55 000 subscribers, for Bergen 10 000 for 8 000 subscribers, for Stavanger 2 000 for 6 000 subscribers, etc.

In 1935, these circumstances gave Ericsson the idea of designing a talking machine for sending out weather forecasts from telephone exchanges. A preliminary proposal submitted to meteorologists and telephone administrations was very well received, and suitable text was drawn up and recorded in collaboration with meteorological institutions. The first talking machine for weather forecasts was put into service in Stockholm on June 1, 1936, being the first of its kind in the whole world. A second machine was put into operation at Stavanger in Norway on August 22 of the same year and a third will be available at Oslo during the autumn of 1936. The number of calls to the Stockholm machine in the period July—August has varied between 15 000 and 2 000 per day, leaving out of account the rush of calls due to curiosity at the beginning, which reached a maximum of 23 000 per day. The number of calls depends not only on the day of the week but also, and to a considerable extent, on the weather prevailing. Thus on a fine day in mid-week the traffic is comparatively small, while rain on Saturday will give rise to a remarkably large number of calls.

The talking machine, shown in simplified form in Fig. 1, consists of six talking film discs *F1—F6* with the necessary operating mechanism, as shown in more detail for disc *F4*. The film disc *F4* is supported and protected on either side by flat circular glass plates *2* and *3*. At one side of the film disc

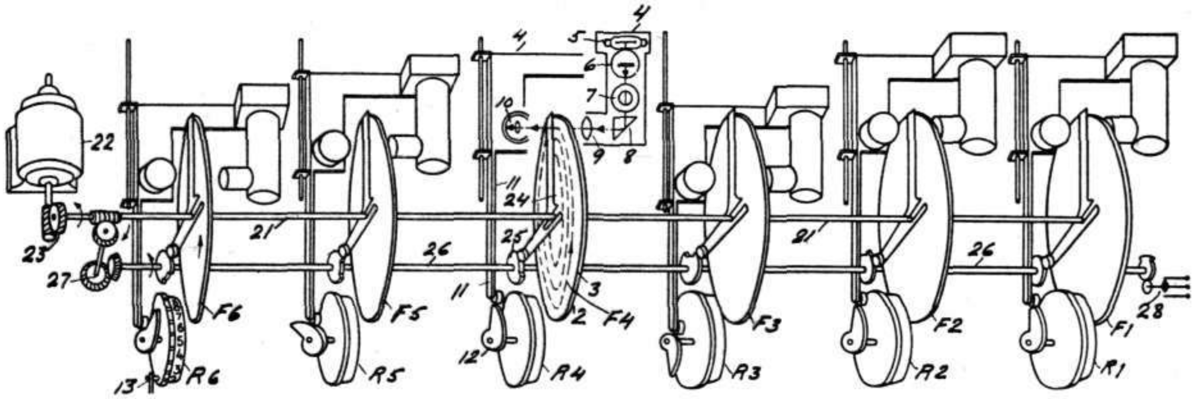

Fig. 1 X 7098
Diagram of talking machine for weather forecasts

is the projector *4* consisting of a lamp *5* with straight filament, a screen *6* with a narrow oblong slit, a screen *7* with a circular opening, a prism *8* which diverts the light rays from the lamp at right angles, and a lens *9* which refracts them. The distance of the projector from the disc is fixed so that a sharp image of slit *6* appears on the film. The purpose of the screen *7* is to prevent rays reflected on the inner side of the valve from falling on the lens and giving rise to disturbing spots of light on the film. On the other side of the film there is a photo-cell *10*, on the sensitive layer of which the light from the projector falls after passing through the film.

On the flat film discs the various text or items to be communicated are recorded in concentric tracks, one within the other. Each item of text has thus the form of a dark broken track on the disc. Each disc can take up to 20 tracks, the innermost of which should preferably be left clear. When a film disc rotates the light passing through the disc varies in intensity on account of the variation in blackness of the sound track, the photo-cell being thus subjected to varying strength of light. The current passing through the photo-cell is thus varied in strength and the variations are amplified in a four-valve resistance-coupled amplifier, receiving the necessary amplitude to be heard in the subscriber's receiver.

The projector *4* is mounted on a freely moving slide, see Fig. 2. A spring tends to push the slide towards the centre of the disc but is prevented by a cam *12*, on which runs a wheel fixed to a freely moving arm attached to the slide, see Fig. 3. The cam is adjustable and is set by a dial *R* having 20 divisions. By means of the dial the projector can be directed against the middle of any desired sound track on the film, see Fig. 5.

All the discs are mounted on the one shaft *21*, driven by motor *22* through the spiral gear *23*. All the photo-cells belonging to the discs are parallel connected. For each disc there is a screen *24* which normally shuts off the light rays from photo-cell *10*. The screens are operated by cam *25* on shaft *26* driven from the motor over a transmission gear. The cams are fixed to shaft *26* in such a way that on rotation of the shaft the screens belonging to the different film discs drop one after the other out of the path of the respective light rays for an interval of time corresponding to one revolution of the disc. In this way the different film discs are caused to speak one after the other in a fixed order.

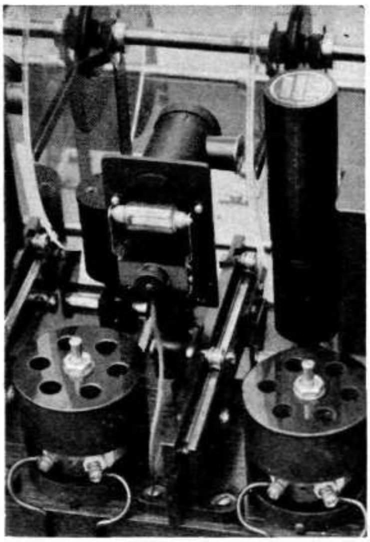

Fig. 2 X 3626
Details of reproducing device
left, slide with projector, right, photo-cell, therebetween, film record; in foreground, regulating resistance for projector lamp

The film discs contain records of various kinds of communications respecting weather prospects. Thus disc *F1* may have various indications of the period to which the forecast applies, disc *F2* may have text relating to wind strength and disc *F3* might give the direction of the wind; disc *F4* might state the cloud conditions, disc *F5* the rain prospects and *F6* the temperature. Naturally, the discs could be arranged to give communications in other ways. If now the dials *R1*—*R6* are all set for the communications corresponding to the probable weather conditions, then the machine will give out at intervals of

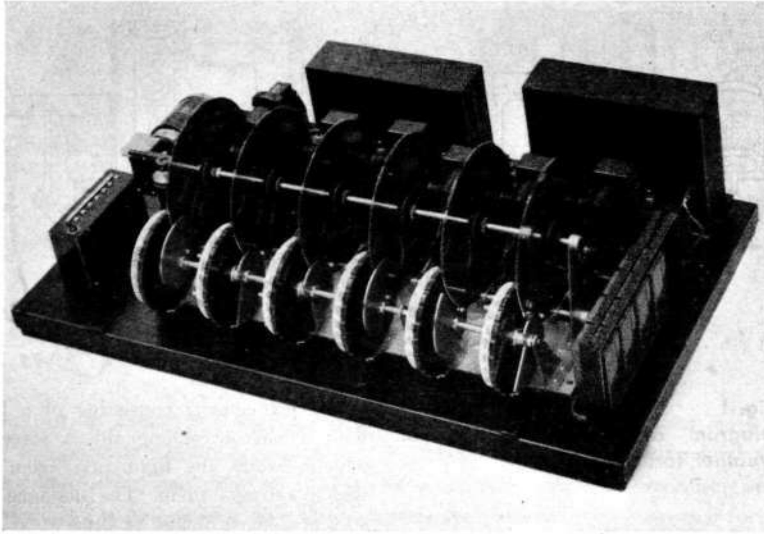

Fig. 3 X 5306
Front view of talking machine for weather forecasts
left, alarm lamps, main switch and driving motor; foreground, dials for setting the projectors, middle, shaft bearing six film records; background, amplifier and filter, right, alarm relays

12 s a complete forecast, *e.g.*, »*Sunday; moderately increasing; northerly wind; cloudy; mostly fine; colder.*» For the following day the prospects may have changed, so that instead of »*cloudy*» the information »*becoming clearer*» would be more applicable. In that case »*mostly fine*» would be unnecessary and disc $F5$ would be set for the twentieth track on which nothing is recorded. Then suppose that wind and temperature have changed. The weather forecast would then read, *e.g.*, »*Monday; fresh to strong; northerly wind; becoming clearer; — — —; rather colder.*» The last item in that case would be preceded by a pause which however would in no way cause misunderstanding of the forecast given.

As the projector lamps, the photo-cells and the films display optical differences each projector lamp has been provided with a regulating resistance, by means of which the sound volume in the discs can be regulated to be alike internally. In addition, for regulation of the whole sound volume there is a potentiometer built in the amplifier. The amplifier has a maximum output of 50 mW with a harmonic content of 5 %. The output impedance is only 4 ohm, allowing for the connection of up to 150 subscribers. No change in sound volume is noticeable on the connection or disconnection of a subscriber. In view of the low output impedance the attenuation between two subscribers connected to the talking machine is about 5 neper, which prevents conversation

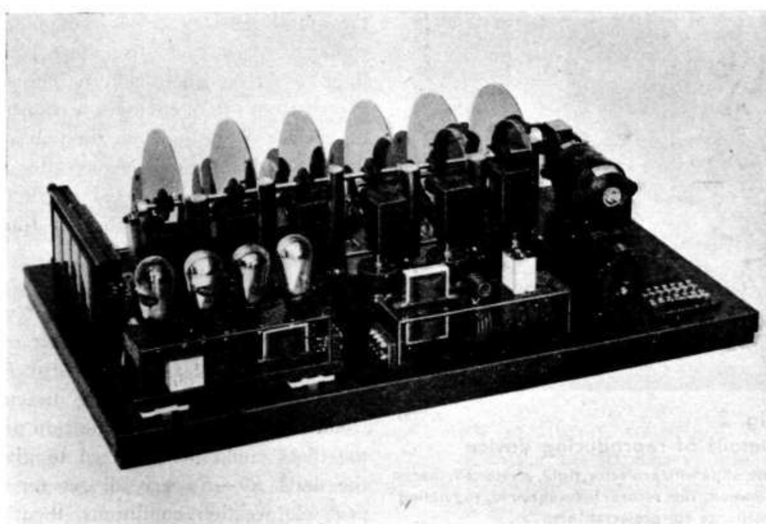

Fig. 4 X 5304
Back view of talking machine for weather forecasts
foreground, amplifier and filter; middle, projectors and photo-cells; background, film records

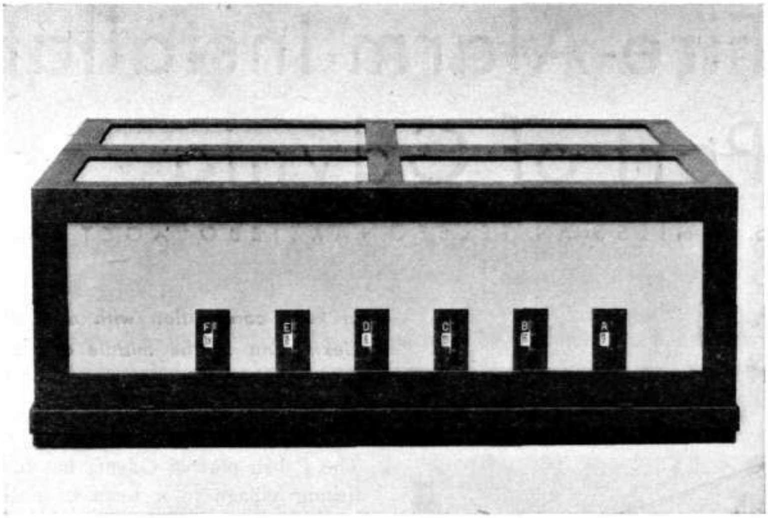

Fig. 5 X 5307
Talking machine for weather forecasts
with cover

between the two subscribers while the machine is talking. To prevent conversation during pauses the speaking circuit should be short-circuited and this can be done by means of a relay controlled by the spring-group *28*, see Fig. 1. The relay is not located in the talking machine, but at that point in the telephone exchange where the speaking circuits run together, which ensures that the short-circuiting shall be as effective as possible. The spring group *28* may also be used for controlling the operating relays, *e.g.*, in cases where the number of times the subscribers are allowed to listen to the weather forecasts is limited.

The operating tension of the talking machine is 24 V. The anode current to the amplifier valves is taken from the driving motor which is in the form of a single armature converter. The speed of rotation of the film discs is 45 r/m. The speed of the motor is regulated by a variable resistance in the exciter circuit. The spiral gear *23*, see Fig. 1, is enclosed in a gear-box which forms part of the motor. Both commutators of the motor are easily accessible from above for inspection and cleaning. To facilitate locating of faults the machine is provided with a number of alarm relays with necessary signal lamps which indicate interruptions in any of the projector lamps or in the anode current circuit. Immediately alarm is given transmission is automatically cut off by a relay in the machine.

Fire-Alarm Installation for the Port of Gdynia

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

In keen competition with a number of other firms, Ericsson Polska A. S. Elektryczna in the middle of last year obtained the order for a fire-alarm installation for the port of Gdynia. This installation was put into operation on 1st July last.

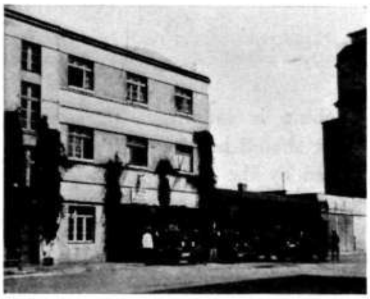

Fig. 1 X 3615
Gdynia fire station

The Polish port of Gdynia has in the last ten years grown up from a little fishing village to a town of nearly 50 000 inhabitants. The town has an exceedingly large port which has been laid out and constructed by Polish engineers. No expense has been spared to make the port one of the most modern and well-equipped in the world. The traffic of the port is exceedingly lively and a considerable number of warehouse and administrative buildings have been erected in the harbour area. In order to protect the buildings and ships in the port, a fire station for the port was built some years ago, Fig. 1. Here are stationed a permanent fire brigade of 20 men with motor vehicles and fire-fighting appliances. With a view to utilising the fire brigade to the best advantage it was decided last year to provide a fire telegraph installation, and this was ordered from Ericsson Polska A.S. Elektryczna, Warsaw.

The installation comprises a central exchange to which 20 fire alarm boxes are connected. Order for a further 40 boxes has since been received and these will be delivered before the end of this year. Altogether 90 boxes can be connected to the exchange. The fire alarm boxes are provided with signal devices by means of which the public can give alarm to the fire station. The signal devices include arrangement which on test give revision signals. The boxes are also fitted with telephone apparatus of CB-type.

The central board, Fig. 2, is made on the Ericsson double-telegraph system and consists of three marble panels; that on the left contains arrangements for charging and supervising the batteries, for calling the men in the station, etc., while the two panels to the right are intended for connection of fire-alarm-box loops, two loops to each panel. On a shelf in front of the panels there are mounted two telegraph instruments of the sounder type; that on the right is fitted with a punching device which punches on the telegraph instrument paper strip the time of an incoming signal and the time at which alarm is sent to the firemen.

Above the marble panels there is mounted a figure indicator with relay and selector devices to indicate the box from which signal has come. Similar figure indicators are mounted in the firemen's quarters and in the garage. There are press-buttons on the left-hand panel for manual setting of the indicators and for restoring them. Right to the left of the indicators are two transparent signs which show whether a signal is for alarm or revision. Signal bells may be connected to the relay- and selector devices, arranged to give code rings for alarm signal corresponding to the number of the box shown on the indicator.

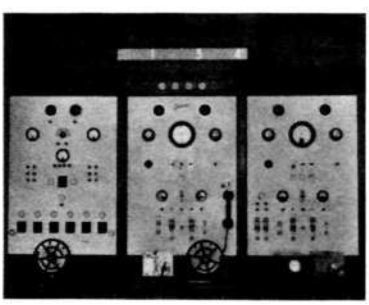

Fig. 2 X 3616
Central board in Gdynia fire station

When the paper of one of the telegraph instruments has run out or if the telegraph instruments are not wound up, this is signalled by a bell mounted at the back of the left-hand panel. At the same time the fault is shown by a lamp above the middle panel. The right-hand panel is arranged for the connection of telephone and junction lines to the police station and to a fire station for the whole town which is projected.

New Magneto Telephone Instrument

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

In Ericsson Review No 3, 1935, a new bakelite table magneto instrument was described; there has now been designed a similar wall instrument, also in bakelite, which both as regards appearance and efficiency is superior to the old magneto instruments, which moreover were rather bulky.

Fig. 1 X 3619
Wall magneto instrument

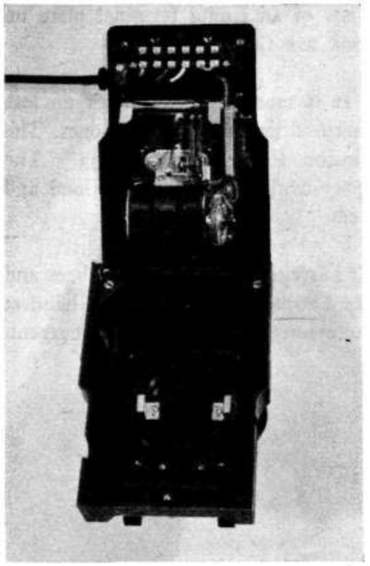

Fig. 2 X 3620
Wall magneto instrument
with cover lowered

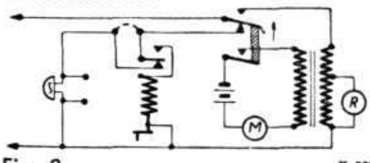

Fig. 3 X 3621
Diagram of magneto telephone instrument

The instrument, Fig. 1, is in the main of the same design as Ericsson's normal telephone instruments, as described in Ericsson Review No 1, 1933. The handset and cover are of bakelite. To provide room for the magneto the bells have been taken out of the instrument and located at the front of the cover. This placement gives increased ringing output, a particularly important matter with an LB instrument which most often has to work on long lines not of very high quality.

The magneto, see Fig. 2, is of new type with cobalt magnets, the same as used for the table magneto instrument; it is screwed on to the bottom plate and fixed at such an angle that the crank projects slantingly from the side of the instrument cover. This leaves suitable space between wall and crank for operating the magneto.

The bell mechanism leans forward so that the clapper projects through a hole in the front of the cover and takes up a fixed position between the gongs. The screw-holes in the gongs are made slightly eccentric, so that each gong may be adjusted to the clapper without interfering with the position of the bell mechanism. When the gongs have once been adjusted, the instrument cover with gongs attached can be lowered or raised without affecting the adjustment of the bell mechanism to the gongs.

The instrument is antisidetone-connected, see diagram Fig. 3. Normally the instrument is connected so that its own bell does not ring for outgoing signals, but the connection can easily be modified on the terminal block of the instrument so that the bell is connected in parallel with the line when signalling.

With the exception of the magneto the parts making up the instrument are the same as for a normal wall instrument for CB or automatic system, which is a great advantage as regards standardization and besides allows the instrument to be used when changing over to another system.

The instrument is supplied in two forms, *viz:* Type DAN 1001 with two-magnet magneto, or Type DAN 1002 with three-magnet magneto. For microphone feed a 3 V battery is required, conveniently made up of two series-connected dry cells, which may be fitted in a battery case, *e.g.,* Type RK 2300.

Field Telephone Instrument

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

The new Ericsson field telephone instrument described in Ericsson Review No 2, 1935, was chiefly designed for military use, and as regards equipment satisfied the severe demands of field service.
To meet the demand for a simplified type of this instrument for use also in civilian operation a design has been completed, mainly based on the earlier design. For example, the same instrument set is used, except that some of the special equipment has been left out. The shape of the instrument is also the same.

Fig. 1 X 3622
Field telephone instrument
in leather case

Design

The telephone instrument, Fig. 1, consists of an inset with handset and dry battery, fitted in a box which goes into a leather case with carrying strap, the whole having the following dimensions: length 265 mm, breadth 90 mm and height 180 mm; the weight is about 4.5 kg.

The parts making up the *inset,* Fig. 2, are mounted on a metal stand and form a unit which can be tested and adjusted separately before being fitted in the box. The set comprises magneto, bell, magneto coil, condenser and handset. The upper part of the stand consists of an isolite terminal plate on which two terminals for connecting the line are fitted.

The *magneto* is of Ericsson's latest type. It is more efficient, takes up less space and is lighter (1 kg) than those hitherto fitted in field telephones. The polarized *bell* is of normal type, see Ericsson Review No 1, 1933. The gongs are designed to suit the restricted space available. The bell is loud and works for less than 2 mA between 16—25 c/s.

The *induction coil* also is of normal type. It has closed core of alloy sheet and is antisidetone-connected. The *condenser* has a capacity of 1 μF. The handset is of normal type, of bakelite with key to connect the microphone current.

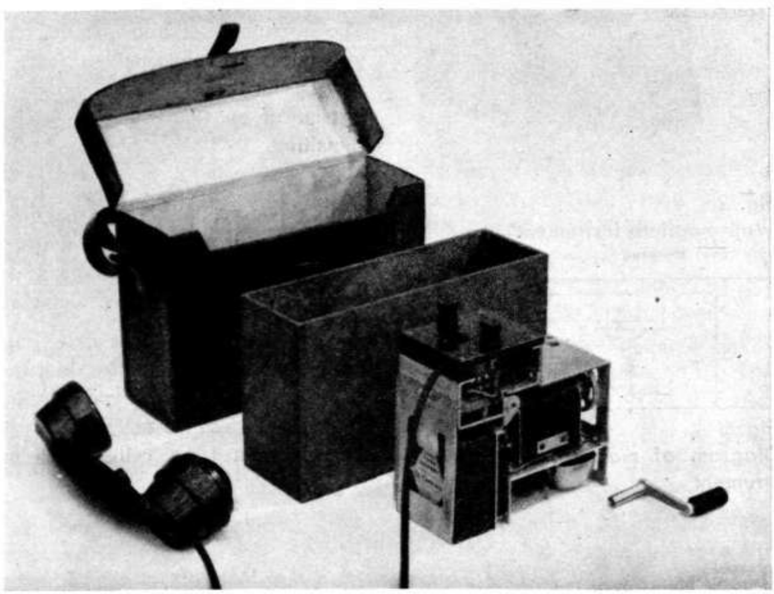

Fig. 2 X 5305
Field telephone instrument
taken apart
left to right: handset, leather case, box, inset and magneto crank

The design of this key is described in Ericsson Review No 2, 1935. The handset is provided with three-wire cord made as a rubber cable with circular section. Connection to the instrument is by a terminal inside the instrument set. This terminal is easily accessible when the isolite plate has been screwed off.

The *dry battery* has an EMF of 3 V and a capacity not below 3 Ah with normal use. The battery consists of two series-connected rod cells built together in a packet measuring 36×68×85 mm.

The battery may be changed without taking the instrument set from the case. When fitting the battery in the instrument it is put in from the side and pushed into place. It is held by a lid fastened by a nut. Electric contact between battery and set is ensured by two stud contacts on the battery, against which a pair of flat springs press. This method of contact allows of quick battery changing and ensures safer contact than with flex connected to screws on the battery.

The box is made of 5 mm toughened masonite sheets dovetailed and glued. It is cellulose painted inside and out. Tests carried out show that the box is very strong, despite its comparatively light weight. The instrument is screwed into the box by three screws which can be loosened from outside. The nuts inside the box have a certain play making it unnecessary to have the set fit too accurately in the box. The *leather case* has a jointed lid, fastened by a simple buckle, and is made of 4 mm black cow-hide. The case is handsewn throughout. The carrying-strap is adjustable and is stitched on to a pair of rings on the ends of the case.

Operation

The diagram of the instrument is shown on Fig. 3. When connected to the line the instrument is normally out of operation and speaking position is obtained by closing the local circuit with the handset key. Incoming signal current actuates the bell, whereupon the current goes past the magneto, which is short-circuited in rest position. The speaking current circuit is connected in parallel to the bell through a 1 μF condenser. The diminution of strength in the incoming signal current on this account is of no practical significance. Parallel connection is necessary as the instrument may be called by tone from an instrument equipped with buzzer for voice frequency telegraphy. On outgoing signal current the magneto is connected direct to the line, whereupon the speaking set is short-circuited.

Incoming speaking current passes through the condenser which is connected in series with the antisidetone-connected speaking circuit. The bell, connected in parallel with this, has such high impedance to voice frequency that the shunting through it is of no importance.

For outgoing speech the local circuit, consisting of battery, microphone and magneto coil, is closed through the handset key. Because of the antisidetone connection the speaker's own voice and other noises are hardly heard in the speaker's receiver. This method of connection is therefore very important for a field telephone which is often used in places exposed to noises of all kinds.

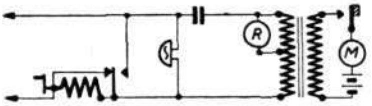

Fig. 3 X 3623
Diagram of field telephone instrument

As is known, CCIF has fixed certain norms for the measurement of the efficiency of telephone instruments, which are given in comparison with the international standard SFERT. Tests carried out on this instrument give the following figures for transmission in relation to SFERT: sending + 0.3 neper and receiving + 0.1 neper.

Mains-Supply Set for Long-Distance Transmission Equipments

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

It is often desirable to install, e. g., the terminal rack of a single-channel carrier-telephone system at a small office, where the necessary batteries are lacking. If AC mains are available, however, the power supply may be easily arranged by means of a mains-supply set. The set, Type ZL 480/ZL 485 is specially designed for the Ericsson single-channel system, Type ZL 400, described in the Ericsson Review No 2, 1936, but may also be employed for other similar purposes.

The mains-supply set is designed for connection to 110—440 V AC, 50 c/s, and consists of two separate panels, the mains supply panel, Type ZL 480, and the converter panel, Type ZL 485. The former contains two metal rectifiers, one for 24 V and max. 0.9 A DC and the other for 130 V and max. 80 mA DC. The mains-supply panel is combined with the converter panel and a 24 V floating battery if stand-by for meeting failures of the mains voltage is desired. The converter panel holds a rotary converter and a relay, which connects the converter to the floating battery when the AC voltage fails. The converter delivers 130 V for the anode circuits while filament current is drawn directly from the floating battery.

The filament circuits of the single-channel system, Type ZL 400, contains iron-resistance ballast lamps, which take care of voltage variations of ± 4 V. Consequently the voltage of the filament source may vary between 20 and 28 V. The mains voltage may vary correspondingly, *i.e.*, within ± 15 % of the mean value. At greater variations in the mains voltage o floating battery may be used in order to decrease the filament variations. The anode voltage variations are limited by means of neon lamps.

Rectifier Panel

The underlying principle of the supply panel is shown to the left in Fig. 1. The alternating current is supplied through the fuses *1* and *2* and a four position switch *3*. The filament transformer *5* and the anode transformer *9* are fed with AC through the auto transformer *4* equipped with tappings for the usual voltages of 120, 150, 220, 380 and 440 V. At the installation the point S_4 is connected to a tapping corresponding to the existing voltage by means of soldering.

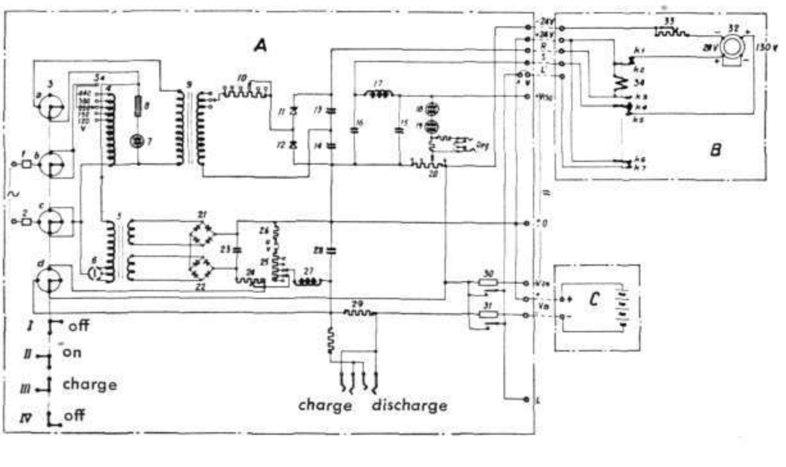

Fig. 1 X 5322

Circuit diagram of mains-supply set

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

B converter panel
32 rotary converter
33 rheostat
34 starting relay

C floating battery

In addition to these voltage tappings there are adjustment tappings on the auto transformer for ± 10 V and ± 25 V. The filament and anode transformers are connected to a portion of the auto transformer and across the same portion the neon lamp *7* and its series resistance *8* are connected. This lamp when alight indicates that the panel is switched in and that the AC mains are under tension. The secondary current of the transformer *9* is fed to the anode rectifier *11, 12* through the resistance *10*. The rectified current is passed by the smoothing circuit *15, 16, 17* to the terminals $+V_{130}$ and ± 0. Two neon lamps *18* and *19* connected in series are inserted between the $+V_{130}$ and a potentiometer *20* forming a shunt on the 24 V tension. These lamps are intended to reduce the anode voltage variations caused by variations of the mains voltage. The current through the lamps is measured in the jack *Reg* equipped with a shunt adjusted for the millammeter of the single-channel equipment, Type ZL 400. At normal mains voltage the current should be adjusted to 20 mA plus one third of the anode current between $+V_{130}$ and ± 0. Adjustment of the neon lampe current is made by selecting a suitable tapping of the secondary of the transformer *9* in connection with the short-circuiting of the greatest possible portion of the resistance *10*, while the anode drain is normal with regard to current and voltage. The latter is adjusted by means of selecting a suitable tapping on the potentiometer *20*.

The transformer *5* feeds the filament rectifiers *21, 22* with the smoothing circuit *23, 27, 28*. Filament voltage is obtained at the terminals $-V_{24}$ and ± 0. The filament voltage is adjusted by means of a commutator *6* selecting different tappings on the primary of the transformer *5* and a resistance *24*. A shunt formed by the resistances *25* and *26* reduces the voltage variations at varying drain from the terminals ± 0 and $-V_{24}$. If a floating battery is used the shunt is superfluous and must be disconnected by means of removing the strap *u—v*.

A floating battery, when used, is connected to the terminals $\pm V_B$. From the lead ± 0 the current flows to the positive pole of the battery and from the lead $-V_{24}$ at the choke coil *27* through the shunt *29* of two jacks »charge» and »discharge» for measurement of the charge and discharge currents. The shunt is designed to suit the milliammeter on the terminal rack of the single channel system. The charging current is adjusted by means of the rheostat *24*.

Converter Panel

The converter panel is connected in accordance with the right-hand part of Fig. 1. The converter *32* is fed from the terminals $+24$ V and -24 V. The latter terminal is connected to the negative pole of the floating battery through a special contact *d* in the switch *3* closed only with be switch in position »on». Between the lead *R*, connected to the positive pole of the anode rectifier, and $+24$ V, connected to the terminal ± 0, a relay is inserted. When mains voltage is available the relay is actuated. The positive pole *R* of the anode rectifier is then connected to the lead *S* through the contact k_3k_4 and through the coil *17* to the terminal $+V_{130}$. The motive current of the converter is broken at the open contact k_1k_2 and the $+130$ V pole of the converter is insulated by the open contact k_4k_5. If the mains voltage fails the relay *34* is released and the converter is started by the closing of the contact k_1k_2, whereas $+130$ V is connected to the lead *S* through the contact k_4k_5 and through the filter *15, 16, 17* to the terminal $+V_{130}$. The anode voltage is adjusted to 130 V at normal drain by means of the rheostat *33*. This may easily be done without lighting the neon lamps, which would mean extra load on the converter. When the contact k_6k_7 is closed -24 V is connected to the lead L^1, which in turn may be connected to the alarm lead *L* through the soldering tags *x, y* and consequently also to an audible and visible alarm system. When the mains voltage returns, the relay *34* is actuated, the converter stops and normal mains supply conditions recur.

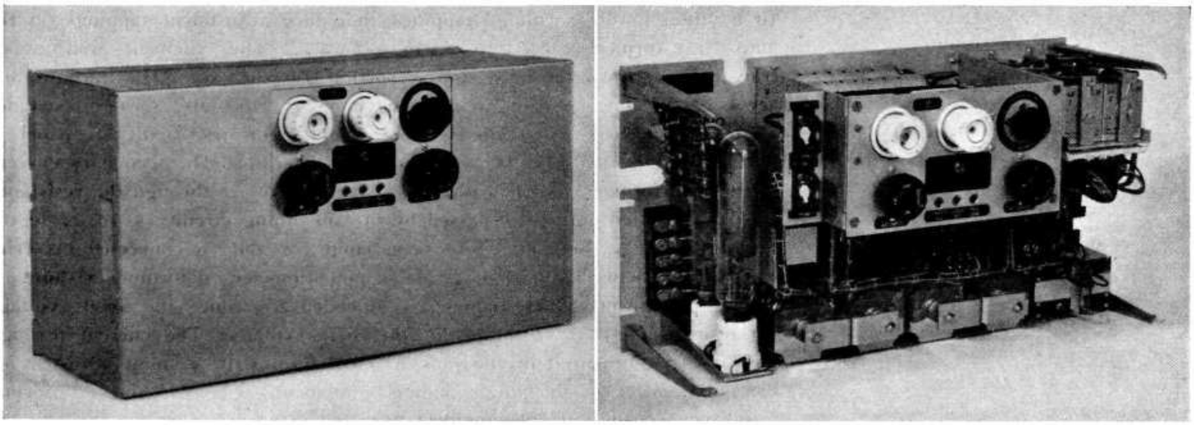

Fig. 2
Mains-supply panel
left with cover, right without cover

X 7101

If the floating battery has been discharged during a period of failing mains voltage charging is required as soon as possible in order to obtain stand-by. If the single-channel system remains in service the charging current will be limited by the fact that the total drain from the filament rectifiers must not exceed 0.9 A. A device for charging when the single-channel system is not in service is also available. The switch *3* is then set on »charge», at which the anode rectifier is disconnected by the contact *3a* and the converter by the contact *3d*. Consequently the battery may be charged with the total available current of 0.9 A.

When calculating the battery capacity covering a certain period of emergency service the motive current of the converter must be taken into account in addition to the normal filament drain in accordance with the following table

anode drain	mA	20	40	60	80
motive current	A	1.5	1.7	1.9	2.2

Mechanical Assembly

The mains supply panel, Fig. 2, and the converter panel, Fig. 3, are mounted on 482.6 mm sheet-iron panels and intended to be mounted in racks, *e.g.*, in the terminal rack of the single-channel system, Type ZL 400. By means of a simple device the panels may also be fastened to a wall. The height of the mains supply panel is 266 mm and that of the converter panel 177 mm. The panels are equipped with removable covers. Any suitable 24 V accumulator may be used as floating battery. The accumulator has to be installed separated from the mains-supply set.

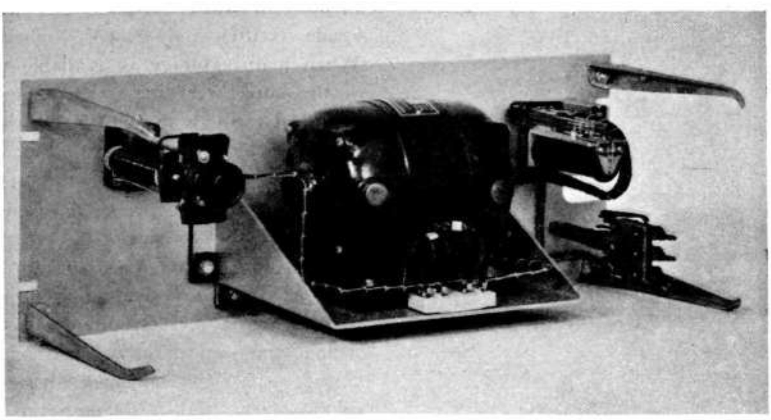

Fig. 3
Converter panel

X 5321

Precision Instruments for the Measurement of Capacitances

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

Measuring instruments allowing precise reading of capacitance and power factor are nowadays a necessity in the manufacture and testing of various condenser types. The two AC bridges described below are designed as routine instruments with great accuracy, stability and easy setting.

A thorough analysis of the possibilities available for designing instruments for routine testing with great precision of capacitance and power factor shows that there was no advantages in combining these two measurements in one instrument because of the great range in capacitance to be covered and the extremely low values of power factor to be handled. Therefore, two separate instruments in the form of special AC bridges had to be designed. In this way the advantage is gained that the bridges may be of a simple and stable type having a great accuracy. The bridges made by Ericsson on this principle have been found very useful in many fields where the measurement of capacitances is necessary.

Capacitance Bridge, Type ZA 156

This bridge, Fig. 1, is a resistance ratio bridge, Fig. 2, where the object to be measured C_x, is compared with the fixed capacitance $C_1 + C_2$ by means of the decade resistance R_2 and the ratio arm R_3. The fixed capacitance C_1 consisting of a thoroughly aged mica condenser is connected in parallel with a variable condenser C_2, which is fixed when the bridge is tested, thus compensating for small additional capacitances due to the wiring and shielding of the bridge. By means of the resistance r_1 the power factor of C_x is compensated. The resistance R_2 is divided into three decades and a continuously variable resistance, while the resistance R_3 consists of four resistance units. The bridge elements are so dimensioned that the capacitance measured may be read directly from the setting of the decade resistances save for a multiplying factor, which may be set to 0.1, 1, 10 or 100 by means

Fig. 1 X 5302
Capacitance bridge, Type ZA 156

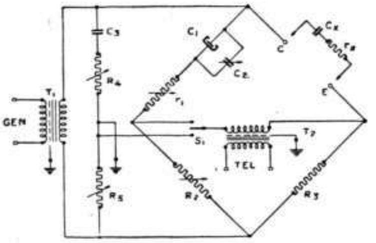

Fig. 2 X 3617
Principle diagram of capacitance bridge

C_1	fixed condenser
C_2	adjustment condenser
C_3	fixed condenser
C_x r_x	object to be measured
R_1	variable resistance
R_2	resistance decades
R_3	ratio resistances
R_4, R_5	variable resistances
T_1	input transformer
T_2	output transformer
S_1	switch

of the ratio arm R_3. The measuring range covered is 1 $\mu\mu$F—1.11 μF. The absolute accuracy is ± 0.1 % or ± 0.5 $\mu\mu$F, whichever is the larger. The accuracy is limited practically only by the adjusting accuracy of the resistances as electrostatic and magnetic shielding is fully utilized. Thus capacitances as small as about 0.05 $\mu\mu$F may be determined by means of a simple difference measurement.

The bridge is equipped with a Wagner earth consisting of the fixed condensers C_3 and the variable resistances R_4 and R_5. This device causes a more complicated setting of the bridge compared with an ordinary four-armed bridge; but benefits by simple shielding and great accuracy, and further it is possible to measure direct capacitances, *e.g.*, in cables, transformers and valves. The bridge elements are so selected that the settings are distinctly convergent and practically independent of each other in the way that sound minimum in the telephone is obtained with a few adjustments of setting. There have been used as variable bridge elements only resistances combined with reliable switches by means of which good electrical and mechanical stability of the bridge is obtained. The bridge is mounted on an iron panel furnished with a sheet-iron dust cover and may also be fitted in a portable wooden case. The panel dimensions are 550 × 230 × 220 mm.

Power-Factor Bridge, Type ZA 157

This bridge, Fig. 3, is a capacitance ratio bridge with Wagner earth and shielded input and output transformers. The bridge itself, Fig. 4, consists of the condensers C_x, C_6, C_7, C_8 and the resistance r_8 and the Wagner earth is formed by the condensers C_9, C_{10} and the resistances r_9, r_{10}. By means of specially shielded variable air condensers the dielectric losses of the bridge elements have been reduced to insignificant values. Moreover, in order to reduce further losses due to oxidation, the condenser plates both of the rotor and of the stator are gold-plated.

The bridge is direct reading in power factor ($\tan \delta = \omega \cdot C_x r_x$) at 1 000 c/s. With the built-in fixed condenser C_6, a capacitance range of 100 $\mu\mu$F—0.2 μF is obtained but, by employment of an additional condenser mounted on the panel surface, the range may be extended to about 2 μF. Owing to the large capacitance range and the accuracy in measurement of $\tan \delta$ the bridge elements have been divided in such a way that the capacitance C_7 consists of two variable shielded condensers, one for coarse and the other for fine adjustment of the setting. The resistance r_8 consists of five resistance decades,

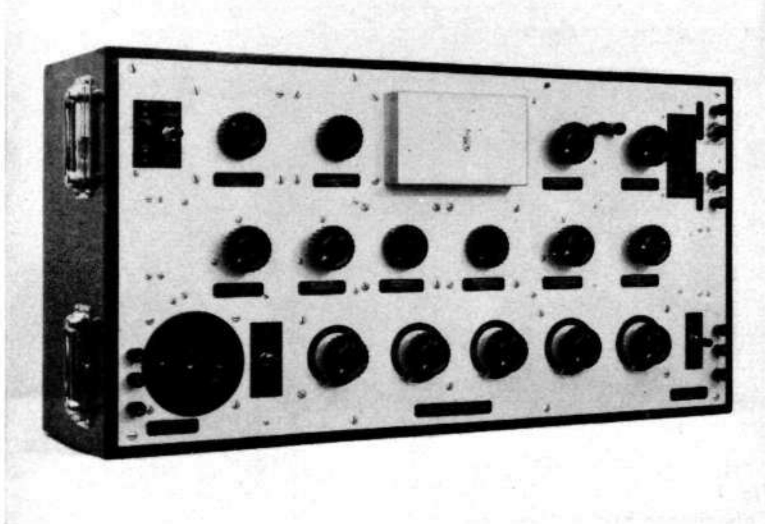

Fig. 3 X 5303
Power-factor bridge, Type ZA 157

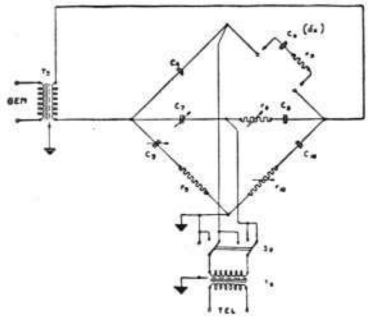

Fig. 4 X 3618

Principle diagram of power-factor bridge

C_6	fixed condenser
C_7	variable condenser
C_8	condenser variable in steps
C_x r_x (δ_x)	object to be measured
C_9	variable condenser
C_{10}	fixed condenser
r_9	fixed resistance
r_{10}	variable resistance
T_3	input transformer
T_4	output transformer
S_2	switch

giving the power factor $\tan\delta$ in ten-thousandths. The maximum reading in $\tan\delta$ is $1\,111 \cdot 10^{-4}$ and the minimum reading $0.01 \cdot 10^{-4}$. Also the condensers and the resistances of the Wagner earth have been divided into several decades in order to allow a sufficient setting accuracy for every value of C_x and δ_x within the measuring range. The relative measuring accuracy is about $\pm 1.5\,\%$ when the power factor exceeds $30 \cdot 10^{-4}$. For smaller values the measuring accuracy is determined by the absolute maximum error of the bridge, which does not exceed $\pm 0.15 \cdot 10^{-4}$ for capacitances below 0.2 μF.

As mentioned above, this bridge is intended for the measurement of small power factors, for instance on condensers with a dielectric of mica, ceramic materials, impregnated cellulose in the form of paper, fabric etc. A special field of importance is to be found in certain measurements in the chemical industry, where recent experience indicates that the measurement of the dielectric losses are of paramount value when inspecting oils and impregnating materials, as compared with chemical analysis, which often is very burdensome and sometimes, *e.g.*, with non-electrolytic materials, is replaced by power-factor measurements, which is much easier to perform. The power factor is very low for mineral oils, especially the highly refined and stable grades used as transformer oil and for impregnation purposes.

The bridge is carefully shielded electrostatically and magnetically and is mounted on an iron panel in a shielded wooden case with the dimensions $800 \times 425 \times 300$ mm.

Sieverts Gebe Cable

E. JENSEN, SIEVERTS KABELVERK, SUNDBYBERG

Sieverts Kabelverk having recently completed a thorough-going re-designing of the Gebe system, a detailed description will be given of the system in its present form. The article below covers the development of the Gebe cable and in the next number will follow a description of the Gebe fittings.

In 1923 Sieverts Kabelverk put on the market a system of installation which at that time was called the SS system. It consisted of a rubber-insulated lead-sheathed cable and a three-part fitting which could be built together as required in various combinations: distribution box and lamp-holder; distribution box, switch and lamp-holder; distribution box and switch; finally, distribution box alone. As years went by the system was improved in various ways, dictated by experience. The changes have been rather comprehensive; even the original name has been altered, and the »SS system» has been christened the »Gebe system».

Gebe Cable for fixed wiring

The first Gebe cable very much resembled a ship's cable: the space around the twisted, insulated and wrapped wires was filled with fibrous material; the mantle lacked real corrosion protection, it was wound with paraffin impregnated paper tape and outside this came the armoured band and the braiding; the braiding was impregnated with black compound or red lead.

The first, and very valuable, improvement was that all the space between the copper conductors and the sheath was filled with rubber. By thus taking away the fibrous material inside the cable, the cable became highly impervious to humidity which might arise through sweating or condensing in more or less ill-fitting boxes. The next important improvement was the provision of an efficient protection against corrosion of the sheath; it was soaked in a specially tested black compound. Round this compound layer was wound paper tape which in turn was soaked in the same kind of compound; then came the armoured band, compound, paper tape and impregnated outer braiding in the order given. By these two alterations the resistance of the Gebe cable to action of a chemical nature was very considerably increased, and it is certainly no exaggeration to say that it is not possible further to improve it appreciably in this respect. It may be worth mentioning that the cable, Type EDJL, Fig. 1, that Sieverts Kabelverk thus produced, has served chiefly as the pattern for the drawing up of several countries' norms and specifications for this type of cable. The next stage of development was that Sieverts Kabelverk, in addition to black and red cables, began to manufacture white cables. This combined with the system of iron cable clamps, developed specially for this cable, contributed to improving the appearance of the completed installation — a point of view hitherto not particularly provided for.

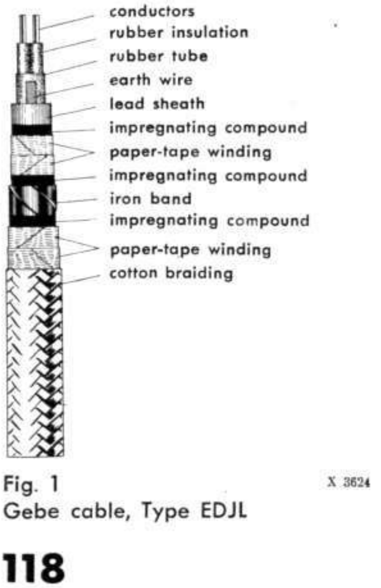

Fig. 1
Gebe cable, Type EDJL

As the years have gone by the number of Gebe cables has grown to an imposing figure, *viz:* no fewer than 230 different cables, according to Sievert Kabelverk's latest catalogue. There are 1.5—16 mm², two-, three- and four-wire cables with and without earth wire under the sheath, cables with bare sheath, with protected unarmoured sheath, and with protected armoured sheath, and, finally, there are black, white and red cables. There is, however, hardly real necessity for all these different types, so that it is possible to reduce the number without adversely affecting the interests of customers. Against the armoured cable it has lately been observed that the protective effect of the iron bands is doubtful, as they are but 0.25 mm thick. Even

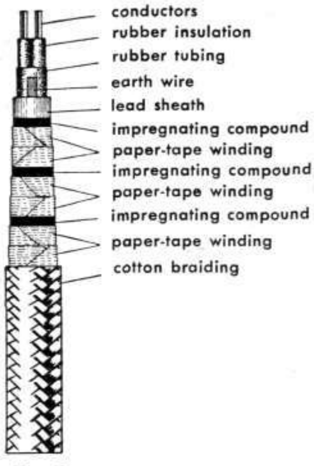

Fig. 2 X 3625
Gebe cable, Type EDIL

without the iron bands, however, the cable is so strongly made, that the bands fulfil no real purpose. On the other hand, it has been observed that the iron bands in very bad places have rusted despite the protective covering above them; the rust has in its turn contributed to further internal damage in the cable. When Sieverts Kabelverk a couple of years ago took up the question of radically weeding out unnecessary cables, tests were made with a cable, Type EDIL, Fig. 2, in which the iron bands were replaced by a corresponding thickness of paper strip and this cable was approved for use without special protection even in places where the iron-band armoured cable had formerly been stipulated. The projected cutting down of the number of cables has now taken place. Thus in the price list sent out recently there are only listed cables with bare sheath and with protected sheath, the latter having white braiding. Cables 1.5—6 mm² have earth wires under the sheath, while cables 10 and 16 mm² are without these. As there are cables of two-, three- and four wires, the number of cables has thus been reduced to 36.

Though it is stated above that it is hardly possible to make the cable more resistant to corrosion than it now is, a little addition should be made. Experience up to now has shown that the cable lasts for a long time even in very bad conditions, but still there is one kind of place, where it is hard for even the Gebe to resist, namely places where nitrous gases occur to a large extent; in time these gases affect both the outer layer and the lead mantle. For such places Sieverts Kabelverk has manufactured a cable which is armoured with bands of stainless steel. As both cotton and paper are affected by the gas, even when impregnated, these are of no value outside the armour bands and the cable has nothing outside the steel bands. The layers on the lead mantle are thus made up as follows: compound — two paper strips — compound — two steel bands. During the time this cable has been in use it has shown no signs of being affected.

Gebe Suspension Cable

As a suspension cable in the Gebe system quite another cable, Type RDCU, Fig. 3, is employed, this being a rubber tube cable with cellulose-lacquered cotton braid. In the infancy of the system the suspension cable also consisted of a lead-sheathed cable. Unlike the ordinary cable it was armoured with wire, the 1 mm thick iron wire being laid in spiral with considerable pitch around the cable. The cable was, however, clumsy and stiff and not particularly easy to handle. It was later replaced by the above type of cable which was considerably more flexible and of better appearance, without being any dearer. In its initial form it had, like ordinary suspension cables, two extra multi-wire conductors, cotton braided, rubber insulated and banded; the area was 1.5 mm². To aid in supporting the fitting there were two insulated multi-wire steel conductors.

This cable has also undergone change. As an area of 1.5 mm² is altogether unnecessary even where the largest lamps are concerned, this was reduced some years ago to 1 mm². A suspension in general and a Gebe suspension in particular is a comparatively stationary apparatus, and there is therefore no reason for using the extra multi-wire conductor; one with few wires is in that case stronger and a single-wire even stronger. As a single-wire would be unnecessarily stiff, Sieverts Kabelverk has for the time being decided for a seven-wire conductor, and in conjunction with this the cotton braiding has been taken away; it is in fact only used on the thin conductors with an extra large number of wires.

As already stated, the fibrous material inside the Gebe cable has been taken away and only rubber is employed for filling. The same is the case with the suspension cable; and, besides the disappearance of the cotton braiding from the conductors, the impregnated cotton tape on the rubber insulation has been taken away.

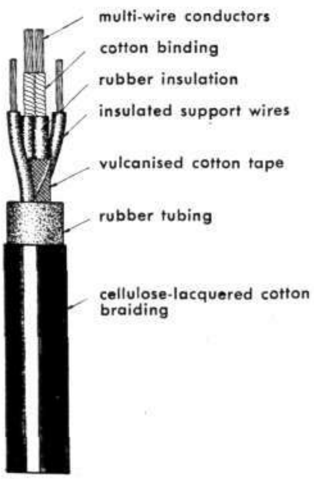

Fig. 3 X 3643
Gebe suspension cable, Type RDCU
as formerly supplied

Fig. 4 X 3644
Gebe suspension cable, Type RDCU
as now supplied

If a distribution box which is fitted in a particularly damp place is not tight the humidity can gradually condense in the box. If it is a ceiling box and the suspension cable contains fibrous material, this can suck up the humidity like a wick and draw it into the cable until the cable is damp from one end to the other. Even though the cable may not be wholly spoiled by this, the insulating property will be considerably reduced, which in its turn may cause the whole of the cable group to which the suspension is connected to have poor insulation. The exclusion of the fibrous material may thus be regarded as a definite advantage.

The last alteration is that the supporting conductors have been taken away. For a long time the VDE specifications and the national standards based on them, contained a stipulation that suspension cables should have support wires. Once when technique was young, it is said, there were lamp-holders which had a special fastening for fixing the support wires, but there was hardly a suspension with a corresponding fastening upwards, and the support wires therefore never really fulfilled their purpose, *viz:* to bear the fittings at the lower end of the hanging. When Sievert's suspension cable began to be made it was duly furnished with two support wires and the Gebe fitting provided with a proper fastening for them both above and below. On an investigation made to discover the utility of the support wires, it was found that the main strain was on the packing round the cable where it entered the hanging cover; the natural result was that the support wires were doomed to disappear. The cable, Fig. 4, now included in the new cable standards, consists of two seven-wire insulated and twisted conductors, furnished with a common strong rubber tube and a cellulose lacquered cotton braid.

New Ericsson Wireless Sets

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

The range of sets presented this year by Svenska Radioaktiebolaget comprises three stand-cabinet console models and three table models, all of which may be had in AC or universal current type.

Two of the stand-cabinet models, Ericsson 368 and Ericsson 369, may be described as standard apparatus, while Ericsson 367 is a special design in the de luxe class. The table models, Ericsson 365 and Ericsson 366, are like the stand-cabinet models superheterodyne receivers. The smallest type, Ericsson 362, though designed chiefly as a local receiver, is equipped with such improvements that agreeable reception of foreign stations is possible under normal conditions.

Fig. 1 X 3627
Ericsson 368

Ericsson 368

Ericsson 368, Fig. 1, is a wireless receiver of entirely new design. With its new attractive lines the receiver is an ornament to any home, and at the same time it is perfect from the acoustic point of view. The sloping front gives correct distribution of the higher tones without troublesome directional effect. At the same time the massive front forms an ideal sound screen on which the loud-speaker is mounted direct, with the result that the bass-register reproduction is fully natural right down to the deepest tones of the counter-bass and the tuba.

The receiver is a six-valve superheterodyne, with seven tuned circuits, exclusive of the oscillator circuit, see Fig. 2, and has the following sequence of Marconi valves: VMP4G met. as HF amplifier, X 41 met. as frequency shifter, VMP4G as IF amplifier, MHD4 met. as rectifier and LF amplifier, N 41 as final pentode and U 12 as rectifier valve. The corresponding sequence in the receiver for universal current are: W 31 met., X 31 met., W 31 met., DH 30 met., N 31 and U 30. The sensitivity, measured at 50 mW output with 30 % modulation by 400 c/s, is practically the same over the whole range of wave-lengths and amounts to 5—10 μV. The sensitivity is adapted to the frequency allocation of the sending stations and amounts to 55, 65 and 75 db for short-wave, medium-wave and long-wave respectively on a frequency spacing of 8 000 c/s.

The wave-length ranges are 200—570 m, 725—2 000 m and 16.7—50.5 m; intermediate frequency is 120 000 c/s. When tuned in to short or medium waves the long wave coils are automatically short-circuited. The image frequency suppressor has been further developed with a view to giving even suppression of the image frequencies over the whole wave-length range. This is attained by taking the compensating tension from two different circuits, with resonance frequencies above and below the wave-length band respectively.

Fig. 2 X 7100
Connecting diagram for superhet receiver, Type 368 V
for AC, 6 valves incl. rectifier, 7 tuned circuits and oscillator circuit, wave-length range 16.7—50.5, 200—570 and 725–2000 m, intermediate frequency 120 000 c/s, output 3.2 W

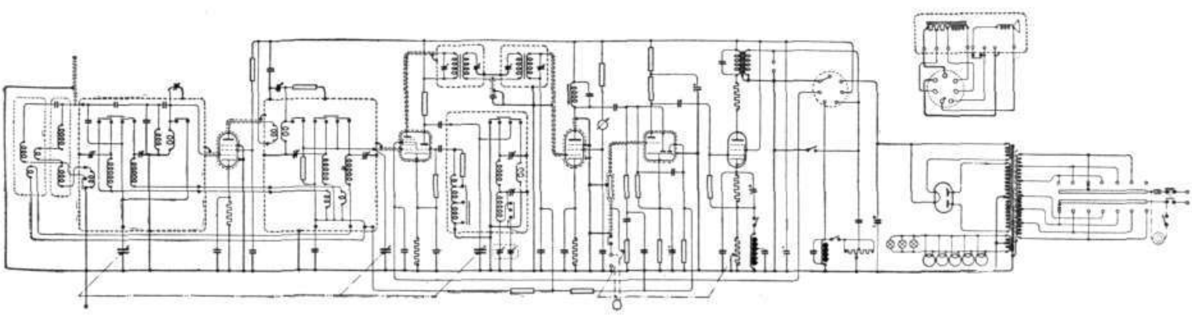

Fig. 3
Ericsson 369
X 3628

When receiving short wave the sensitivity and stability are increased by a stage of high-frequency amplification before the frequency shift. The excellent mixing and amplification qualities of the triode-hexode valve have been sufficiently dealt with in Ericsson Review No 4, 1935. The intermediate-frequency amplifier comprises five stages, four of which are contained in a band-pass between the frequency shift and the intermediate-frequency amplifier valve. Selectivity for a frequency spacing of 8 000 c/s is 50 db; the band width is 6 000 c/s and constant, *i.e.*, independent of the power of the station received. In view of the good results obtained with this method of connection it is now possible to do without the band-width selector. Rectification, delayed automatic volume control as well as low-frequency amplification are carried out with the same devices as in earlier Ericsson receivers. Tone-compensated volume control ensures that the sound quality is independent of the sound intensity. With great sound volume the frequency curve is fairly straight; with weak signals, however, the bass register and the highest tones require to be amplified to a higher degree than the middle register. A device providing this correction is combined with the volume control and is connected continuously when the sound volume drops. The choke in the final valve filament wire, see Fig. 2, provides negative reaction to the grid circuit so that the bass is amplified more in proportion than the rest of the register. A small condenser connected in parallel with the choke restores the amplification for the higher parts of the register. By turning the tone control to the right the higher register is increased, with full bass reproduction; by turning to the left the high tones are increased at the same rate as the bass becomes somewhat weaker. The latter position is important when receiving speech from a station with faulty modulation. The high tones are damped through the connection of a large reversible electrolytic condenser over the secondary side of the output transformer by means of a variable resistance. In the loud-speaker circuit there is in addition, in order to suppress interference tones, an oscillating circuit, which in highest tone position is short-circuited by the said resistance. The final valve in the AC apparatus delivers a distortion-free output of 3.2 W. On the universal type the corresponding output is 2 W.

The electro-dynamic loud-speaker with 30 cm cone diameter is of Svenska Radioaktiebolaget's own manufacture throughout and is naturally specially

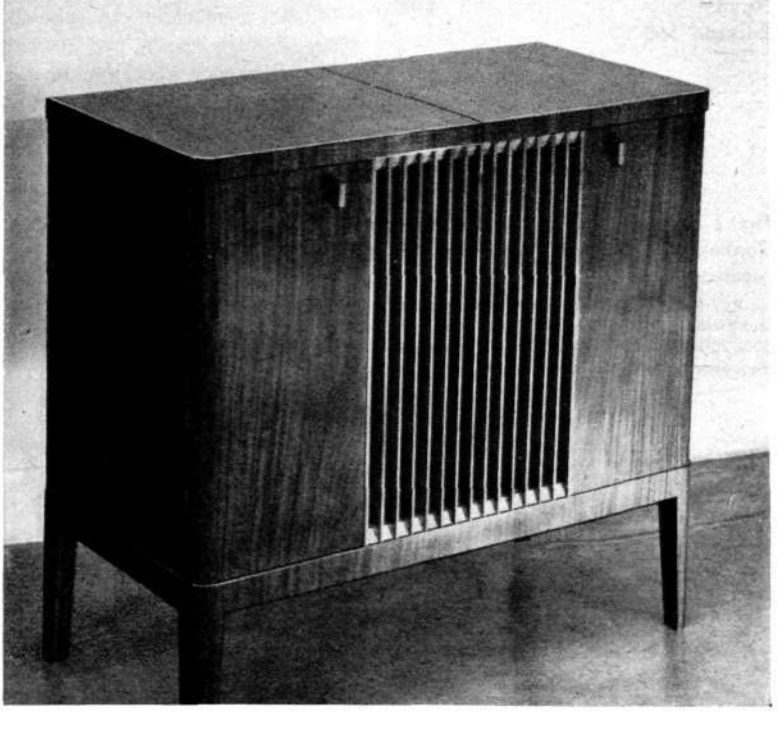

Fig. 4
Ericsson 367
X 5308

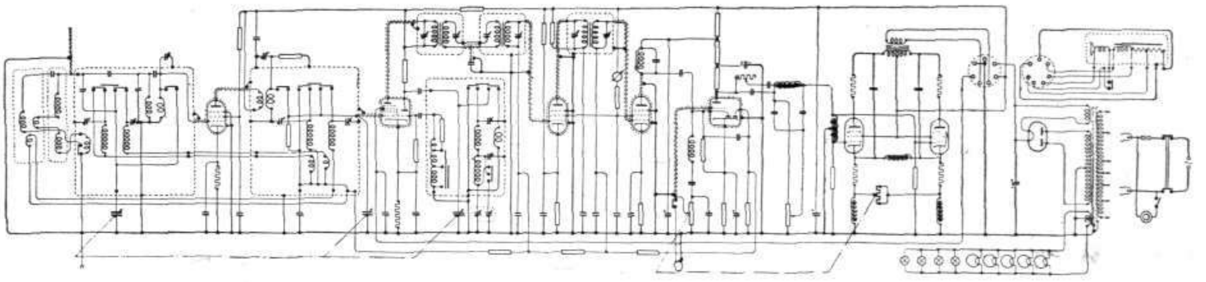

Fig. 5 X 7102

Connecting diagram for superhet receiver, Type 367 V

for AC, 8 valves incl. rectifier, 9 tuned circuits and oscillator circuit, wave-length range 16.7—50.5, 200—570 and 725—2000 m, intermediate frequency 120000 c/s, output 8 W

designed to suit the large tone register obtained with the improvements mentioned above. A diffuser of entirely new type ensures floating mounting of edges of the membrane, with the result that bass resonance is noticable only in the very lowest tones of the register. A curved pressed membrane of paper pulp compound, which combines mechanical durability with freedom from resonance, gives the last touch to the quality of reproduction. Moreover the sloping front of the cabinet contributes to the quality of the sound. The acoustic outpout of the loud-speaker is considerably higher than on earlier models.

The operating devices are four: two dials and two controls. The volume control is used both for wireless and for gramophone. The station dial drives a luminous line which indicates the station setting. The line, which completely eliminates parallax at the tuning, moves with the change of wave-length to the division on the scale corresponding to the wave-length tuned in. The station dial may be drawn out, setting in operation a planet vernier gear which facilitates tuning to short-wave reception. A good aid to correct tuning in all the wave-length ranges is the orthoscope at the right of the scale window. The on-off switch and the wave-length-gramophone switch are combined and operated by a convenient control. A similar control at the left regulates the character of tone. The apparatus has a tapping for connection of pick-up and extra loud-speaker. The loud-speaker built into the apparatus may be disconnected.

Ericsson 369

The Ericsson 369 receiver, Fig. 3, is similar to Ericsson 368, but has in addition a built-in gramophone with automatic starting and stopping device. The volume resistance curve is of such a shape that the regulating part for the pick-up falls into a section where the tone-compensation device rather exaggerates the bass register. In this way correction is obtained of the cutting down in the bass register which is required when playing gramophone records. The gramophone reproduction thus becomes fully equal to the wireless reception.

Ericsson 367

The largest apparatus among the cabinet models is Ericsson 367, Fig. 4, a wireless receiver in the *de luxe* class. Nine tuned circuits, see Fig. 5, connected to three high efficiency band filters with two to four links give a damping curve which is nearly rectangular. The sensitivity is driven to its highest point through high-frequency amplification before the mixing valve and a two-stage intermediate frequency amplification. The output, 8 W, is obtained from a push-pull connected final stage.

Ericsson 367 has moreover automatic record-changer which can play without attention eight 25 cm or eight 30 cm records in succession. The tone control is continuously variable both for bass and treble. The receiver which is

Fig. 6 X 3629
Ericsson 365

made as an elegant model in mahogany is in other respects on the same principles as the other Ericsson receivers. The same improvements, particularly the tone quality, are naturally even more perfect because of the great distortionless output and the large resonance-free cabinet.

Ericsson 365

The small superheterodyne table model, Ericsson 365, has a case of horizontal type, as may be seen on Fig. 6. The chassis is constructed in the same way as the console model and is thus equipped for short-wave. It has not, however, the high-frequency amplification for short-wave to be found in the larger types. The AC apparatus is provided with the following sequence of Marconi valves: X 41, VMP4G, MHD4, N 41, U 12, and the universal current type has valves X 31, W 31, DH 30, N 31, U 30. The scale is vertical type, with the result that the indication line illuminates the whole name of the station and not merely the setting point. The luminous line moves automatically on tuning in to the corresponding section of the scale. The loud-speaker is of normal size and of the new design with curved membrane.

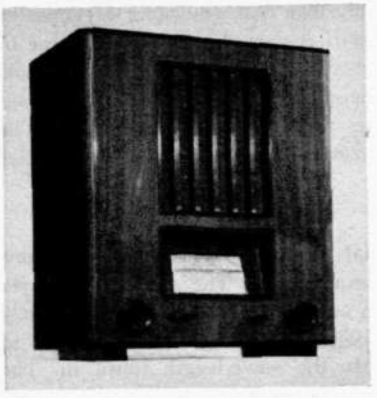

Fig. 7 X 3630
Ericsson 366

Ericsson 366

This receiver, Fig. 7, very much resembles Ericsson 365, but the mechanical details are even more developed. Thus this type is provided with horizontal scale and vernier tuning gear in the tuning shaft. The loud-speaker is of larger type and this, in conjunction with the larger cabinet, gives complete reproduction of the bass register. Like the console models this apparatus is provided with orthoscope.

Ericsson 362

Ericsson 362, Fig. 8, is a three-valve single circuit receiver with compensated aerial coupling, see Fig. 9, by means of which the sound strength may be regulated without affecting the station setting or the return connection. The scale is calibrated both in wave-lengths and stations. The control knobs are three, one for wave-length switching and tuning, the others for return connection and aerial. As a result the receiver is exceedingly simple to operate and good reception of all the stronger European stations may be counted upon with a normal aerial. The sensitivity reaches 300 μV and the maximum output is 2 W. The wave-length ranges are 190—580 and 715—2 000 m. The apparatus is provided with electro-dynamic loud-speaker and has a tapping for connection of a pick-up. The tone character can be varied from light to dark by means of a switch.

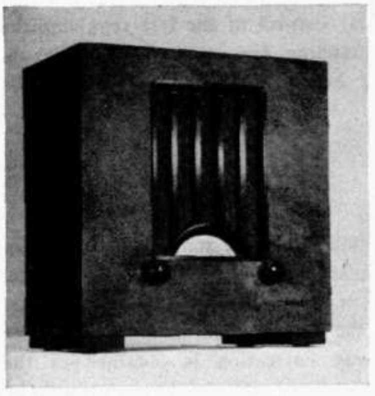

Fig. 8 X 3631
Ericsson 362

Ericsson 362 is made for AC, for universal current and for battery operation. The mains connection has a high-frequency pentode as detector, an 8 W final pentode and rectifier valve. In the battery type the detector is a screen-grid valve, followed by a triode and a class-B double valve. The total anode-current consumption at rest is about 6 mA with 120 V anode tension.

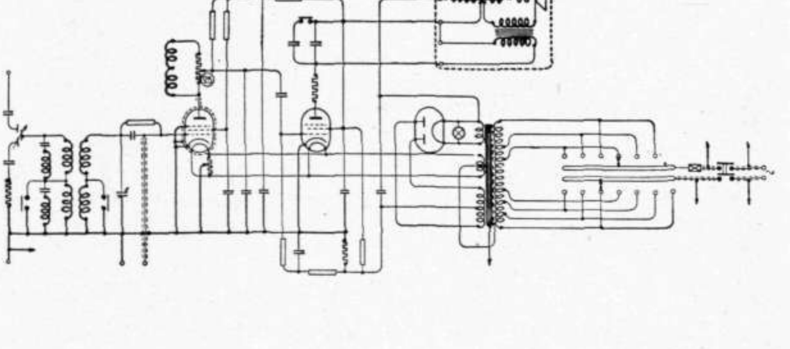

Fig. 9 X 5309
Connecting diagram for single-circuit receiver, Type 362
for AC, 3 valves incl. rectifier, wave-length range 190—580 and 715—2000 m, output 2 W

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On the cover: 500-Line Selector for the Ericsson Automatic Telephone System

Telegraph and Telephone in the Service of the Railways

I. BILLING, ADMINISTRATIVE DIRECTOR, SWEDISH STATE RAILWAYS, STOCKHOLM

The following article gives a survey of the development of telegraphy and telephony in the service of the railways, particularly a picture of their importance in different fields of the Swedish State Railways.
The article is reprinted by courtesy of »Teknisk Tidskrift», December 5th, 1936.

Indicator and Morse Telegraphs

The first lines of the Swedish State Railways were opened for traffic on December 1st, 1856, i. e., 80 years ago. The Stockholm—Gothenburg line was completed on November 8th, 1862, and Stockholm—Malmö on December 1st, 1864.

In a report on the Swedish State Railways of 1872 the electric telegraph is described as follows: »two telegraph lines were installed along the railway, one for telegraphy by means of electromagnetic indicator apparatus manufactured by Siemens and installed at every station along the railway, the other for telegraphy at greater distances with Morse writing apparatus and installed at the more important stations 50 to 60 km apart. With a spacing of 200 feet the wires were carried by porcelain insulators attached to poles about 24 feet high and 0.4 feet wide at the top, mostly of impregnated spruce wood. The poles were placed about 12 feet from the centre of the track with the tops as far as possible at the same height above the tracks in order to make the wires easily accessible for connection of the telegraph apparatus needed for telegraphy from a train stopping on the line.» Thus already from the beginning there were two separate telegraph systems: the indicator and the Morse system.

Fig. 1 X 3685
Indicator telegraph apparatus

The transmitter, Fig. 1, of the indicator telegraph consists of an inductor coil with iron core which is made to revolve between the poles of a permanent steel magnet. The induced AC is led through the telegraph wires to the receiver formed by a polarised magnet the armature of which is brought to move between the poles of the magnet. This movement is transferred to a pointer by means of a lever and a toothed wheel, the pointer being moved step by step over a dial with letters. The transmitter has a handle, which by acting on a toothed brass ring makes it possible to regulate the movement of the inductor so that a number of impulses corresponding to the letter to be telegraphed is transmitted. Letters and figures are marked on a dial over which the handle turns.

For all State Railway lines built up to 1906 the indicator telegraph system was used and the number of apparatus reached a maximum of 364 in the year 1893. From then the number decreased because of the introduction of Morse telegraphy on closed circuits and the indicator telegraph system was wholly discarded in 1913.

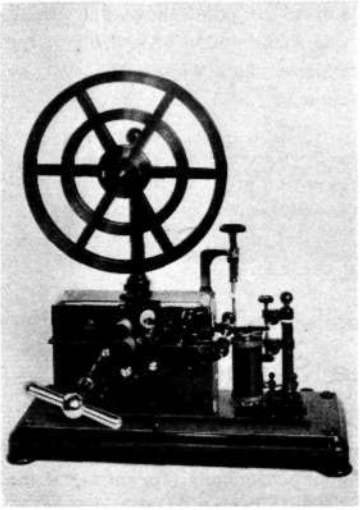

Fig. 2 X 3686
Morse telegraph apparatus

The Morse telegraph system, Fig. 2, is so well known that it does not need to be described here. In addition to the Morse circuit arranged at the time a railway was built, need for further circuits arose with increased traffic, especially for great distances. The telegraph network reached its maximum length of about 23 600 km in 1919. The original Morse telegraph was designed for operation on open circuits characterized by no current flowing when telegraphy was not going on. For local telegraphy on circuits with many stations, on the other hand, the system with closed circuit was more suitable. This is characterized by current flowing also when telegraphy is not going on; when telegraphing the current is first interrupted and marks are then made by the closing of the current. Another application of this system is found in Germany and other places, where the marks are made when the current is interrupted.

The Morse system for closed circuit, an advantage of which is the use of only one battery common for all the stations on the line, was tried by the State Railways in 1892 and later replaced the indicator telegraph system. The development of the system for closed circuit is shown by the following figures: in 1892 68 km of lines were installed and in 1900 the number was 817; by 1905 the length had increased to 2 331 km and it reached its maximum of 8 338 km in 1925. In 1935 the total length of the network was only 222 km.

Magneto lines

The telephone came into use by the State Railways about 1880 and was employed for connection of stations not equipped for telegraphy. In 1906 local telephone circuits to a number of about sixty were installed, the length of double-wire lines being 65 km and that of single-wire lines 15 km. The number of telephone instrument was about 200.

The first double-wire telephone circuit was completed in 1905 in the north of Sweden and comprised 36 lines and 22 telephone instruments. In 1911 the State Railways decided to equip all new railway lines with telephone facilities and in the beginning of 1936 the telephone network comprised 10 500 km of circuits and 4 050 telephone instruments.

The open wire lines consist of 3 mm iron wire on insulators. The telephone sets have a five-magnet hand-generator and a bell with a resistance of 2 000 ohm. The lines are generally sectioned for certain stations so that 8 to 10 instruments are connected to a section. The sections may be interconnected by means of switchboards. Morse code signals are used. The stations are further divided into two groups, one group being called with earth return and the other on the loop circuit. The linemen call each other as usual on the double line but when they call a station they earth the line through the hand-generator by means of a press-button switch.

Where cables have been provided one 0.9 mm circuit is used for the linemen's dwellings and another for the service posts.

As long as the indicator telegraph system was in service an indicator apparatus was carried by the trains on certain lines in order to enable the sending of messages when the train stopped on the line. After the indicator telegraph was abandoned, it was decided in 1911 that a telephone set mounted in box in the luggage van with wires for connection to the telephone or telegraph circuits should be available on certain trains. Where a telephone set was not carried by the trains arrows of zinc plate on the poles showed in which direction the nearest telephone instrument was to be found. After about ten years this train telephone system was abandoned and wholly replaced by arrows indicating the nearest telephone instrument.

On electric railways also such arrows are to be found. The line-men patrolling the line carry a light portable telephone instrument which may be connected to terminal boxes mounted on their houses or at unattended stations or to special telephone posts arranged along the line.

Selective-Calling Telephone System

After telephony had been installed along all railways a demand for an increased number of telephone circuits rapidly arose, especially for greater distances than could be covered by the ordinary telephony, for instance for connection between the stations and the principal station of the section, in order to facilitate urgent communication about train dispatching etc. The first step was to construct new lines with better transmission characteristics, i. e., copper lines instead of the iron lines used for the ordinary telephony. Further it became necessary to introduce a new signalling system where several stations were connected to a line, in order to enable the calling of a certain station without disturbing stations not concerned.

Fig. 3 X 3687
Selective-calling keyboard
Western Electric system

In 1914 selectors manufactured by Western Electric Co. were installed on trial. This equipment, comprising 8 stations on a line 32 km in length, resulted in a further equipment with 25 stations on a line of 200 km being installed in 1916. The experience gained led to installation of selective calling systems being continued. On certain lines even two or more systems were installed. In 1931 there were 5 000 km or 77 % of the State Railways equipped with selective-calling systems comprising about 6 780 km of circuits and 824 way stations.

The selective-calling system of Western Electric Co. is so designed that the principal station is equipped with a cabinet with associated battery and a selector key for each station, Fig. 3, enabling the selective calling of any station. The way stations are equipped with a selector with accessories, Fig. 4, for receiving the signals. The selector keys are so adjusted that different signals are transmitted for each station on the line. The selective calling system is based on signals with AC impulses and each key transmits 17 impulses. Through the dividing of the impulses into three different groups separated by pauses and each group comprising at least 2 and at most 13 impulses, 78 different signals may be transmitted by means of these keys. On the State Railway lines never more than 36 stations are connected to a section.

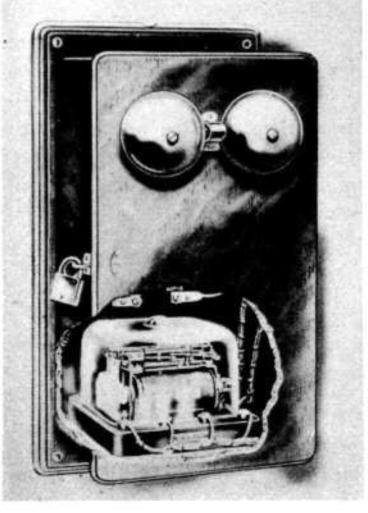

Fig. 4 X 3688
Selector apparatus
Western Electric system

The way-stations have one selector each, adjusted for the calling signal of the station in question. It is true that the selectors work in all the stations when calling but, thanks to the signals being divided into groups and the adjustment of the selectors, only the selector of the called station arrives at a position where a locally operated bell is started. In all other stations the selectors stop in a position not causing a signal. After the signal has been given all the selectors return automatically to their normal position. A special arrangement enables the principal station to check that the signal has been given correctly. A signal may also be sent during a call, in order to allow the putting through of urgent calls and to save time. A call from a way-station is put through by means of the hand-generator

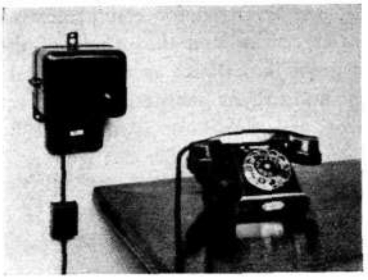

Fig. 5 X 3689
Telephone instrument with selector
Ericsson system

of the telephone set and may be received only by the principal station, which either receives the message or calls selectively another way-station.

During recent years the State Railways have also installed the selective-calling system, Fig. 5, manufactured by Telefonaktiebolaget L. M. Ericsson. The first equipment was installed in 1933 on the line Gävle—Uppsala with direct connection to Stockholm. The Ericsson selective-calling system is designed for decentralized selection, *i. e.*, the way-stations along the line may call each other directly without the assistance of a main station. A detailed description of this system may be found in the Ericsson Review Nö 1, 1933, and elsewhere in this issue.

A great advantage of the Ericsson system is that it can cooperate directly with automatic telephone exchanges. This arrangement has come into wide use in the State Railway network.

At the beginning of 1936 there were selector systems of both types in use on about 12 000 km of lines and with about 1 250 selectors. During the year about 300 selectors have been added.

Train Dispatching

In connection with the electrification of the ore-carrying railway in Lapland some new telephone circuits were provided, one of which was a train-dispatching telephone circuit with inductor signalling intended for the direction of the trains, the supervision of train passings etc. This circuit has not been used as anticipated, however, and the train dispatching is chiefly operated on the selective-calling lines. Further there was installed a selective-calling circuit intended for connection with the power station and the transformer stations and also for all the technical departments such as the railroad and engine departments.

As electrification has continued one or more selective-calling circuits in telephone cables have generally been provided. Signalling on these circuits has been arranged according to different systems depending on local circumstances, traffic intensity etc. Thus on the train dispatching circuits either inductor and bells with code signals according to the Morse system or buzzer or selective calling have come into use.

The train dispatching circuits are used chiefly for the direction of trains and for the distribution of rolling stock but on certain lines other circuits with selective calling have also to be used for these purposes. The trend is to adopt exclusively the use of selective calling circuits for the direction of trains and rolling stock distribution, at least on the more important lines.

As a further development there have lately been added direct telephone circuits between the power stations or transformer stations and the converter plants of the State Railways. Especially when the line faults occur it is of great importance that reports and orders concerning switching etc. may be dispatched immediately. Generally selective calling is used on these circuits also.

Direct Telephone Circuits

Even before electrification some railway lines were equipped with direct long-distance telephone circuits in spite of their cost often being high. In connection with electrification, however, cables have been provided and a network of direct telephone circuits has been arranged for communication between the section principal stations, district centres and the offices of the railway board. These direct circuits are of great importance as they facilitate a clear and detailed discussion of important and urgent questions. The direct circuits are introduced in the switchboards and signalling is obtained by means of voltage from the mains, ringing machines or pole changers.

Carrier Circuits

In the north of Sweden, where the electrification and laying of cables have not yet been completed, the urgent need of direct telephone circuits has been met by means of single-channel carrier-telephone systems, each system offering a second facility on the existing circuit. The first single-channel system was installed in the beginning of 1935 on the line Ånge—Vännäs, 373 km, where a selective-calling circuit was available but no direct circuit. After laboratory and practical tests Ericsson had succeeded designing suitable by-pass filters, which take the voice-frequency channel to the selector equipment as usual but let the carrier channel pass by. The number of way-stations is twenty. This equipment was described in the Ericsson Review No 1, 1935. A second single-channel carrier-telephone system was installed on the line Vännäs—Boden in 1936. The total length of the carrier circuit is 660 km and the results have been exceedingly good, the traffic between Stockholm and the north of Sweden being extremely improved.

Cable Network

The continued electrification of the railways in the north of Sweden has caused an increased demand for telephone facilities. It is true that no cable has been arranged yet along the ore-carrying railway in North Sweden but the existing pole line was moved away from the tracks about 50 m. There is only one telegraph circuit but the telephone circuits number 3 to 7 on different sections. With the electrification of the Stockholm—Gothenburg line in 1924 the first long-distance cable was provided. The cable was designed for the number of existing telegraph circuits but for telephone circuits five times the existing number. The number of telegraph circuits was thus not yet being decreased, but when later, the Stockholm—Malmö cable was installed the shifting over from telgraphy to telephony was carried through. This cable contains only one telegraph circuit but a number of side and phantom telephone circuits.

When designing the Stockholm—Ånge cable, telegraph facilities were also reduced. This cable, however, is interesting from another point of view, *i. e.*, it was designed for use in common by the State Railways and the Telegraph Administration and is consequently of a heavy type. Compared with the former open-wire lines 19 990 km in length the cable contains, phantom circuits included, about 80 500 km of circuits.

The cables are designed for a break-down voltage of 2 000 V, 50 c/s to earth and 1 000 V between the circuits except for the Stockholm—Gothenburg cable where the test voltage is 2 000 V also between the circuits. The wire diameter is 0.9 and 1.3 mm except for the lines Stockholm—Gothenburg and Stockholm—Malmö, where the diameter is 1.4 mm and Stockholm—Uppsala, where some wires have a diameter of 1.1 mm. Between Stockholm and Ånge a four-wire circuit operated on two phantom circuits is used by the State Railways.

All cables are loaded. As a rule about 10 pairs have been left unloaded, *i. e.*, circuits for block signals, registering, calling, telegraphy etc. The cut-off frequency is generally 2 800—3 000 c/s and the attenuation 0.009—0.010 neper/km for 1.3 mm circuits and 0.017—0.018 neper/km for 0.9 mm circuits. The cut-off frequency of the phantom circuits is higher, for two-wire circuits 3 500—3 700 c/s and for four-wire circuits 4 400 c/s. Details about the cables are to be found in the Ericsson Review No 3, 1934.

The growth of the cable network since 1924 is shown in Fig. 6. The present length of the cable network is more than 3 000 km, considerable quantities of local cables on railway stations etc. not included.

Telephone Repeaters

The first telephone repeaters were installed about 1920 on the open-wire lines Stockholm—Gothenburg. The direct cable circuits on this line contain two repeaters each; there is a total of fourteen repeaters which were installed in 1924.

On the line Stockholm—Malmö each cable circuit contains three repeaters. The total number of repeaters is 72 installed in 1932, spread over six stations.

On the line Gothenburg—Malmö 15 repeaters are installed and between Stockholm and Ånge there are 45 two-wire repeaters and 4 four-wire repeaters. Recently Ericsson has installed repeater stations on the Stockholm—

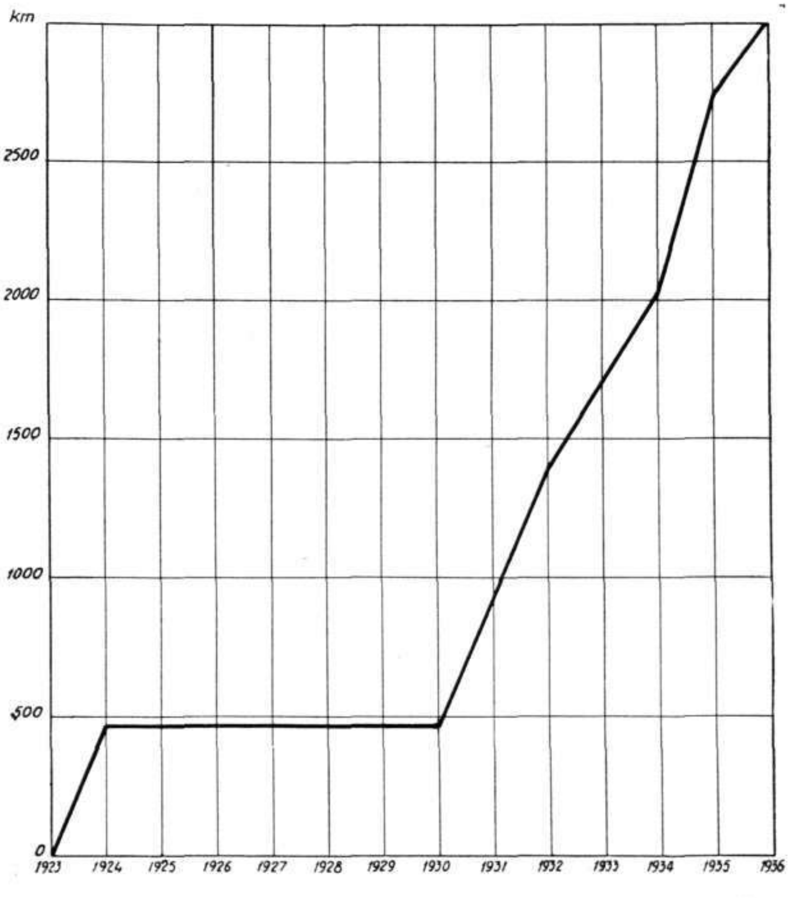

Fig. 6 X 5349
Development of the State Railways telephone-cable network

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Gothenburg and Stockholm—Oslo lines, containing a total of 16 two-wire repeaters. These stations are described elsewhere in this issue.

Transition from Telegraphy to Telephony

As shown in the diagram, Fig. 7, there were in 1930 about 20 000 km of telegraph circuits and the same length of telephone circuits. At that time a new regulation to ensure safety was put in force by the State Railways, thanks to which it became possible to use telephony alone instead of telegraphy for giving orders and exchanging information. This arrangement was found to save time and staff and also offered the advantage that train dispatchers did not need to be skilled telegraphists. Following this experience the State Railways decided in 1930 to change over successively from telegraphy to telephony as new telephone circuits were installed to be used for train dispatching and information about goods and passengers traffic. This change over is now practically completed.

At the beginning of 1936 the total length of telegraph lines was only about 3 500 km compared with 62 000 km of telephone lines. The number of telegraph apparatus at the same time was about 100 compared with about 8 000 telephone instruments.

Telephone Exchanges

As the telephone was introduced a demand for telephone exchanges became apparent, especially in the principal stations of the sections, for connection with the local lines. At first small manual exchanges for 4 section lines and 16 local lines were provided. Later on the capacity of these exchanges was increased to 50—100 local lines. Larger manual exchanges with connection to the public telephone network were installed in many places, e. g., in Stockholm where an exchange with 450 lines and 9 positions was installed

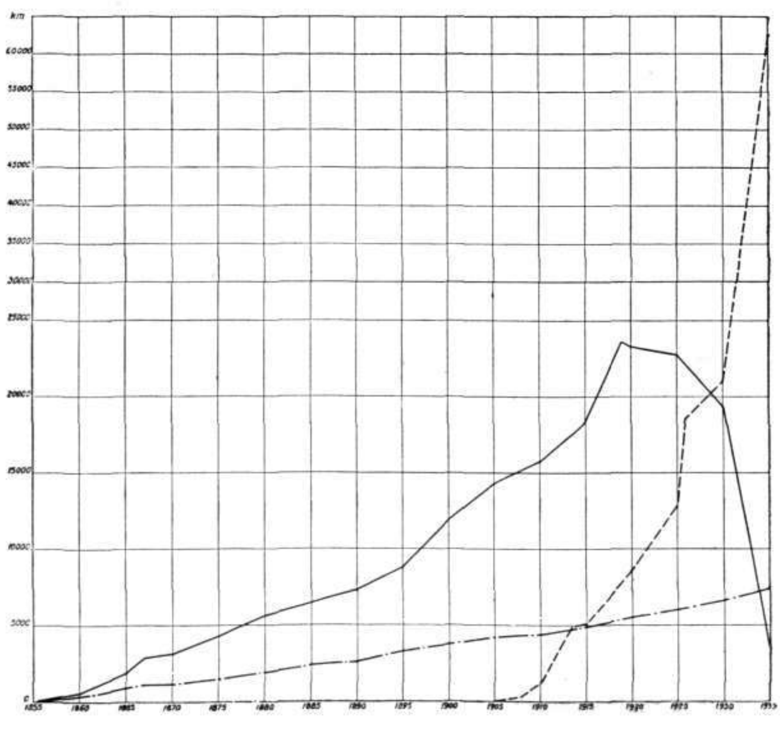


Fig. 7 X 5347
Development of the State Railways telegraph and telephone network
——— telegraph circuits
— — — telephone circuits
—·—·— railroads in service

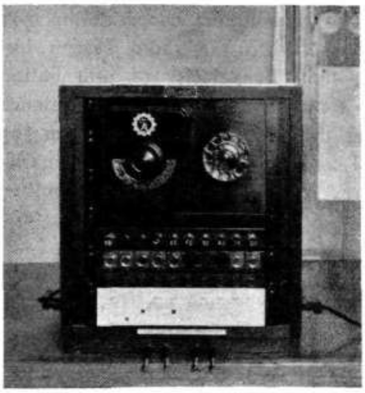


Fig. 8 X 3691
Telephone switchboard

in 1917. Automatic exchanges were introduced in 1924 by a 20-line installation at Stockholm N. In 1926 a 50-line exchange was installed at Stockholm C for communication between offices, platforms etc. In Gothenburg an automatic exchange for 100 to 200 lines was installed in 1929.

The development in the field of exchanges has followed the increase of the telephone-cable network. Not only large manual exchanges but also new important automatic exchanges with connection to the public telephone network have been installed. In Stockholm an automatic 1 000-line exchange has been provided and in Malmö one for 150 lines. An new automatic exchange is also to be installed in Gothenburg. In other places of importance also automatic exchanges to a number of about 30 have been installed and extension exchanges, Fig. 8, provided with keys for about 10 lines and a dial for calling on automatic lines are to be found.

Radio Telegraph Circuit

On the train-ferry line Trälleborg—Sassnitz opened up for traffic in July 1909 it was soon found necessary to arrange wireless telegraph link for urgent service information. The first apparatus were arranged as spark telegraph for 300 to 600 m wavelength, Telefunken system. They were put in service in January 1912, and made available for private messages in the following month.

In order to keep pace with modern technics and not to disturb the broadcasting service then in development the wireless stations were modernized in 1925 with valve transmitters for continuous waves on normally 720 m. Later on the stations have been extended, especially with a view to ensuring safety at sea.

At present tests are being carried out with short waves, 85—190 m, in order to enable a change-over from telegraphy to telephony but it seems necessary to let the telegraph stations remain in service for transmission of messages in foreign languages. After the test the radio link will be connected to the public telephone network for private use at first over Gothenburg Radio and, when Malmö Radio becomes ready, over this station.

Radiogoniometry

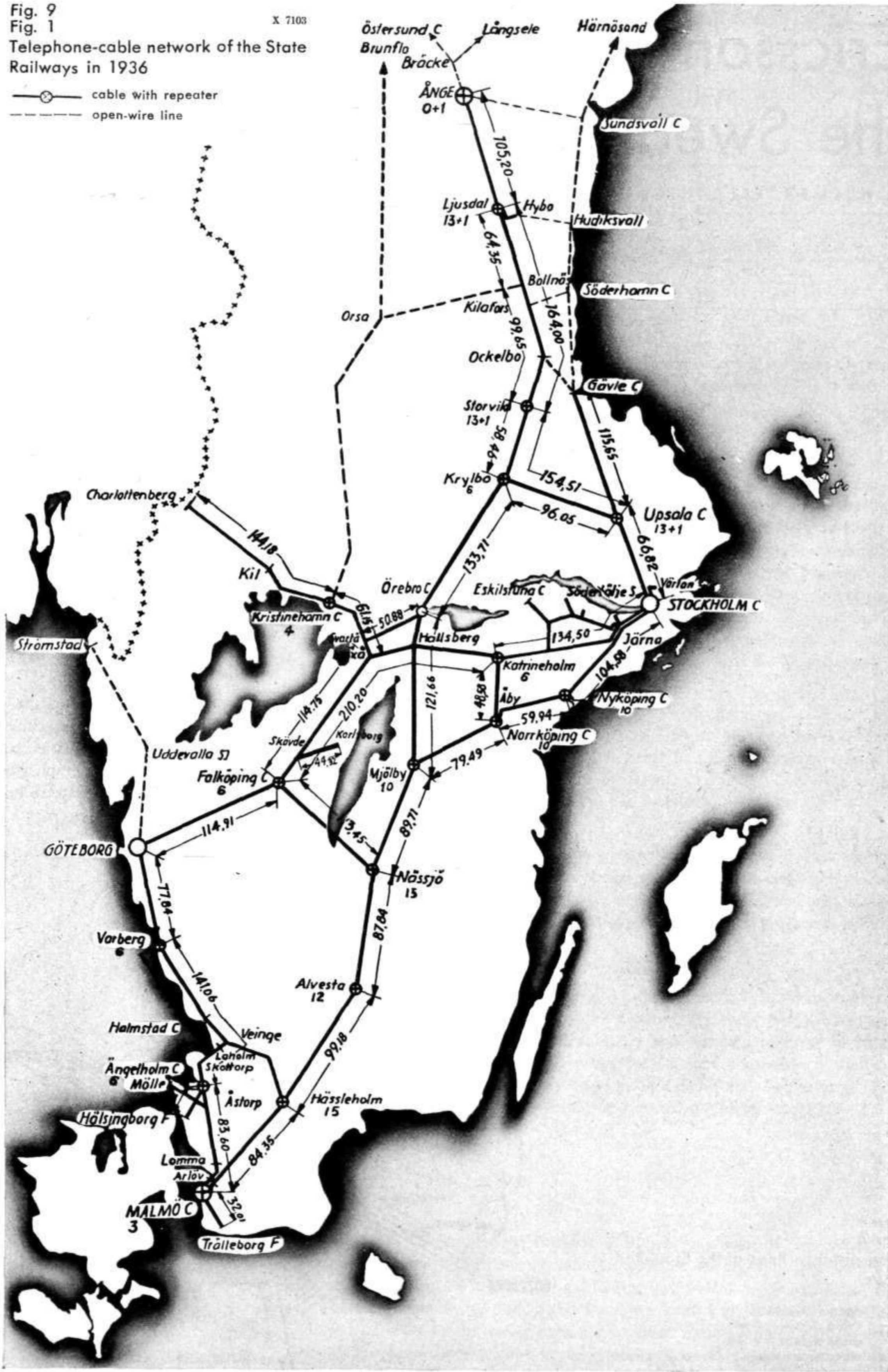
The Swedish ferry-boats on the line Trälleborg—Sassnitz were equipped with radio direction-finders in 1927 in order to facilitate navigation in cooperation with the German transmitters on Rügen. Two years later a fog-signalling station was installed in Trälleborg. This station comprises a radio beacon, a submarine-transmitter and a sound transmitter controlled from a common control room at the ferry station in Trälleborg.

The radio beacon consists of a transmitter placed in line with the harbour entrance channel at the outer end of which the submarine diaphragm transmitter is placed on the bottom of the sea and connected with the control room by a cable. The radio beacon, started automatically from the control room, transmits continuous waves at a frequency of 297.5 kc/s modulated with 423 c/s. It transmits the letters *TR* three times and then 14 marks each of a duration of 1 second and with a spacing of 0.3 s. The submarine-transmitter is driven by AC 525 c/s and gives a tone of 1 050 c/s in the form of the letters *TR* every 8 s. The two transmitters cooperate in such a way that the submarine-transmitter starts when the radio beacon has transmitted its last letter *R*. Considering that the velocity of propagation of sound in the water of the Baltic sea is 1 nautic mile in 1.3 s the distance may be determined by means of counting the marks transmitted from the radio beacon before the submarine signal is heard. The number of marks found gives the distance between the ferry and the submarine transmitter in nautic miles.

The direction-finding receivers have 8 valves, 4 high-frequency amplifier valves, 1 detector and 3 low-frequency amplifier valves. A frame aerial on top of the bridge serves as a receiver aerial. The frame is turned by means of a wheel moving round a fixed disc, on which the position of the frame in relation to the keel line of the ship may be read. The frame is turned until sound minimum is found, which occurs when the frame is perpendicular to the direction of the radio beacon. As an example of the exactness of the direction-finding equipment it may be mentioned that at tests carried out over a distance of 10 nautic miles the error was $\pm 1^\circ$ to $\pm 0.5^\circ$ only.

Fig. 9
Fig. 1
Telephone-cable network of the State Railways in 1936

X 7103



Ericsson Telephone Repeaters for the Swedish State Railways

O. HELMER, ELECTRICAL ENGINEER, SWEDISH STATE RAILWAYS, STOCKHOLM

The Swedish State Railways have ordered from Telefonaktiebolaget L.M. Ericsson three modern repeater stations for modernizing long-distance circuits of the State Railway telephone-cable network between Stockholm and Gothenburg and for the provision of new circuits between Charlottenberg and Kristinehamn on the one side and Stockholm or Gothenburg on the other.

The first State Railway line in the South of Sweden to be electrified was Stockholm—Gothenburg, 458 km in length. In order to protect the telephone and telegraph lines removed to a distance from the railroad against disturbance from the traction system this was equipped with a special return wire of copper and a number of booster transformers inserted in the trolley and return wires. This arrangement, however, was not sufficient to protect the signalling circuits of the railway as long as these were open-wire lines on poles along the railroad. It thus became necessary to adopt cable circuits in order to keep the telephone and telegraph lines inside the area of the railways. An iron-armoured lead-sheathed cable was installed in the road-bed about 2 m from the centre of the tracks.

The cable used contained 25 pairs between Stockholm and Järna and 21 pairs between Järna and Gothenburg. As during the first half of 1926 the whole line Stockholm—Gothenburg had already been electrified the cable was put in service a little before that time. A considerable number of telegraph circuits was still in use at that time and consequently only a few circuits were loaded.

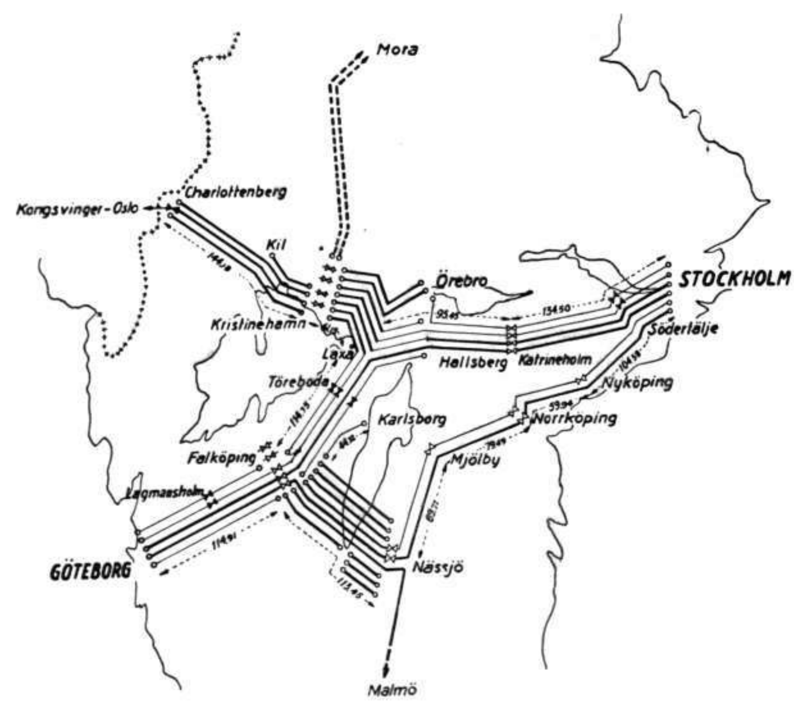


Fig. 2 X 5331

Long-distance lines of the State Railways

- open-wire circuits
- cable circuits 1.4 mm
- cable circuits 0.9 mm
- repeater stations
- rural-line repeaters

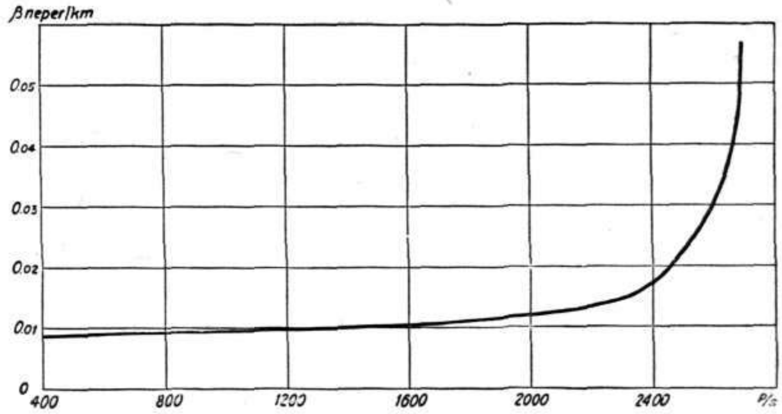


Fig. 3 X 5332
Attenuation characteristic of 1.4 mm cable circuit

Six of the pairs with a diameter of 1.4 mm were reserved for long-distance telephone communication and equipped with telephone repeaters in Katrineholm and Falköping and, to begin with, also in Hallsberg.

During recent years further electrification has been carried out and telephone cables provided. Among these may be mentioned the lines Mjölby—Hallsberg—Krylbo and Nässjö—Falköping which have connection to the line Stockholm—Gothenburg. At present the line Laxå—Charlottenberg is electrified, see Fig. 1, which has caused new demands on the telephone circuits, requiring a new repeater station in Kristinehamn. The old repeaters in Katrineholm and Falköping with their reduced gain have been judged out of date. The State Railways therefore ordered three modern repeater equipments to be installed in Katrineholm, Falköping and Kristinehamn. All three equipments have been manufactured by Telefonaktiebolaget L. M. Ericsson.

The repeaters are all of the two-wire type. In Katrineholm two repeaters are operated on 1.4 mm circuits, two on 0.9 mm circuits and two repeaters are spares. In Falköping two repeaters are inserted in 1.4 mm circuits, one in a 0.9 mm circuit and three repeaters are operated as cord-circuit repeaters. In Kristinehamn four cord-circuit repeaters are installed.

Fig. 2 shows schematically the repeatered circuits. At 800 c/s the attenuation of the cable pairs is 0.0089 neper/km on the 1.4 mm circuits Stockholm—Falköping, 0.0090 neper/km on the 1.4 circuits Falköping—Gothenburg; 0.0089 neper/km on the 1.3 mm circuits and 0.0163 neper/km on the 0.9 mm circuits Laxå—Charlottenberg.

Fig. 3 shows a typical attenuation curve for a cable section. In order to obtain an overall attenuation of max. 1.50 neper between Stockholm and Gothenburg the gain of the repeaters in Katrineholm has been set to 1.30 neper and that of the Falköping repeaters to 1.75 neper for 1.4 mm wire. Fig. 4 shows a level diagram for a 1.4 mm circuit between Stockholm and Gothenburg. The gain of the repeaters may be adjusted in steps of 0.1 neper up to 2.2 neper, see Fig. 5.

Design

The repeaters are mounted on iron racks with a maximum of four repeaters in each bay, see Fig. 6. Each repeater is mounted on its own panel and the two amplifier valves as well as the gain-adjusting devices are accessible at the front of the panel. Ballast lamps and fuses are located at the top of each bay and rows of jacks for incoming lines are found at about the middle of the bay. Beneath the jacks there are two keys by means of which the ringers located at the bottom of the bay are tested.

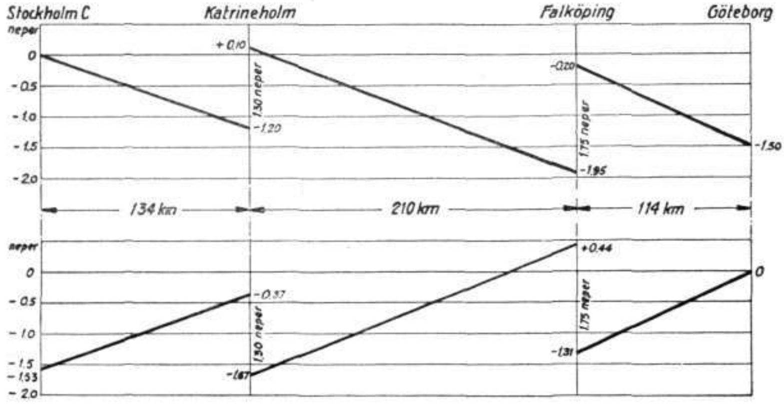


Fig. 4 X 5346
Level diagram for 1.4 mm cable circuit

The repeaters with accessories are housed in a separate room in the station building. The long-distance cables enter this room and are terminated in boxes. From here the telephone circuits are carried in lead-sheathed cables to the tops of the repeater racks, where they are terminated in connecting strips on the rear side. From the strips the circuits are brought to the above-mentioned jacks and thence to the different repeaters and associated apparatus. All the wiring is located at the rear of the bays.

The middle bay of the station is the *test bay*, Fig. 7. Immediately beneath the ballast lamps and fuses at the top of the bay is the voltmeter with associated keys for connection to the filament and anode circuits. Beneath the voltmeter there is a panel holding instruments and adjusting devices of the level-measuring receiver; on the scale to the right attenuations and gains are read.

By means of the three keys on the lowest panel any of the frequencies 300, 500, 800, 1 000, 1 400, 2 000 and 2 400 c/s are obtained from a valve oscillator connected to the level measuring set. The oscillator and the level-measuring set are started by removing insulating plugs from jacks in the jack panel. From the other rows of jacks the measuring set may be connected to any of the repeaters or incoming cable circuits by means of plug cords. Further an attendant's telephone set operated by keys is provided on the test bay.

To the left of the test bay, Fig. 6, the bay holding line transformers and balancing networks are found and further to the left the *power-supply bay*. The power supply of the repeater station is drawn from the single-phase 220 V, 50 c/s, lighting mains of the railways. The AC is rectified by means of metal rectifiers located at the rear of the power-supply bay. A DC voltage of 130 V is provided for the anode circuits of the valves and 24 V for the filaments. The voltages are adjusted by means of dials on the front of the power-supply bay. In case the AC fails, two spare current sources are started by means of relays on the power bay. These current sources consist of an accumulator

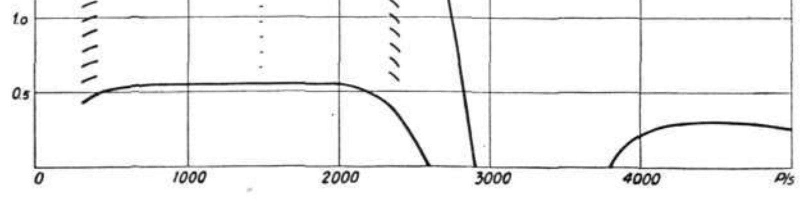


Fig. 5 X 5333
Gain characteristic of a repeater at different settings

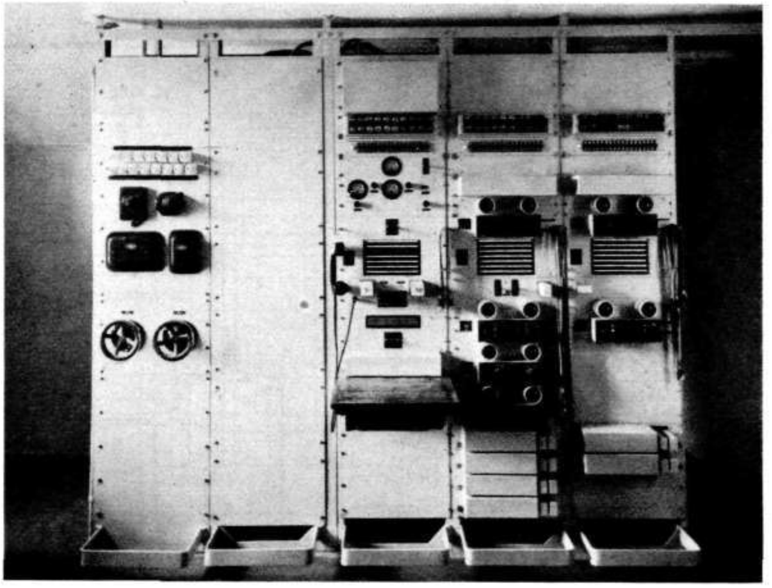


Fig. 6 X 5334
Katrineholm repeater station
left to right power bay, transformer bay, test bay, two repeater bays

battery providing 24 V for the filaments and a rotary converter for 130 V operated on the battery. The DC voltage of the converter is adjusted by means of a resistance.

The ringing relays are designed for 16 $^2/_3$ c/s, normally obtained from a rotary converter operated on 220 V 50 c/s single-phase. If the 50 c/s AC fails, however, ringing current is drawn from the spare converter. Fuses for all the converter and battery circuits are found at the top of the power supply bay. Beneath these fuses and to the right of the regulating resistance is a main switch disconnecting the repeater station. The rectifiers with accessories are mounted at the rear of the bay.

Principle Diagram

The principle diagram, Fig. 8, is applicable to all the stations as only two-wire repeaters are used. The line L_A is connected through the differential transformer *1* both to the balancing network B_A and through the filter *2* to the ringer RL_A—RF_A, this latter having a ringing relay and a condenser *8* connected in series between the branches. The ringer transmits the new ring signal through the relay *9*. The equalizer *3* and the potentiometer *4* regulating the input on the grid transformer *5* are connected inside the ringer RF_A. The output side of the valve is connected to the line L_B through the transformer *6*, the filter *7* and the differential transformer *1*. The transformer *1* is also connected with the ringer RL_B—RF_B through the filter *2*. The equipment for the opposite direction is shown at the bottom of the diagram and the ringer at the top of Fig. 8.

Metal rectifiers, Fig. 9, deliver DC required for the valves and other purposes. The single-phase supply 220 V is connected to the transformers *1* and *2* variable in steps and further to the metal rectifiers *5* and *6* arranged as a bridge. The resistances *3* and *4* are adjusted by means of two wheels on the power-supply bay, Fig. 6. Smoothing filters *7* and *8* are inserted between the rectifiers and the valves. The filaments of two valves are connected in series.

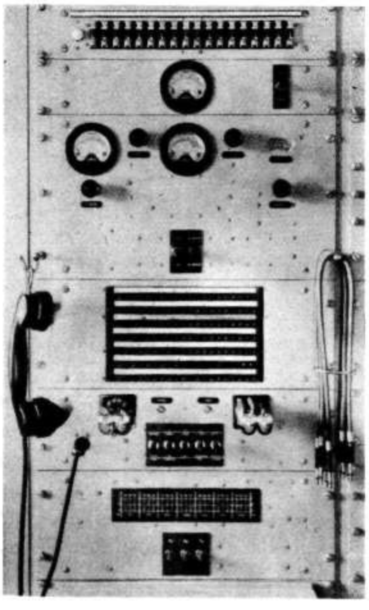


Fig. 7 X 3684
Rear view of test bay
top to bottom fuse panel, voltmeter panel, level-measuring instrument, jack panel, attendant's panel and oscillator panel

The filament drain of each repeater is 0.25 A. Consequently the disconnecting of a repeater causes a voltage increase on the 24 V circuit. In order to avoid this increase, resistances combined with jacks where the filament current is interrupted have been arranged, *i. e.*, when the current is interrupted the resistances replace the filaments. By means of this arrangement the 24 V

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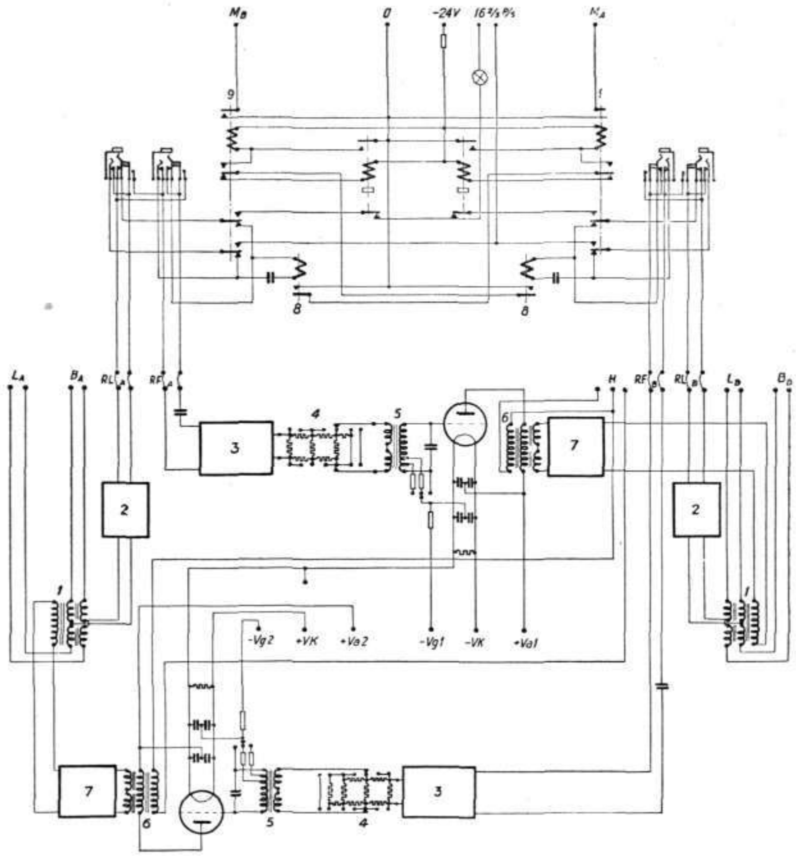


Fig. 8 X 5335
Principle diagram of repeater equipment

top ringer, bottom telephone repeater

1	differential transformer
2	filter
3	equalizer
4	potentiometer
5	grid transformer
6	anode transformer
7	filter
8	relay for incoming signal
9	relay for outgoing signal
B_A, B_B	balancing networks
H	monitoring jack
L_A, L_B	lines
RF_A, RF_B	repeater sides of ringer
RL_A, RL_B	line sides of ringer

rectifiers always deliver the same current irrespective of the number of repeaters in use. Further regulating devices have been supplied in the form of ballast lamps, the principle task of which is to neutralize voltage variations on the 220 V mains. On the 130 V side no provision for automatic voltage regulation has been made.

Fig. 10 shows the lower part of the power supply bay. From the top to the bottom are to be seen the two regulating resistances, the 24 V rectifier and the 130 V rectifiers in two groups, the smoothing condensers, the 130 V choke coil and the two 24 V choke coils. The transformers are mounted above the regulating resistances.

Power Sources

The ordinary rotary converter, see top of Fig. 9, gives ringing current, 90 V, $16\,^2/_3$ c/s, when the rectifiers are in service. The motor is a single-phase induction motor with auxiliary winding connected through a condenser. The generator is a self-excited DC generator which delivers ringing current from two diametrically opposite points on the rotor to two sliprings. The spare converter consists of a shunt motor for 24 V connected to the accumulator and a compounded shunt generator delivering 130 V DC and 90 V, $16\,^2/_3$ c/s ringing voltage on two sliprings. The motor current increased by the generator load passes the compound winding of the generator and maintains the voltage.

The battery consists of 20 Nife elements of 100 Ah spread over three boxes with 6 elements each and one box with 2 elements, *i. e.*, the battery is arranged in the same way as the ordinary train lighting batteries, by means of which exchange of the batteries is conveniently effected when necessary. The battery is charged by a separate metal rectifier for max. 3 A adjustable in three steps.

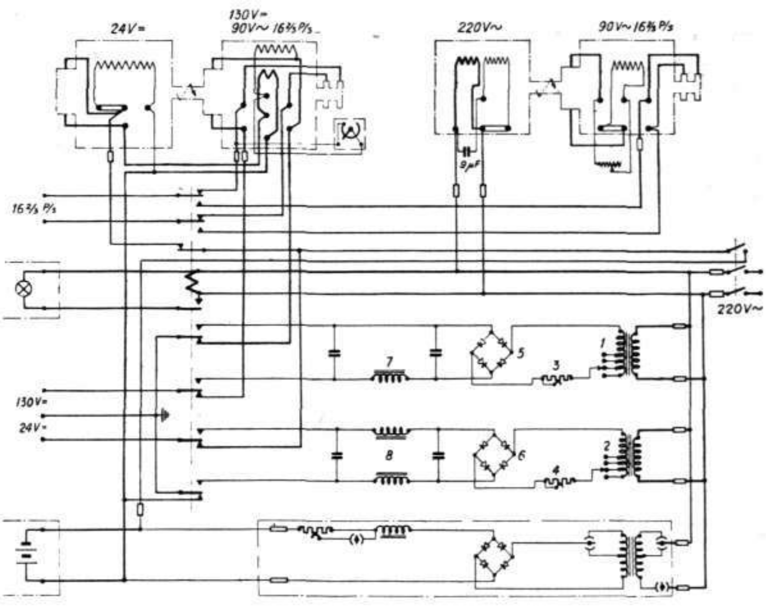


Fig. 9 X 5336
Diagram of power plant
top spare and ordinary converters; beneath, left relays, right anode, filament and charging rectifiers

1, 2 adjustable transformers
3, 4 regulating resistances
5, 6 rectifiers
7, 8 filters

The relay, left in Fig. 9, consists of two relay units operated by 220 V, 50 c/s. The main switch disconnects the battery circuit as well as the AC mains simultaneously. Otherwise the relay would start the converter on the battery when the AC is disconnected.

Cord-Circuit Repeater Exchange

In Falköping and Kristinehamn cord-circuit repeater exchanges have been provided. As the lines are different in length and consequently have different attenuations it would be necessary to adjust the gain for each case; this troublesome operation has been avoided, however, by setting the gain of the repeaters to different values. The operator has then only to select a repeater with a gain suitable for a certain line or group of lines. In Katrineholm only through repeaters are provided.

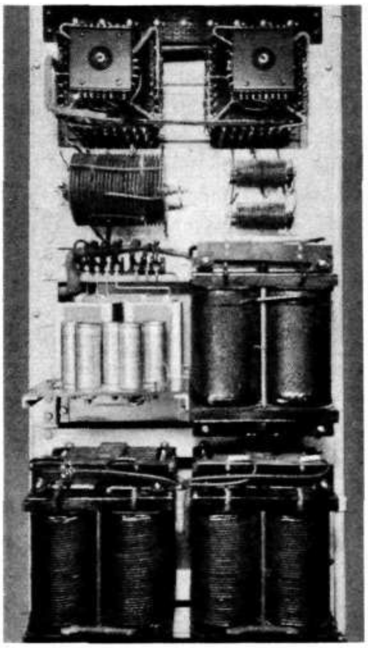


Fig. 10 X 3669
Rear view of power bay
top to bottom regulating resistances, rectifiers, condensers and choke coils

Rural-Line Repeaters

In addition to the permanent repeater stations the State Railways also make use of rural-line repeaters of Ericsson's design in order to improve the transmission conditions on lines already equipped with repeaters or local lines of considerable length, for instance on the lines Stockholm—Gothenburg and Laxå—Kil, Fig. 1. The gain of the repeaters is usually adjusted to 1 neper. The Ericsson rural-line repeater described in the Ericsson Review No 1, 1933, is a two-wire repeater mounted on a panel with sheet-iron cover and intended to be fixed to a wall. The repeater is mains operated on 50 c/s, AC. If the mains voltage fails the incoming lines are interconnected by a relay. The line may consequently still be used but without a repeater. If a gain decrease is suspected a telephone is connected to a jack on the panel and a button pressed; should the telephone sing the gain is satisfactory, but if the telephone does not sing a gain decrease of at least 0.2 neper requires to be neutralized by a changing of valves. In the network of the State Railways rural-line repeaters have been in use five years without supervision and no valves have required changing.

Selective-Calling Telephone Plants on Railways in Sweden

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

In 1932 Ericsson delivered the first selective-calling telephone plant on the system with DC impulsing now in use. Since that time a large number of plants have been installed or are under construction. The greater number of these naturally are owned by the State Railways. However, most of the larger and a number of the smaller private Railways have likewise installed the modern telephone equipment represented by the Ericsson selective-calling telephone system.

Selective-Calling Telephone Plants on the State Railways

Stockholm

The lay-out of the network may be seen on the map, Fig. 1. The lines belonging to the State Railways stretch from Stockholm to Upsala and to Södertälje where the lines branch off to Krylbo, Gävle and Hallsberg, Eskilstuna. In this plant selector lines for four main purposes have been put into operation.

Lines for calls of general nature between stations

For this purpose there are employed two lines northwards and two lines southwards, equipped with the Ericsson decentralized selective-calling system. At the larger stations there are in addition small local exchanges for 8 lines, which are connected to the selective-calling system. All instruments connected to the system can thus be called by means of the dial on the telephone instrument. It should be noted that the network is divided into two sections, terminating at Stockholm, which have no through connection. This division is in accordance with the distribution of the railway into traffic sections. Each of these main divisions is further divided into a number of line sections, constituting independent units permitting calls among themselves. The different line sections can, however, be joined up by means of prefixes, so that priority calls may be connected through. All stations and important points for the service are connected to these line sections.

Lines in the track section, connected to stations, line men and line masters

These lines are also installed on the Ericsson selective-calling system with decentralised selection. The instruments are called by means of the dial without the intervention of an operator. Unlike the lines referred to above these lines have no facility of communication with other line sections. They thus correspond to what are usually called *line-men telephones,* which are most often equipped with magneto instruments, with calls to different instruments by code-signals. This represents the first stage of a development which will probably in the not far distant future be completely adopted, namely, change-over from code-signalling telephone lines to those with selective call.

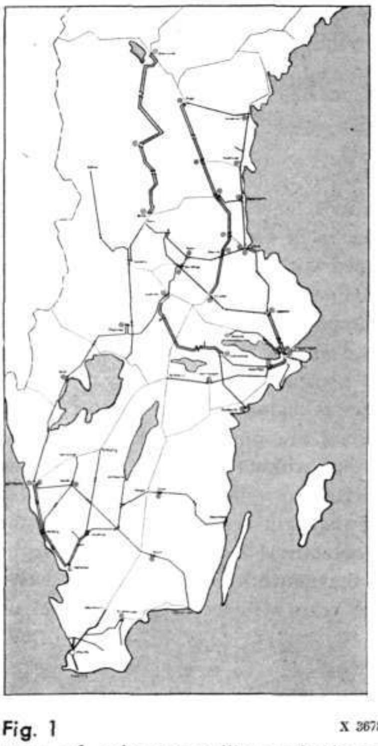


Fig. 1 X 3678

Map of selective-calling telephone plants on railways in Sweden

Lines intended for traffic to and from the telephone exchange at Stockholm

Stockholm constitutes the most important traffic centre in the network, so that a large number of calls are made from there to stations along the line.

For this purpose some of the lines are equipped with selectors for centralised selection. They are connected to the manual exchange in Stockholm C. All calls from the line come to the operator who deals with them. Outgoing calls from subscribers connected to the automatic exchange for Stockholm C and the State Railway Administration are connected by means of a dial on the operator's board who is called by a special number. These lines are thus equipped with a selective-calling telephone system for centralised selection.

Lines for communication with train dispatchers and shunting foremen

The greater number of calls to and from Stockholm are exchanged with train dispatchers and shunting foremen. It is therefore desirable that these persons be furnished with special traffic facilities and this has been arranged by giving the train dispatchers and shunting foremen for each traffic section, *i. e.*, for traffic northwards and southwards respectively, four selector lines in each direction. Each line is connected to all the stations on a certain stretch. These lines are equipped with selectors for centralised selection.

The equipment for train dispatchers and shunting foremen may be seen on Fig. 2. Each of these officials has moreover an assistant who must also be in a position to operate the lines, so that impulsing facilities must be arranged at four points. Each operating point is equipped with a telephone instrument with dial — a normal selective-calling instrument — which can be connected to ten different lines by a ten-position switch. Four of these ten lines are selective calling lines for centralised selection. When a call comes on the line a lamp lights up on a board, showing the number of the line from which the call comes. When the switch is moved to that number and the call is answered the lamps goes out. This can be done at all four places.

It often occurs that more than one selective-calling line connection is to be found at each instrument. At stations, for instance, three to five selective-calling lines may be connected. Thanks to the great simplicity of the Ericsson selective-calling system it is possible for one and the same telephone instrument to be used for all the selective-calling lines. The instrument consists in the main only of a speaking set and a dial, so that connection to the selective calling set may be by two wires only. Connection to the various lines is by means of a ten-position switch of the kind referred to above, see Fig. 3. The selective-calling lines may be of both the centralised and the decentralised systems. The same instrument may be used in both cases, though the dial serves no purpose in the centralised system.

Fig. 2 X 3679
Diagram of telephone equipment for train dispatcher and shunting foreman

The selective-calling units are provided with bells and lamps which light up when the bell rings. As it may be difficult to pick out the number of the calling selector line, each station is equipped with a normal indicator board which is connected to the selective-calling unit. Connection is over a relay group with slow-acting relays, which prevent the indicators from acting should the selector pass ringing position. The simple connection of the telephone instrument also makes it possible to connect more than one instrument to the same selective-calling unit, a facility often employed to connect more than one working place to one and the same selective-calling unit.

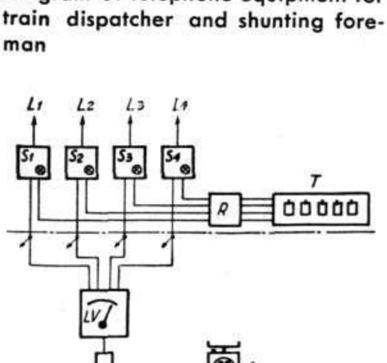


Fig. 3 X 3680
Diagram of telephone equipment at stations

Gothenburg

At Gothenburg there are at present only two selective-calling lines, from Gothenburg to Halmstad. These lines are arranged on the system of decentralised selection. Of the two parallel lines one is sectioned at three places and the other at one place only. The former is equipped with selectors for all stations while the latter line is only connected to the more important stations. At one point the two lines have through traffic facilities and may be joined up automatically. There is also belonging to this district a selective-calling plan which consists of five sections equipped with instruments on the decentralised system.

Malmö

In the Malmö district the main traffic centre, Malmö, is provided with an automatic local exchange on the Ericsson system with 500-line selectors. This system has automatic junction traffic with the selective-calling lines leading out from Malmö. The total number of outgoing lines is nine, all of which are equipped with instruments on the decentralised system.

From the selective-calling lines the automatic exchange is called by a prefix and the operator by another prefix. From the automatic exchange to the selective-calling lines outgoing traffic is also connected automatically—or with the aid of the operator if so desired. It should be noted that on the most important traffic routes two parallel selective-calling lines are connected in PBX connection to the automatic exchange, so that if the first line is busy the call is automatically connected over the other line. If this latter is also busy, the call is nevertheless connected on to the line in question so that the call going on may be hurried up. Thus the traffic route can in no circumstances be entirely blocked.

Östersund

In the Östersund district are to be found the largest network groups, consisting of automatic exchanges, junction lines between these exchanges, selective-calling circuits etc., see network plan, Fig. 4. Automatic exchanges are located at the larger stations. There are junction lines between most of the automatic exchanges, in certain instances two parallel ones. The lines consist of cable on the section Krylbo—Ånge. The remaining portions of the network are made up of open-wire circuits. The length of the cable circuits necessitates repeaters on the longer junction lines. All the junction lines can be switched over to manual operation when traffic is heavy or for other reasons. For example, a line may be switched over throughout the day for manual operation, and only work automatically during the night hours of light traffic.

All the selective-calling lines are on the decentralised system. There are two parallel selective-calling lines between Krylbo and Ånge. All the other sections have but one selective-calling line. At the automatic exchanges the selective-calling lines are equipped with equipment to provide for through traffic. The whole system is designed for open prefixes. These, however, are so selected that the junction line for a certain automatic exchange always has the same number.

In addition to the lines mentioned there is also a large number of lines for code signalling. These lines are used as train order or line-mens' telephone lines. Traffic from the stations where there are automatic exchanges goes through these exchanges, and arrangements have been introduced by which, when a train-regulation line is connected through an automatic exchange to an instrument, code signals can be sent out on the line by means of the dial on the automatic instrument. Thus one impulse gives a short signal and three impulses a long signal. In this way it is possible for the code signal to have a number, *e. g., 1 3 1*. This method of indication is also adapted for use with magneto instruments out on the line, the corresponding code signal being obtained by giving the handle one, three and one turns.

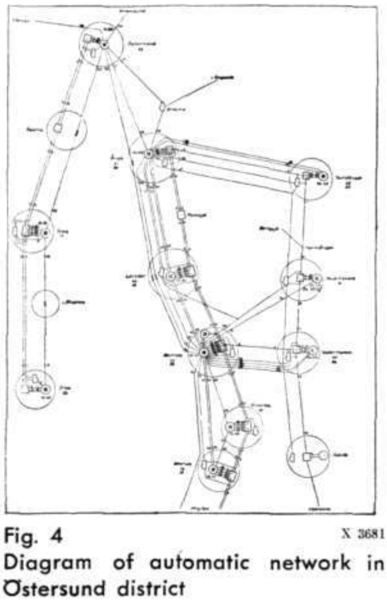


Fig. 4 X 3681
Diagram of automatic network in Östersund district

Fig. 5 shows the station equipment at Bollnäs. This station is equipped with a 90-line automatic exchange, while the station at Storvik has a 48-line exchange. As regards Bollnäs it should moreover be noted that at the repair shops situated a few hundred metres from the station there is in addition an automatic exchange equipped for 32 lines.

To the Östersund district is also attached a selective-calling telephone installation consisting of two parallel selective-calling lines with a total of eight sections. Automatic intercommunication is arranged with the automatic exchanges located at some of the stations. Later this installation will be connected up to the larger system.

Selective Calling Installations on Private Railways

Gothenburg—Småland—Karlskrona Railway

A selective-calling line has been installed between Gothenburg and Karlskrona, this being divided into three sections. At Gothenburg and Växjö small 8-line automatic exchanges are connected. This installation was the first to be delivered by Ericsson.

Halmstad—Nässjö Railway

From Halmstad, where a local automatic exchange is installed, eight sections with automatic joint traffic lead out. This installation is of a certain interest. Normally the Ericsson selective-calling system is so designed that, when calling on a disengaged line, buzzer tone is sent out on the line to indicate that impulse sending from the dial may begin. In the installation here referred to this buzzer tone is divided into code signals differing for each section. It is thus possible always to distinguish which was the last section connected in, which is of importance when the call in question goes over a number of sections.

Grängesberg—Oxelösunds Railway

On this line a selective-calling installation divided into five sections has been installed. There are in addition automatic exchanges at two stations. In respect of this installation it should be particularly noted that double lines have been laid on part of the stretch. The one line is connected to all the stations and divided into three sections, while the other line is not sectioned and is provided with selectors for the more important stations only; this latter line is moreover provided with joint-traffic facilities with the first line at two stations. Consequently it is also available for through traffic.

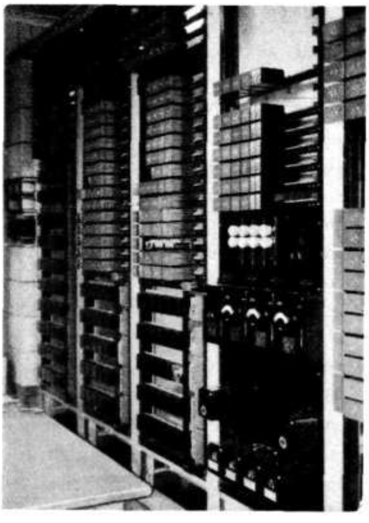


Fig. 5 X 3682
Automatic exchange at Bollnäs

Gothenburg—Dalecarlia—Gefle Railways

This installation is the largest selective-calling installation on any private railway in Sweden. It is divided into eleven sections and is moreover connected to automatic exchanges of large type at three stations. There are moreover automatic exchanges of smaller type for eight lines at other stations. This installation is naturally not designed to handle traffic between the terminals of the line, the possibility of getting through along the whole stretch being very small, as there would be great likelihood of finding at least one section engaged. It is only during the times of light traffic that the line may be counted on for long-distance calls.

In addition to the above installations there are smaller plants on several other private railways.

Impulsing on Selective-Calling Telephone Lines, Ericsson System

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

In Ericsson Review No 1, 1933, a number of systems for impulsing on selective-calling lines were dealt with. The following article gives a fuller exposition of the problem, treating in detail only the Ericsson system for DC impulsing in loops.

The different selective-calling telephone systems may be divided according to the different principles, *e. g.*, into systems with centralised and systems with decentralised operation. In the former the operation of the selectors and the ringing of a desired instrument is done through some point on the line, while in the latter there is the facility of carrying out this operation from each instrument connected. The former system might also be called semi-automatic and the latter automatic. This basis of division chiefly depends on the traffic conditions.

From a purely technical point of view, on the other hand, the selective-calling systems are properly divided according to the manner in which impulsing is carried out. In this case the main basis for division would be the location of the source of impulsing current. In certain systems this impulse current source is embodied in each instrument while in others the source of impulse current is centralised at some point on the line. It is also conceivable to employ a combination of the two systems. The former group comprises systems with AC current impulsing, systems with inductive impulsing and a few others. Among those belonging to the latter group is the Ericsson system with DC impulsing.

Impulsing Circuits

Originally the impulse circuits were designed as shown in diagram by Fig. 1. The selectors and the dial are connected in parallel and both are in addition connected in series each with its electric valve, a metal rectifier. The polarity of the rectifiers is the reverse of the line polarity. The selectors and their rectifiers are permanently connected on the line. The polarity is, however, so selected that it does not give rise to a call, *i. e.*, relay *R1* does not attract for the current passed through by rectifier *Re1*. When the receiver is lifted a contact is closed in the switch-hook so that the line is closed over the dial and the other rectifier *Re2*. This rectifier has low resistance for this polarity on the line, so that relay *R1* in the line equipment is attracted and connects in relay *R2*, which in turn connects in relay *R3*. This last is held over its own contact and cuts off relay *R2* which falls after having been attracted for an instant. Relay *R2* is provided with contacts which reverse the line polarity. For reversed line polarity rectifier *Re1*, however, has low resistance while rectifier *Re2* has high resistance. Thus selector *S* will receive current so long as relay *R2* remains attracted and all the selectors on its own line are attracted. It should be noted that relay *R1* is not cut off by relay *R2* but is held over one half of the winding so long as relay *R2* is attracted.

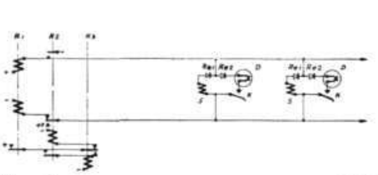


Fig. 1 X 3675
Impulse circuit in the Ericsson selective-calling system
old form

On impulsing by the dial, at the beginning of each impulse the short-circuiting of the line over rectifier *Re2* is broken, so that relay *R1* and thus also relay *E3* are released. At the conclusion of each impulse, when the line is again closed over rectifier *Re2*, the impulse relay *R1* once more is attracted, whereupon the process of relays *R2* and *R3* is repeated. After each closing of the line over rectifier *Re2* and the impulse contact of the

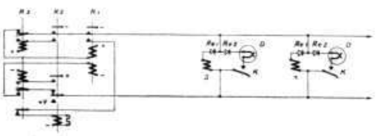


Fig. 2 X 3676
Impulse circuit in the Ericsson selective-calling system
new form

dial, relay *R2* becomes thus attracted for a moment and thereupon reverses the polarity on the line. Each time this is repeated, all the selectors on the line move forward one step.

As is the case with other CB-feed impulse circuits it is difficult here to be able to get the impulsing to work on lines with low leakage resistance. This is due to the fact that relay *R1* must act for marking both making and breaking on the line. The strengths of current for which the relay attracts and falls respectively must be very divergent in order to attain reliability in working. In other words the leakage resistance must be high in relation to the total resistance in the impulse loop. If it is proposed to make use of normal constructive elements, *e. g.*, normal telephone relays, then considerable difficulties quickly arise, when it is a matter of getting the arrangement to work with low leakage resistance.

By radically separating the two functions of the relay, see Fig. 2, much better properties can be attained. The relay *R1* here acts only on closing the line. As soon as its first contact closes, the work of the relay is governed by the local current circuit, and it therefore attracts fully. Current is connected to the correction relay *R2* which sends out the reversed pole impulse current impact on the line to selectors. At the same time the relay *R3* is connected in, cutting off relay *R1* which falls, after which *R2* also is released.

Relay *R3*, however, remains attracted, as it receives current from the line loop, and only falls when the dial breaks the line. We thus see that the two functions of the impulse relay are distributed over two relays, relay *R1* for attraction when the line is closed and relay *R3* for release when the line is broken. Both these relays can therefore be designed to give the best possible results as regards line resistance—or attraction current, and leakage resistance—or repulsion current. Theoretically, with this arrangement it is possible to attain at will closely corresponding strengths for both currents. In practice that cannot naturally be attained, and moreover the device must be able to work with sufficiently great variations in voltage at the central battery.

Impulsing

Fig. 3 shows an oscillogram of the current and tension on a selective-calling line on the Ericsson system. The total line current *IL* is equal to the sum of the currents through the instrument *IA* and the current through the selectors *IS*. Let us now consider the oscillogram more closely. At the instant T_1 the impulse contact on the dial is broken for the first time. Prior to this instant the line is idle. The line current *IL* has then the intensity which the central battery gives over the line loop with all the integrant resistance elements: impulse relay, line, selector set and instrument. The selector current *IS* is as near as may be equal to zero, since the tension on the line is very small and also directed contrary to the polarity of the rectifier connected in the selector bridges. The instrument current *IA* is therefore as near as possible to the line current. The line

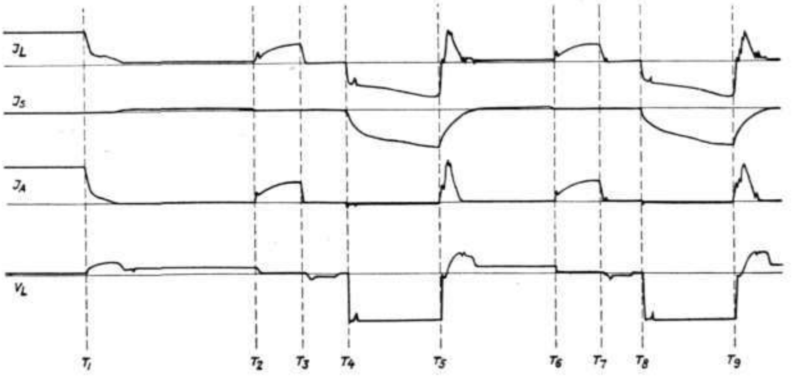


Fig. 3 X 5342
Oscillogram of impulsing process in the Ericsson selective-calling system
I_L total line current
I_S selector current
I_A instrument current
V_L line tension

tension is low and equal to the tension conditions over the selector set and the instrument.

When the impulse contact in the dial is broken, the line current IL falls rather rapidly to zero. The selector current IS remains at zero and the instrument current IA becomes zero at the same time as does current IL. At the same time the line tension becomes equal to the battery voltage after rising for an instant to an appreciably high value due to the stored up magnetic energy of the impulse relay which must be liberated when the current breaks. This state lasts until at the instant T_2 the dial impulse contact is again closed. The line current and the instrument current then rise and, if nothing occurs to prevent it, would quickly attain the values they had prior to the instant T_1. However, relay $R1$ is attracted, see Fig. 2. As soon as the first contact is closed, the relays act independent of the appearance of the line and the line tension becomes zero. At the instant T_4 relay $R2$ is attracted and reverses the line polarity and at the same time the battery tension rises to a suitable figure for the selectors, *e. g.*, 150 V. Now the direction of the line current is reversed, the current through the instrument becomes zero, except for the leakage current passed through the rectifier in series with the dial, and the selectors are energised so that the first step is taken. At the instant T_5 the relay $R2$ is released and the line polarity is restored to the original. This results in a sudden rise in tension accompanied by a rush of current through the instrument. The dial, however, has now once more broken the impulse contact so that relay $R3$, which has taken over the function of relay $R1$, is released. This rise in tension has a very important function to fulfil, as it contributes to making the work of the selectors rapid. It is evident that through it they work on a kind of double-current system which makes the work exceedingly reliable and sure.

When the impulsing to the selectors ceases and the dial contact is broken, the conditions on the line are the same as on the first breaking at instant T_1. At the instant T_6 the impulse contact is made once more and the same process as at instant T_2 is repeated. Thus by this impulse method much more satisfactory conditions for the line may be obtained. This applies particularly to the space of time available from when the impulsing to the selector ceases to when the dial once more makes its impulse contact.

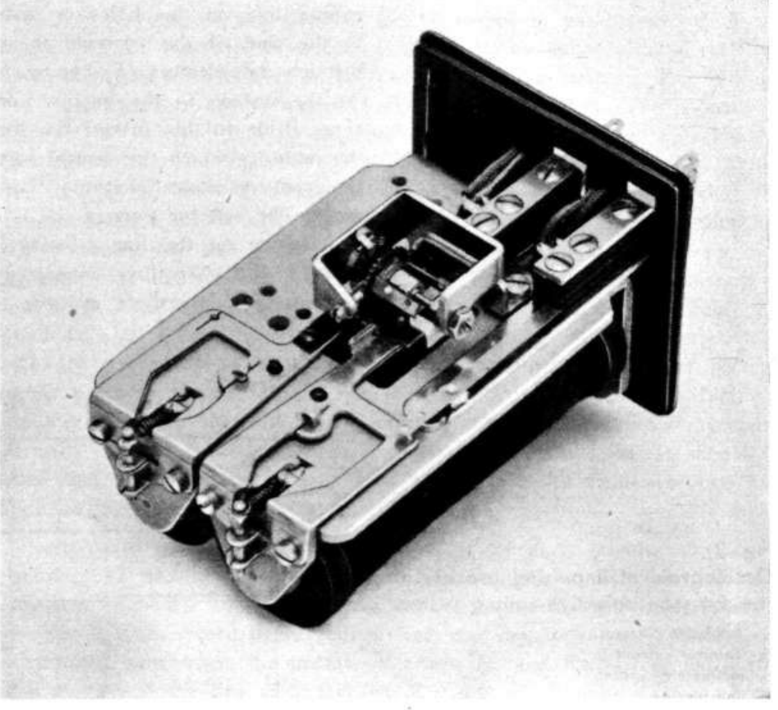


Fig. 4 X 5343
Selector
right step magnet, left, locking magnet, middle selector mechanism

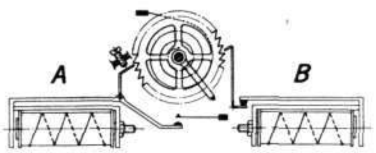


Fig. 5 X 3677
Diagram of two-magnet selector
A step magnet
B locking magnet

i. e., the instant between T_5 and T_6. During this instant the line should as far as possible resume the same condition as it has at rest, and the time should therefore be as long as possible. This is attained automatically by the connection described, as the impulse to the selectors comes as soon as the relays are able to function after the making of the dials' impulse contact. Thus the impulse to the selectors does not come in the *interval* between two makes of the impulse contact but these two kinds of impulses *coincide* for the most part instead, which explains the satisfactory impulse conditions; they allow of a speed of impulsing which corresponds with that normally occurring in automatic technics, *viz:* 10 impulses/s.

Selector

The impulsing process above described is entirely independent of the selector design employed in the instruments. Still it is evident that a good final result is only attainable if all the parts making up the system work together in a satisfactory manner. As regards impulsing it is therefore clear that not only the impulsing principle must be satisfactory. It is just as necessary that the impulse receiving device in the selective-calling telephone instruments should be thoroughly good. In the Ericsson the selector acts as an impulse receiving device without any extra impulse relays. The simplification is rendered possible partly by the method of impulsing and partly by the great sensitiveness and other good properties of the selector itself.

As may be seen by Fig. 4 and 5, the selector consists of two electromagnets — a step magnet and a locking magnet — with the necessary armatures and a step-mechanism with contacts. When the step-magnet is energised and attracted, the locking magnet is connected to the local battery — a three-cell dry battery which also serves as microphone feed. The locking magnet moves a holding dog as well as the step-magnet pawl so that they act on the ratchet-wheel. During the whole impulsing period the locking magnet remains attracted, and the step magnet at each impulse moves the ratchet-wheel one step forward. In one position or two, current is connected over the contact arm to the selector's signal device so that ringing signal is obtained. At the close of impulsing the locking magnet is released and the ratchet-wheel is restored to starting position by means of a small spiral spring.

The winding of the step magnet has a resistance of 21 500 ohm and the number of turns is 90 000. The sensitiveness of the selector is therefore great, and the operating current hardly needs to reach 1 mA. To raise still further the DC resistance of the selector bridge a series resistance of 70 000 ohm is connected. The rectifier, also connected in series, has for this intensity of current a resistanse of nearly 10 000 ohm, so that the total resistance of the selector bridge is about 100 000 ohm. A tension of 100 V then gives a final figure for current of 1 mA.

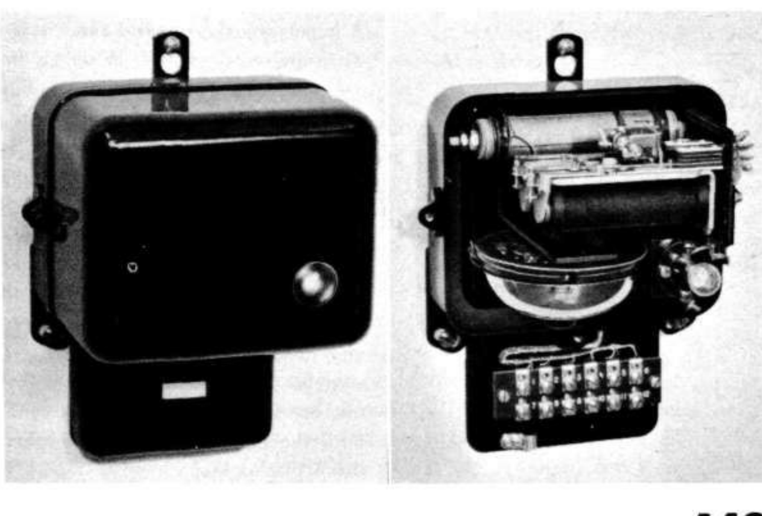


Fig. 6 X 5343
Selector unit
right, from top downwards rectifier, selector, bell with slow-acting device (lamp) and terminal block

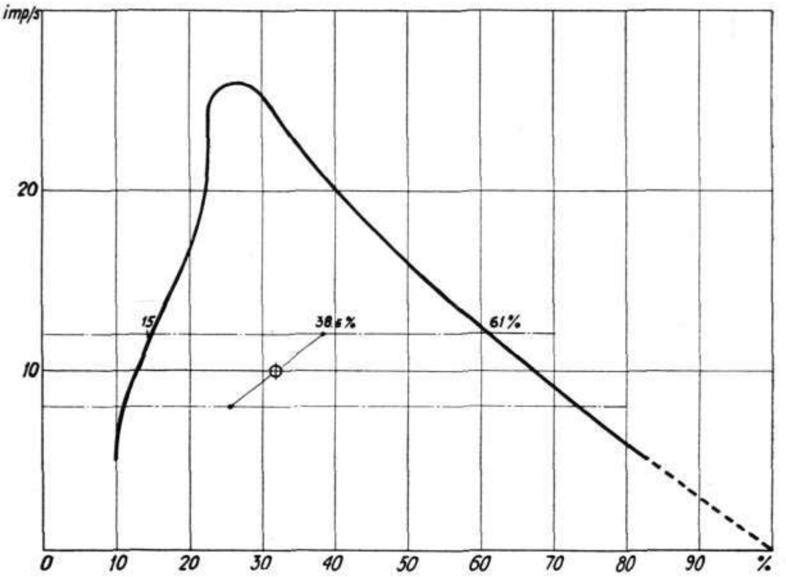


Fig. 7 X 5345

Impulsing properties of selector

the curve shows the limits of impulse speed as function of the impulse ratio

The figure given here for the selector bridge resistance applies to the impulse-current direction on the line. For the contrary direction of current the bridge shows a considerably higher figure, or about 750 000 ohm. This means that so large a number as 75 selectors connected in parallel only cause a leakage current on the line corresponding to a leakage resistance of 10 000 ohm. The impedance of the selector bridge to speaking currents is also of the same order, so that supplementary attenuation due to the connecting in of the bridges on the line may be ignored.

The impulsing properties of the selector are shown by Fig. 7 which gives the conjunction of impulse speed and impulse conditions for 150 V impulse tension on an artificial line with 1 000 ohm resistance and a capacity of 2 μF. The operating range of the selector is then the whole surface below the peaked curve traced. The maximum impulsing speed of the selector is 26 steps/s. This figure is, however, of little importance as the impulsing speeds used in practice may be said to lie between 8 and 12 impulse/s. To ensure greater reliability it is preferable that the selector at this figure should have the widest working range possible and that the working point, *i. e.*, the impulsing condition actually employed should be as near the centre of this range as possible.

If we now turn to the oscillogram, Fig. 3, we see that the length of the impulse to the selectors is 32 ms. With an impulsing speed of 10 impulse/s this give an impulse ratio of 32 %. The impulsing principle, however, gives at all rates of impulse the same length to the impulse to the selector, so that the impulse ratio varies with change in the impulse speed. Thus with 8 impulses/s the impulse ratio is is 25.7 %, with 10 impulses/s 32 % and with 12 impulses/s 38.5 %. With 12 impulses/s the working range lies between 15 and 61 %, giving a mean figure of 38 %, which accords exceedingly well with the above figure of 38.5 %. It is desirable that the accordance should be good for the highest speed, as the working conditions are the most exacting for the highest speed. For a speed of 10 impulses/s the impulsing properties might also be described as follows: The shortest making period of the step magnet is 13 ms, its shortest breaking period 33 ms. Against these, the figures for breaking and making periods available are 32 and 68 ms respectively. In both cases is the margin of safety considerable.

In this connection it may be worth emphasising the role played by the polarity inversion on the line. It has, *e. g.*, been demonstrated that if the inversion be discarded and only the high-tension impulse-current shocks are sent out on the line, the selector generally does not work with any impulse ratio until the impulse speed drops below 10 impulses/s, due to the capacitance of the artificial line.

Ericsson Three-Channel Carrier-Telephone System Bombay–Ahmedabad

R. STÅLEMARK, TELEFONAKTIEBOLAGET L. M. ERICSSON, STOCKHOLM

Because of the geographical conditions in British India, where the distances separating the important cities are considerable, the Indian Posts and Telegraphs Department has naturally come to use carrier systems for long-distance communication. To the carrier circuits, rapidly growing in number during the last years, the Ericsson three-channel telephone system between Bombay and Ahmedabad is one of the latest contributions. This system was put into service in February 1936.

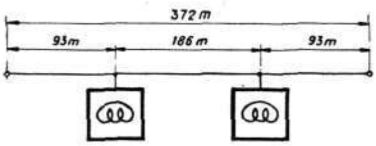


Fig. 1 X 3656
Diagram for loading of cable at Kurla

Ahmedabad is an important seat of the cotton weaving industry and has about 400 000 inhabitants. Formerly the telephone circuits between Ahmedabad and Bombay were three only, two of which were physical lines and one a single-channel carrier-telephone system. The system now installed may be equipped with a fourth channel giving a total of seven circuits.

The new system was to be operated on a 200 lb/mile copper circuit. The distance between the two cities is about 490 km, wherefore an intermediate carrier repeater became necessary and was installed at Surat. At Kurla, about 15 km north of Bombay, the toll line crosses an electric railway, where formerly an ordinary local cable connected the open-wire lines on both sides of the track. To provide for the three-channel system, however, this cable had to be replaced by a cable loaded for carrier frequencies. The total length of the cable is 372 m and it has been divided into one complete and two half loading sections, Fig. 1. The cable was designed to match the characteristic impedance of the open-wire lines, 650 ohm, and to have a cut-off frequency of 70 000 c/s. The cable contains ten quads, the wire diameter being 2 mm. Five quads are intended for voice-frequency communication on the side and phantom circuits and the remaining five quads for carrier channels on the side circuits and voice frequency on the side and phantom circuits. The latter five quads are loaded with 2.88 mH coils. As shown in Fig. 2 the carrier quads are screened from each other by the voice frequency quads. The line has also been equipped with carrier by-pass filters at Broach and Baroda, Fig. 3, by means of which the voice-frequency channel may be employed for traffic between these two towns and on the sections Surat—Broach and Baroda—Ahmedabad.

The attenuation of the lines Bombay—Surat and Surat—Ahmedabad was determined for dry and wet weather conditions. As may be seen from Fig. 4 the measured attenuation in dry weather corresponds approximately to the calculated attenuation for this type of line. During the monsoon the attenuation increased by a further 9 db at 40 000 c/s. All measurements were carried out on the line proper. The total attenuation of the line filters is 8 db at 10 000 c/s and 7 db at 50 000 c/s.

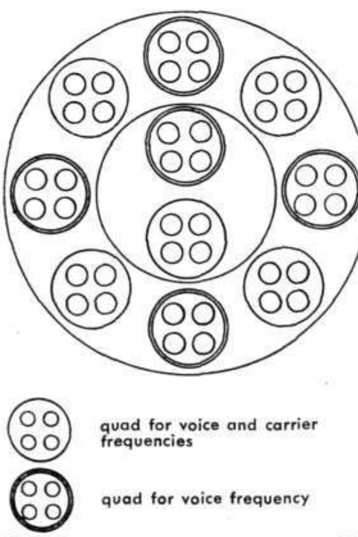


Fig. 2 X 3657
Section of cable at Kurla

Lay-out

The carrier frequencies are multiples of 5 000 c/s, Fig. 5, the lowest carrier being 15 000 c/s and the highest 40 000 c/s. The carrier frequencies of a fourth channel, if added later on, will be 10 000 c/s and 45 000 c/s. The frequencies 10 000, 15 000, 20 000 and 25 000 c/s are used for transmission

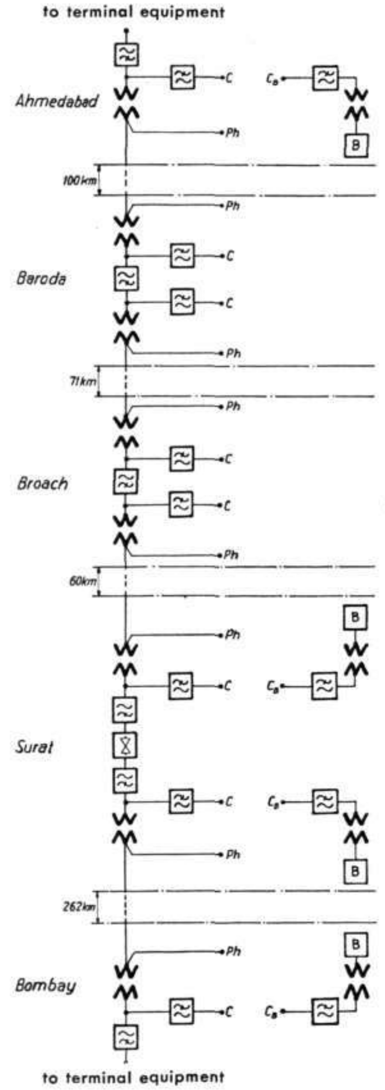


Fig. 3 X 3658

Line-filter equipment

- C voice-frequency channel
- C_B balancing network for two-wire repeater on voice-frequency channel
- Ph phantom circuit
- B line balancing network

from Bombay to Ahmedabad and the frequencies 30 000, 35 000, 40 000 and 45 000 c/s for transmission in the opposite direction. The upper side band and the partly suppressed carrier frequency are transmitted.

The width of the transmitted voice-frequency band is 250—2 750 c/s, Fig. 6. The over-all attenuation of the circuits is kept constant by means of automatic level regulation at the terminal stations. This level regulation is individual for each channel and utilizes the transmitted carrier, the level of which is about 14 db below the level of the side band. The carrier frequency is separated, amplified in a selective amplifier and rectified; the rectified current, the voltage of which is proportional to the arriving level, controls the grid bias of the first high frequency valve of the receiver amplifier, the gain becoming proportional to the line attenuation. Even with considerable variations of the line attenuation the over-all attenuation may be kept constant within ± 0.1 neper (± 0.87 db), Fig. 7.

Signalling is obtained by means of a relay, which transmits the 20 c/s current from the ringing machine or a pole changer to the modulator, where the carrier frequency is modulated with 20 c/s. At the receiving terminal the two signalling side bands are allowed to follow the carrier frequency through the selective amplifier. In the anode circuit of the last valve of this amplifier a filter for 20 c/s is inserted in series with a filter for the carrier frequency. The valve is operated at normal grid bias. As the valve characteristic is bent a certain demodulation will occur resulting in a 20 c/s current in the corresponding anode-circuit filter. This current is rectified and applied to the grid which becomes more negative, by means of which the demodulation power is increased, the 20 c/s current becomes stronger, the grid bias even more negative, and so on. At last the negative grid bias has become great enough to allow only a very small anode current. A normal DC relay in the anode circuit, which is balanced by a compensating current at normal anode current, is then actuated and passes a signal to the switchboard. The operation is accelerated because the amplification of the carrier is decreased, causing a reduced grid bias in the valve of the automatic regulation, which in its turn increases the amplification to a maximum during signalling.

For demodulation of the speech side band a local oscillator is employed. This oscillator is synchronized by the arriving carrier frequency in such a way that a part of the output from the selective carrier amplifier is fed to the grid circuit of the oscillator. No special synchronizing of the transmitter and receiver oscillators is therefore required.

After the system had been brought into service it became necessary to limit the incoming speech level in order to prevent overloading of the amplifier valves. At several occasions the level was found to correspond to 20 mW and more from the subscriber's circuits, which is considerably above normal. The voltage limiters, Fig. 8, which were inserted, cut down the level to 2 mW as a maximum. The principle of the limiters is based on the

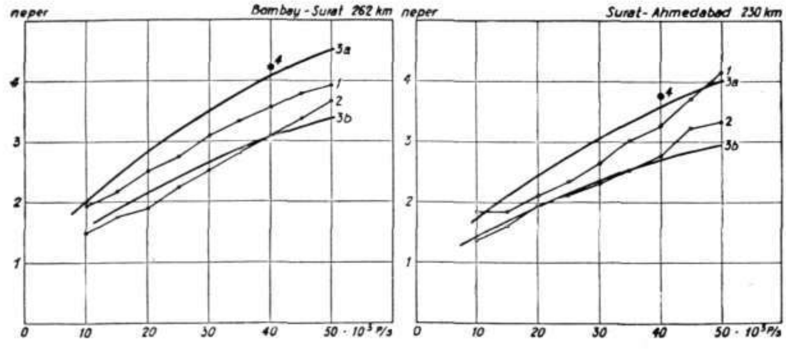


Fig. 4 X 5323

Line attenuation Bombay—Surat and Surat—Ahmedabad as a function of the frequency

1 measured in June
2 measured in January
3 calculated curve
 a wet weather
 b dry weather
4 measured at intense rain on whole line

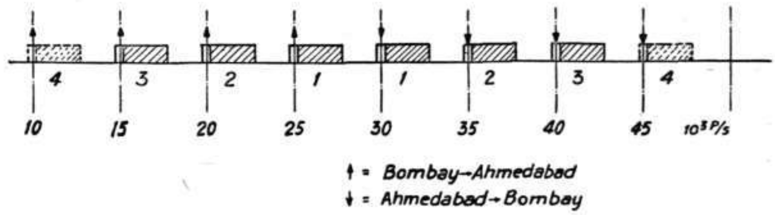


Fig. 5 X 5324
Frequency allocation of three-channel carrier-telephone system

fact that the characteristic impedance of the copper-oxide rectifiers decreases with increased current, by means of which a shunting corresponding to the amplitude is obtained. With an increase of the speech level from 0 to + 20 db the level at the output side of the limiters increases from 0 to + 3 db only, which may be regarded as a very effective limitation. The use of limiters does not cause any noticeable decrease of the transmission quality. The diagram, Fig. 9, gives the main principles of the system.

Design

Each terminal equipment, Fig. 10, consists of four bays: one line-filter bay and three carrier-channel bays. The channel bays contain the carrier equipment proper as well as a level measuring instrument and an attendant's telephone panel. The level measuring instrument is designed as an indicator with two scales, giving a level of 0 or — 20 db at a certain deflection. In combination with an attenuation set mounted in the line-filter bay the indicator may be used for level measurements, *i.e.*, for checking of the line attenuation, the overall attenuation etc. The attendant's telephone panel is equipped with a handset and keys for ringing, monitoring and talking both on the carrier and the voice-frequency channels. The panel also holds two DC instruments for the control of valve voltages and currents.

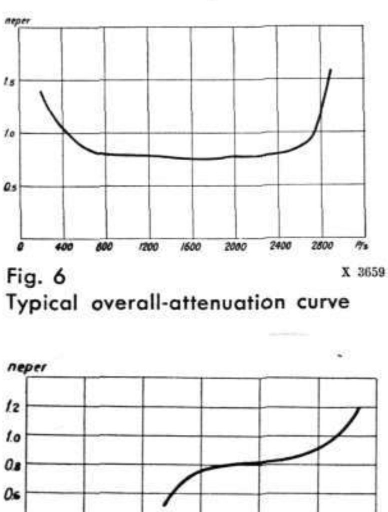


Fig. 6 X 3659
Typical overall-attenuation curve

The intermediate carrier repeater in Surat, Fig. 10, consists of three bays: one test bay, one line-filter bay and one repeater bay. The test bay holds a calibrated high-frequency generator for frequencies from 3 000 to 10 000 c/s at an output level of + 27 db as a maximum. As in the terminal equipments the intermediate repeater is provided with an attendant's telephone panel, a level-measuring instrument and an attenuation set. During measurements at high frequencies Surat serves as transmitter station sending frequencies with constant output level. At the terminal stations the received level is measured by means of the level indicator connected to the office side of the attenuation set. Line attenuations up to 47 db may be measured. In Surat, where the carrier equipment is installed in a separate building, four trunk circuits have been provided for connection with the main office.

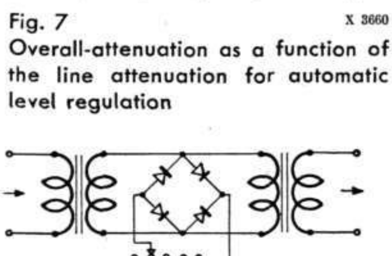


Fig. 7 X 3660
Overall-attenuation as a function of the line attenuation for automatic level regulation

The line transformers employed are of the special Ericsson design passing frequencies from 15 up to 60 000 c/s. The transformers are inserted at the line terminals and have, therefore, been designed with due regard to lightning shocks. Consequently they represent a good protection for the carrier equipment. In each station a spare transformer has been provided, which may be easily brought into service by means of plug cords in case of a damage.

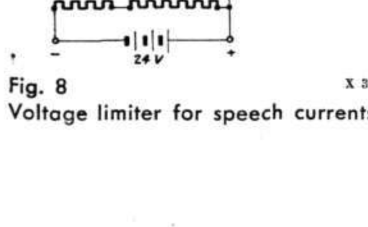


Fig. 8 X 3661
Voltage limiter for speech currents

Power plant

The valves employed have a filament drain of 0.15 A at 4 V. Four valves and one iron resistance lamp 4—12 V are connected in series across a 24 V source. The total filament drain of a terminal equipment is 1.35 A. The total anode current is about 120 mA at an anode voltage of 130 V. The corresponding drains of the intermediate carrier repeater are 0.9 A at 24 V and 160 mA at 130 V.

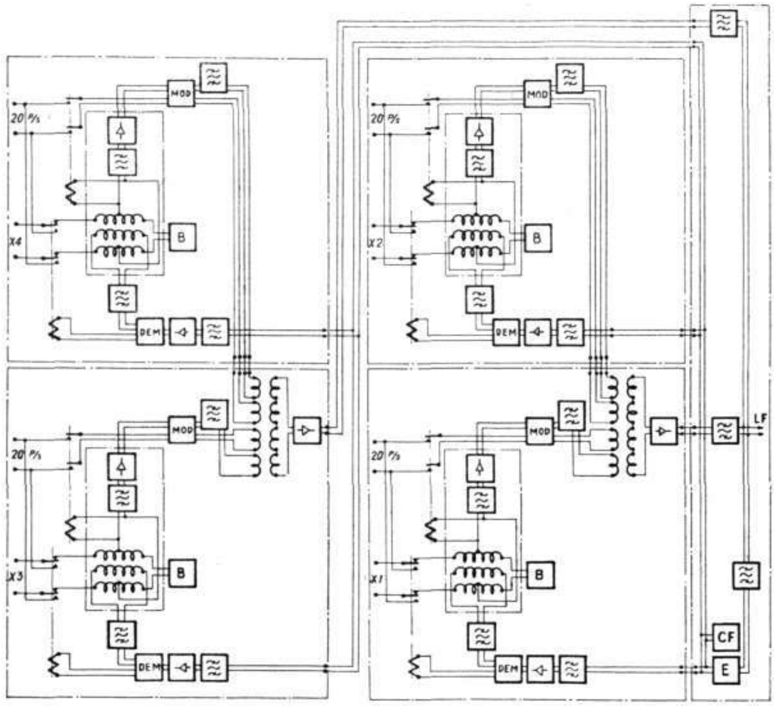


Fig. 9 X 5325
Principle diagram of three-channel terminal equipment

B balancing network **LF** line filter
CF compensation filter **X** switchboard
E equalizer

In Bombay two rotary converters have been provided, driven by the 220 V DC mains, one as a stand by. In Surat and Ahmedabad two sets of metal rectifiers, one as a spare, are in use connected directly to the AC mains.

In all the stations the anode voltage is controlled by a carbon regulator. In the terminal equipments grid bias is obtained individually for each channel from a potentiometer fed by rectifying and smoothing of a part of the carrier oscillator output. In the intermediate repeater a separate rectifier, connected to the AC mains, is used.

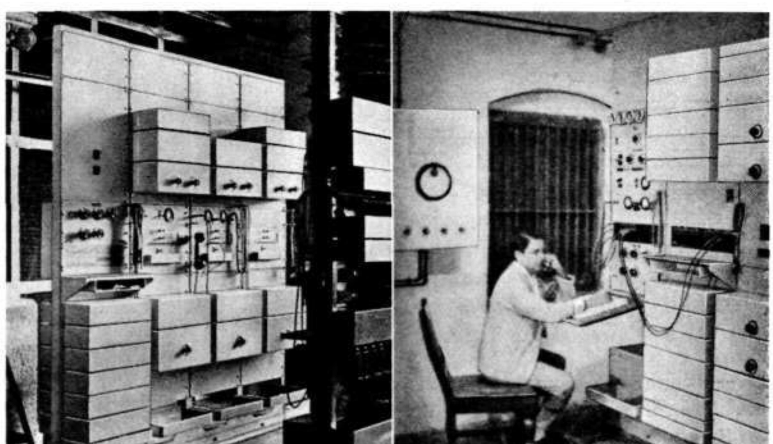


Fig. 10 X 5326
Terminal equipment at Bombay (left) and intermediate repeater at Surat (right)

Automatization of the Schiedam Telephone Network

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

For the city of Schiedam an automatic telephone exchange has been delivered to the Dutch Post, Telegraph & Telephone Department by Telefonaktiebolaget L. M. Ericsson. This exchange was put into service on August 1 this year replacing the previously existing CB-exchange.

In Holland the three big cities Amsterdam, Rotterdam and the Hague have local telephone administrations managing the telephone service for the local networks of those cities. Otherwise all telephone service of the country is managed by the State Post Telegraph & Telephone Department.

As Schiedam immediately adjoins Rotterdam and consequently there is a large number of telephone calls between these two cities, it has been found more convenient to arrange Schiedam as an exchange of the local network of Rotterdam. Owing to this, incoming traffic to Schiedam from Rotterdam was automatic even before the final automatization. This traffic was led via second group-selectors at Rotterdam West to final selectors located at Schiedam. The subscriber numbers of Rotterdam West are *30 000—39 999*, and Schiedam has been allotted the numbers *60 000—69 999*. In order to make use of the normal second group-selectors at Rotterdam West for this traffic, *3* and *6* had been made equal as first digits in the Rotterdam registers. To provide for normal extensions of Rotterdam West during the time of this temporary arrangement it was necessary to lead the traffic to the final selectors at Schiedam over the multiple frames intended for the last 500-line groups of the 10 000 lines of Rotterdam West. For that reason it was necessary to begin with the last batch of the subscriber numbers at Schiedam thus avoiding change in the numbers later. The subscriber numbers used at present are thus *67 500—69 999*.

Exchange

The new automatic exchange at Schiedam is on the Ericsson machine-driven system with 500-point selectors. As it had to operate as a local exchange of the Rotterdam network, it was necessary to arrange it to conform to the existing Rotterdam exchanges. These are equipped with sequence switches for all selectors, and therefore the line finders and the final selectors at Schiedam have also been provided with sequence switches. On the other hand all group selectors are equipped with relay sets. At present the exchange is provided with equipment for 2 500 subscriber lines, the ultimate capacity being 10 000 lines.

Fig. 1 X 3662
Schiedam telephone exchange

The exchange is accommodated in a new building two stories high of the most modern design, Fig. 1. Consequently the exchange localities are very light and spacious. On the ground floor there are among other things a room for main distributing frame, machine room and battery room. The main part of the top floor is occupied by the exchange room, Fig. 2. In addition to this the premises of course contain the necessary office rooms, workroom for mechanics, store rooms etc.

The racks in the automatic exchange room are placed in such a way that there is a passage about in the middle of the room. On one side of this there is place for two racks containing subscriber service meters, two register

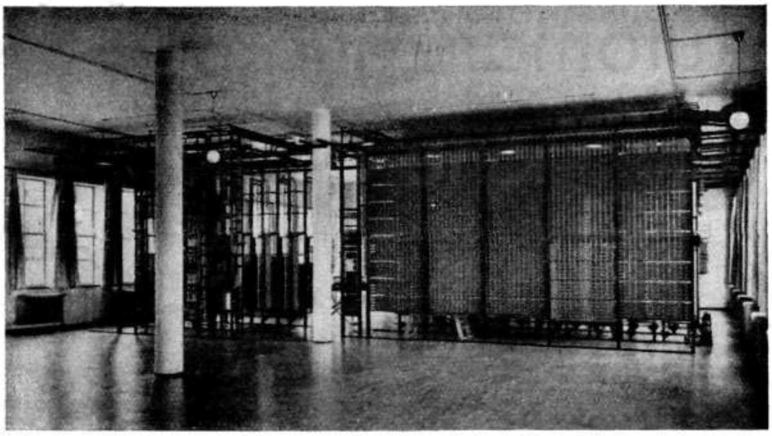


Fig. 2
Automatic exchange room

X 5327

racks and four groups of three racks each. The first rack in such a group contains sequence switches for line finders and final selectors, the second rack contains line finders and final selectors, and the third is the line-relay rack, Fig. 3. Each of these groups of three racks has equipment for five 500-line groups. There is however, only one of the groups mounted at present. In the same way only one rack for subscriber service meters and one register rack are mounted, two of each kind being enough for the ultimate capacity. On the other side of the passage all group-selector racks are placed and also the intermediate distributing frames. At present there is one rack with five panels for the first group-selectors with relay sets. Then there is one rack with three panels for the second group-selectors with relay sets of which one panel is intended for the interurban second group-selectors, and there is also one rack for intermediate distributing frames. On the same side the traffic-supervision desk is placed as well. One of the five mounted 500-line groups is intended for PBX-subscribers. The line relay panel of this group is made with removable line relays. The line finder and first group-selector panels of this group have space for 60 switches, whereas the corresponding panels of the other 500-line groups have space for 40 switches only. The second group-selector and final-selector panels are all made for 60 switches. For the 500-line group of PBX-subscribers there is place for an additional final-selector panel, as local as well as trunk traffic have to be switched via the final-selector panels. For the five 500-line groups in common there is space for a total of 40 registers.

The voltage of the exchange is 24 V, and it is equipped with two storage batteries each of 1 728 Ah capacity. For charging the batteries there are two rotary converters as shown in Fig. 4. In the machine room there are also two aggregates supplying ringing and signalling currents, of which one operates off the three phase AC and the other off the 24 V DC from the batteries. The latter is switched in automatically, if the AC fails.

Local Traffic

As mentioned earlier Schiedam has been allotted the subscriber numbers 60 000—69 999. The registers of the Rotterdam exchanges are at present made for a capacity of 80 000 numbers. The first ten multiple frames of the first group-selector panels thereby lead straight to the final selectors of one 5 000-line group at the same exchange. The other fifteen multiple frames lead to the second group-selectors at the different exchanges, each of these multiple frames thus representing one 5 000-line group.

The traffic routes for the exchange at Schiedam are shown in the trunking scheme, Fig. 5. The internal traffic comes direct via the first group-selectors to the final selectors. For outgoing traffic to the exchanges of Rotterdam a special arrangement is made, owing to the fact that Schiedam is situated west of Rotterdam with the exchange Rotterdam West about half-way between

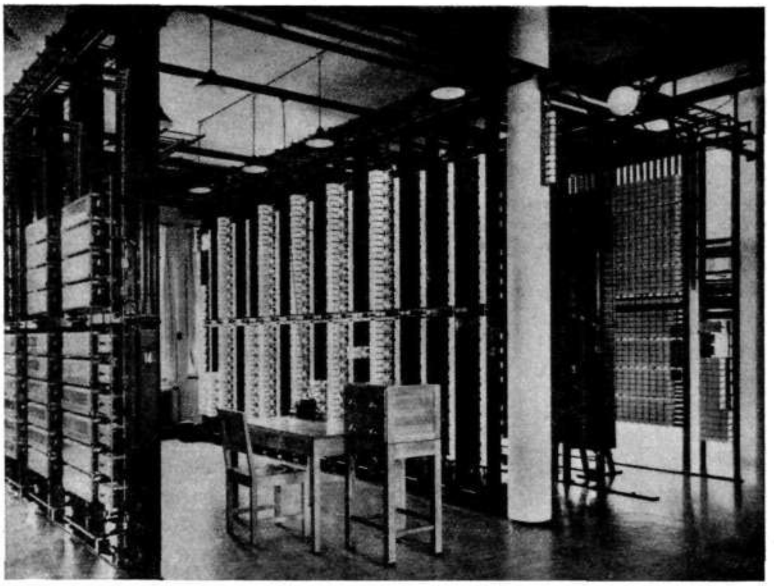


Fig. 3 X 5328
Part of automatic exchange room
left to right register racks, sequence-switch racks, pillar with signal board, line-finder and final-selector rack, line-relay rack

Schiedam and Rotterdam Centrum. The traffic to the various exchanges of Rotterdam is not distributed at Schiedam, but the first group-selector there operates as a tandem selector. For this indeed two multiple frames are used, but they lead to quite equal junction lines connected to first group selectors at Rotterdam West placed in the normal first group-selector panels of this exchange. From there the traffic is distributed to the different 5 000-line groups of the network of Rotterdam. In such a way a saving is made not only in the number of junction lines on the distance between Schiedam and Rotterdam West but also in the network of Rotterdam generally, as the traffic from Schiedam goes over the same junction lines from Rotterdam West as the ordinary outgoing traffic from this exchange. To provide this distribution of the traffic, the registers at Schiedam have been equipped with an additional register unit which receives the revertive impulses from the first group-selector at Schiedam when this is operating as a tandem selector.

The incoming local traffic to Schiedam from the exchanges at Rotterdam is led via special junction lines from each exchange. The traffic is distributed in the normal way over the second group-selectors at Schiedam to the final selectors of the various 500-line groups.

Trunk Traffic

The switching of trunk calls for Schiedam is also made automatically from the Coolsingel trunk exchange at Rotterdam. The trunk operator has first to select a disengaged junction line ending in an interurban first group-selector at Rotterdam Centrum. These group selectors are connected to special registers, into which the operator can dial the wanted number. From the registers the above-mentioned first group-selectors are set to their position, and the same happens to the trunk second group-selectors at Schiedam and finally to the trunk final selectors.

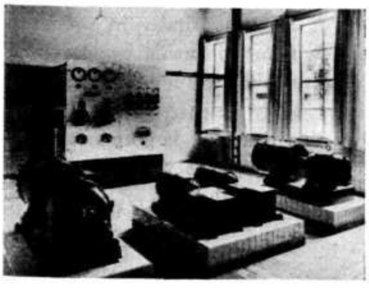


Fig. 4 X 3663
Power plant

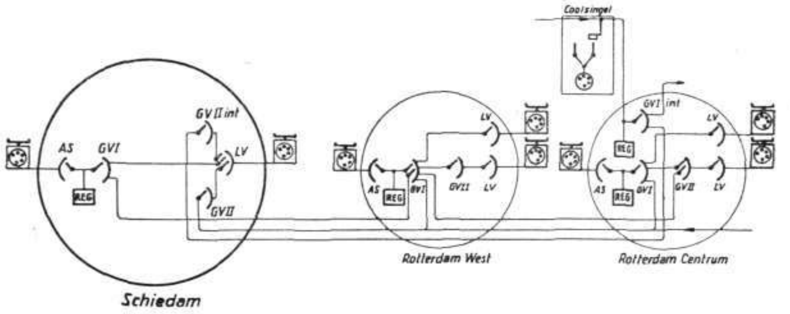
These selectors are arranged to give the operator the necessary signals. If the subscriber is disengaged, the clearing lamp of the operator invariably glows, and the subscriber may be called in the usual way. Should the subscriber be local engaged, the clearing lamp flashes and the operator can offer the call and then eventually cut down the existing local connection by pushing a special key. The subscriber cut off then hears busy tone. On the other hand if the wanted subscriber is already engaged by a trunk call, the clearing lamp flashes, and the operator hears busy tone. Then there is no possibility of offering the call, so the operator has to wait and establish a new connection.

For the PBX-subscribers the trunk final selectors are so arranged that they on testing select only a disengaged line after switching over to PBX-movement

Fig. 5
Traffic routing diagram

AS	final selectors
GVI	first group-selectors
GVII	second group-selectors
GVIint	first trunk group-selectors
GVIIint	second trunk group-selectors
LV	line finders
REG	register

X 5329



during forward radial movement. If there are no disengaged lines in the PBX-group in question, the final selector is switched over again on a stop line after the group, and then it selects by testing also a locally-engaged line. If all the lines in the group should already be engaged by a trunk call, the selector stops on the call number before the group, and then busy tone is sent out to the trunk exchange.

Traffic to Special Lines

At present the numbers *90—99* are used for the special lines. The relay equipment of the special lines is placed at Rotterdam Centrum, and these lines are distributed there from the second group-selector multiples. For traffic to those from Schiedam the first group-selectors operate as tandem selectors, in the same way as described above for local traffic. Then the first group selectors at Rotterdam West distribute the calls to two different multiple frames, as the numbers *90—94* are placed in the second group-selector multiple of one 5 000-line group and the numbers *95—99* in the multiple of another group.

In connection with the automatization of the trunk traffic in the district around Rotterdam the numbers *K00—K09* will later be used for traffic to the special lines; *K* is then the same as the digit *0*. Because of this the registers have already been made in such a way that these numbers can be used. When the first digit *K* is registered as usual on the first register unit, a special indicating switching is made, which causes the second digit to be registered by the third register unit, while then the third digit is registered by the second register unit. In such a way the same controlling circuits of the registers are used, and the directing and setting of the selectors will of course be the same in both cases.

This automatic trunk traffic — or district traffic — has been taken into consideration in the manufacture of registers and sequence switches for line finders. The registers are made in such a way that they can receive four-digit direction numbers within the series *K100—K999*, which by means of repeaters can be sent through to the Coolsingel district exchange at Rotterdam. This thus refers to the outgoing district traffic. The repeaters switch through the necessary decimal impulses for establishing a connection to the exchange indicated by the direction number. For this traffic it is also necessary to make a special switching in the sequence switch of the line finder in order to enable dialling through to the district. This switching is made by means of an indication from the register. At the same time the calling subscriber is indicated as interurban engaged, and calling party release and time-zone metering is introduced. During the time when this metering is going on after finishing the call, the subscriber is blocked for incoming as well as outgoing traffic. If connection is not established by such a call, there is of course no metering at the release.

For incoming district traffic practically the same switches as for the present trunk traffic are used, and the traffic routes from the Coolsingel trunk exchange are identical.

Checking Traffic on Subscribers' Lines

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

In the equipment of the telephone exchange recently installed by Ericsson at Schiedam a special device is included for the periodic recording of traffic on the subscribers' lines.

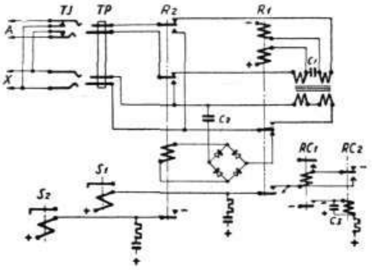


Fig. 1 X 3667
Diagram of traffic-recording device

A	subscriber's line
C_1, C_2, C_3	condensers
R_1, R_2	repeaters
RC_1, RC_2	impulse relays
S_1, S_2	stamps
TJ, TP	connecting device
X	exchange line

The device consists of a recording instrument, Fig. 1, comprising thirty stamps and a paper strip driven by a synchronous motor. The intervals of time are indicated by horizontal lines and the paper moves at a speed of 60 mm/h. The paper is divided into thirty vertical columns over each of which is a stamp. The stamps, which are actuated by electro-magnets, one for each stamp, are connected two by two to contacts in a relay set.

The relay set consists of the impulse repeater for subscribers' lines as described in Ericsson Review No 4, 1935. Each relay in this repeater however, is provided with an extra contact for connection of the stamps. The relay set is connected in by means of the plug *TP* in the distribution jack *TJ* for the subscriber's line on which traffic is to be recorded. By this the relay R_1 is connected on the subscriber's side and the relay R_2 on the exhange side.

As long as a call is proceeding on the line the relay R_1 is attracted and a stamp is connected in series with the impulse relays RC_1 and RC_2, common to all relay sets. These relays are connected in parallel with an electrolytic condenser C_3 through which an impulse is received approximately every sixth second. The stamp thus makes a number of marks on the paper strip while the call is going on. Relay R_2 which repeats the ringing signal going to the subscriber for incoming traffic, connects in via its extra contact the second stamp which thus records every signal going out.

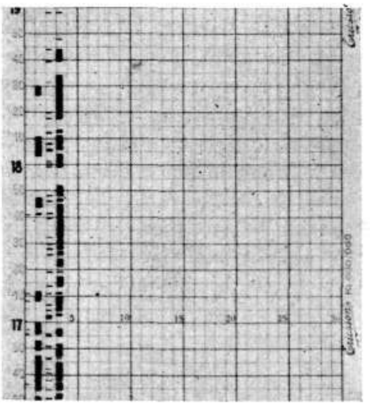


Fig. 2 X 3668
Traffic diagram
for two subscribers' lines

In Fig. 2 is shown a diagram representing two subscribers' lines. The two left hand columns apply to a lightly loaded and the two right hand columns to a heavily loaded line. For each line the right hand column shows the duration of call and the left hand one the ringing signals, *i.e.*, the delay in answering an incoming call. From the duration column of the diagram it is possible to determine the time and duration of each call and the diagram can therefore be used by the telephone administration to support a proposal that a subscriber with overloaded lines should subscribe for an additional line. The column showing delay in answering is useful, *e.g.*, in cases where it is desired to supervise how an operator at an exchange installed on a subscriber's premises deals with incoming calls. Finally it is possible to see from the diagram which calls are incoming and which are outgoing, as the former are invariably preceded by ringing signals.

Timing Devices for Race-Tracks

J. ERICSSON, TELEFONAKTIEBOLAGET L. M. ERICSSON, STOCKHOLM

In Ericsson Review No 4, 1934, there were described starting and timing devices for race-tracks. A similar system has now been installed at a Swedish trotting race-course, being used for the first time on August 16th this year.

Fig. 1 X 3652
Starting apparatus

The installation comprises electric starting machine, electric timing devices, a loud-speaker installation and a local telephone installation. Fifty poles are set up around the track, at 20 m intervals, for holding the starting apparatuses, see Fig. 1, each being provided with two watertight contacts, one for connecting a starting apparatus and the other for connection of a portable telephone instrument. The starting apparatus consists of a loud-speaker and a starting relay mounted in a wooden case, painted grey. In addition there are five power loud-speakers, mounted on high poles, see Fig. 2, used for reproducing music between the races and for announcements regarding the starts etc.

A powerful bell out on the track announces when the competitors must proceed to their starting places where starting apparatuses are placed in accordance with the handicaps of the various groups of horses. When the competitors are in their places the rubber cord is stretched across at the starting instrument under directions from the loud-speaker. The electric starting and timing devices can then be set into operation. After a few seconds the directions »*ready — one — two — go*» are sent out in their order from the starting loud-speakers and from the power loud-speakers. At the word »*go*», the magnets in the starting apparatuses are released whereupon all the rubber cords fly across the track and the start takes place. At the same instant all the alarm bells at the totalisators are set ringing to indicate that backing shall cease.

The operating devices for the electric starting machine as well as the timing device and a microphone are installed in a room at the top of the judges' tower at the winning post, see Fig. 3, where the announcer has his place along with the judges. On the operating apparatus, Fig. 4, there are six press-buttons and four switches. When the start is about to take place the announcer presses a button marked »*stop-watch* to zero», immediately afterwards throwing a switch marked »gramophone» to zero position, connecting the switch marked »microphone» and finally giving the order in the microphone »fix cords». The »microphone» switch is restored to position and in its stead the switch »speaking machine» is connected. The announcer then presses the button marked »starting relay» whereupon all the relays in the starting apparatus attract, so that the rubber cord can be stretched. When the speaker has checked that all the cords are in position and that all the horses are in place, he presses the button marked »start». On this the talking machine is set running, the above directions »*ready — one — two — go*» are sent out over the loud-speakers and the rubber cords are released.

There is a button marked »false start» for use should a horse start before the order »*go*» is given. In such case the announcer presses this button, whereupon all the rubber tapes are released. The horses are then recalled for a fresh start; this is done by the announcer pressing on a separate button marked »siren», which sets in operation a loud siren at the judges' tower to recall the competitors.

Fig. 2 X 3654
Loud-speaker

When the order »*go*» is given by the talking machine, the chronometer on the timing device is automatically started. When the horses come to the

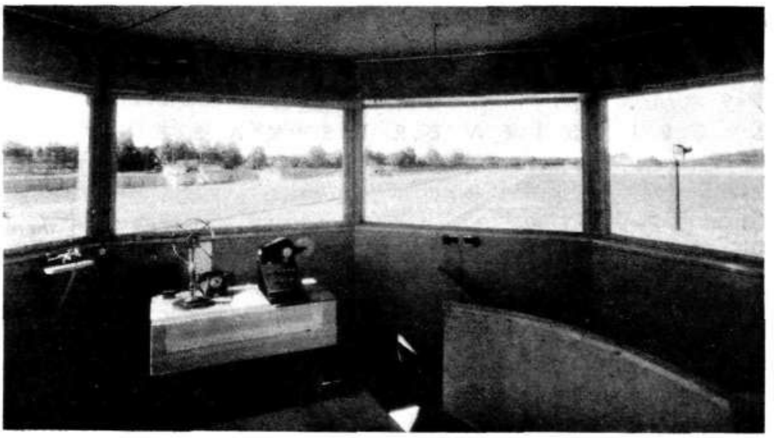


Fig. 3 X 5319
Operating room
left to right telegraph key, microphone, telephone instrument and operating board

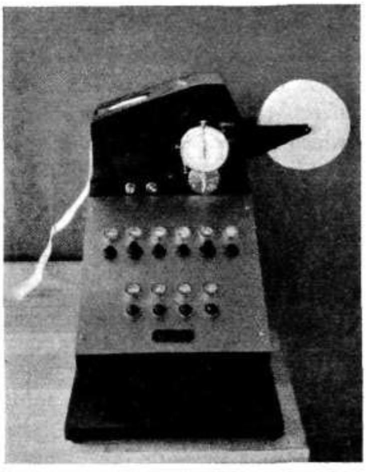


Fig. 4 X 3653
Operating board
with timing device

finishing stretch a paper strip is set in motion by connecting a friction coupling on the timing device. The paper strip moves at a constant speed and is graduated so that readings of tenths of seconds can be made. In addition it is divided into six columns, in which the arrival times of different horses are noted by pressing a telegraph key. The time for the first horse past the post is taken direct from the chronometer which is stopped instantly when the key is pressed for the first time. The time of the second horse is obtained by adding to the time given by the chronometer the interval between first and second arriving at the post, as shown on the paper strip. When the race is over the announcer throws the switch »talking machine» to off and switches on »gramophone» whereupon gramophone music is sent out on the loud-speakers.

In the lower part of the judges' tower is the instrument room, Fig. 5, where are mounted amplifier, talking machine, relay apparatus for the starting machine, private automatic exchange, gramophone, charging devices and distribution panel. While racing is going on, the switching on and off of microphone, gramophone and talking machine is done here in obedience to signals from the judges' box, indicated by different lamps in conjunction with a bell. The plant also includes an automatic local telephone installation with instruments in the rooms of the various officials; a special line goes round the track with connecting jacks at each starting post, so that a portable telephone may be plugged in at the spot where the start takes place. There is an accumulator battery to supply current for the whole plant, this being charged over a rectifier from the AC mains.

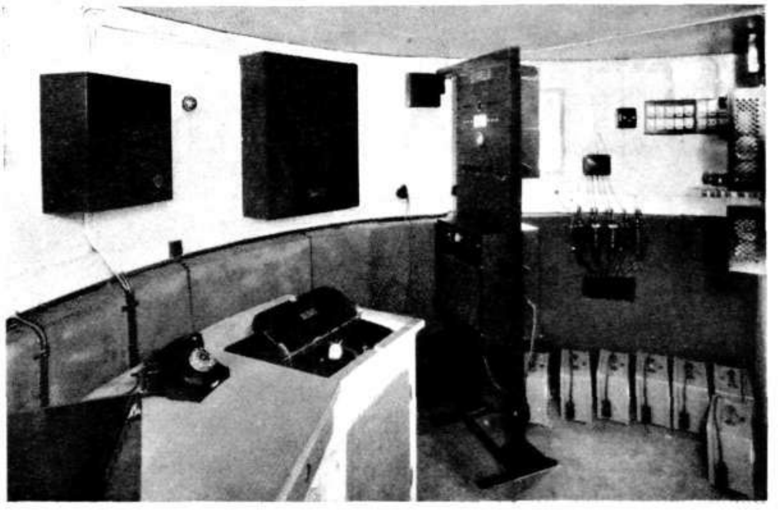


Fig. 5 X 5320
Instrument room
left to right: on table talking machine, telephone instrument and gramophone; on wall relay apparatus, private automatic exchange, amplifier rack and charging device; on floor starting apparatuses

77 kV Underwater Cable

B. ELL, SIEVERTS KABELVERK, SUNDBYBERG

During the autumn of 1935 there was manufactured and laid by Sieverts Kabelverk, Sundbyberg, an underwater cable for 77 kV working tension across lake Mälarj in Sweden. The cable constitutes a part of the Royal Board of Waterfalls three-phase power network for 77 kV, 50 c/s.

Fig. 1 X 3664
Plan of cable lay-out

For the crossing of Lake Mälar it was found to be more economical to make use of cables than of aerial lines, which latter would have had to be sufficiently high not to interfere with navigation. The power line consists, see Fig. 1, of an aerial line between Västerås and Stora Bubbholmen continued by three single-phase underwater cables each 465 m long. The other ends of these cables are brought to land on an island, Farstuholmen, where they are connected to an aerial cable about 200 m long over the island. As this island lies at an angle of about 45° to the cable line it was possible to save a deal of cable. The other end of this aerial cable is joined to three single-phase underwater cables each 1 535 m long, which at Torshälla Huvud on the south bank of the lake are connected to the aerial line. The greatest depth under water is 35 m.

This cable, Fig. 2, which is the first cable for 77 kV working tension to be laid in Sweden, is made as an armoured single-phase cable with oil channel in the copper conductor; this consists of façon wire cabled to a tube without internal reinforcing device. To hold the wires together a 12.5 × 0.15 mm copper band is wound round them. The insulation consists of cellulose paper of special quality in the form of tape, wound round the conductor to form an insulation 10 mm thick. The lead sheath contains 2 % of tin and takes an internal stress of 8 at. The drying and impregnating with thin mineral oil is not done until the lead sheath has been pressed on, a method first employed in 1906. The 3 mm thick lead sheath is covered by a 0.5 mm anti-corrosion layer and armoured with 45 hot-galvanised 4 mm iron wires, held in place by a spiral wound aluminium wire. The armouring is embedded between two impregnated jute bindings. The outside diameter of the cable is 65 mm and it weighs 13 470 kg/km.

The oil channel area, 100 m², and the copper area, 200 mm², have been selected so that the inside stress shall not exceed 6.5 at with a load of 5 000 A during 1 s or 1 900 A during 6 s. These figures are estimated to apply to

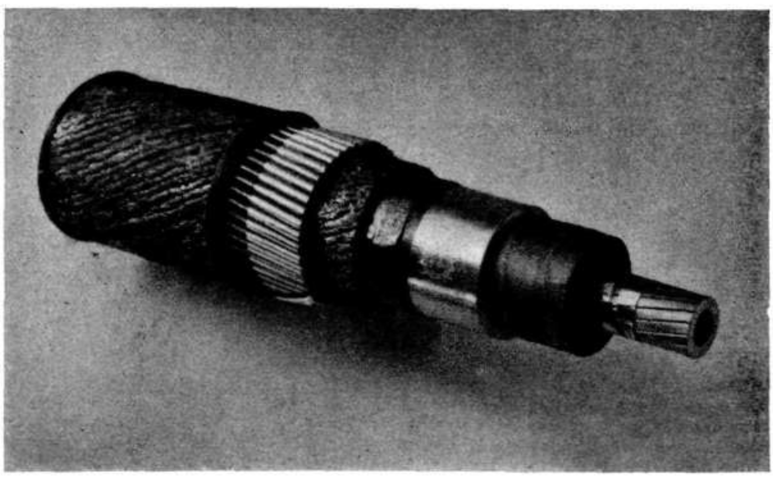


Fig. 2 X 5330
Single-phase cable for 77 kV

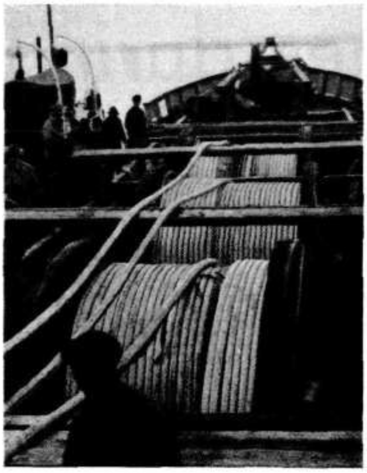


Fig. 3 X 3665
Laying three 77 kV single-phase cables

an oil temperature of 0°C. Moreover the cable will withstand direct connecting to 300 A in cold state without the pressure exceeding the above figure. The loss factor at 15 kV is tg $\delta = 0.0035$. Voltage tests were carried out on a length of 8 m with 200 kV, 50 c/s, without break-down. After laying the cable was tested with 180 kV DC for 1 s.

The cable was delivered and laid with hermetically sealed ends and oil filled. The laying was carried out by Sieverts Kabelverk in two stages, first the shorter section Stora Bubbholmen—Farstuholmen being laid and then the longer, Farstuholmen—Torshälla Huvud. For the laying use was made of a barge, Fig. 3, on which the three lengths of single-phase cable were wound on wooden drums. Each drum was provided with brake acting direct on the drum flanges. All three cable lengths were laid simultaneously parallel with one another. The barge was moved by a petrol motor with capstan taking up a steel wire rope previously laid out in the line of the cable, as the three cables were laid out. By this means it was possible to lay the cable in the shortest line despite stormy weather. On the shores the cables were laid in loops 10 m out in the water and on land reaching to just under the poles, Fig. 4, carrying the cable end distribution boxes and also used for the aerial lines. The loop in the water is intended to allow for the stretching of the cables which tend to sink lower because of the muddy nature of the lake bottom. The loop on shore, on the other hand, is designed to facilitate change of end distribution box should there arise a defect in this latter.

To protect the cables on the shore they are laid in channels blasted in the rock and lined with a layer of sand. The cables are covered with a layer of brick over which is a cover of earth. On the surface of the water the cables are protected against ice screwing by double U-beams, forming a pipe and stretching out to a depth of 2 m. Close in to the shore the pipe is protected by a layer of stones.

Fig. 4 X 3666
Connection of cable to aerial line
on pole below aerial wires, the three cable end-distribution boxes

The cable end distribution boxes are set at least 6 m above the ground and in such a way that all of them are the same height above water-level. This facilitates the mounting of the boxes, as for the working tension in question it is of the utmost importance that the cable oil does not run out and air penetrate the cables. As the cable on being submerged in the water of Lake Mälar became exposed to a lower temperature than it had during manufacture and laying, the oil volume in the cable contracted. This caused a vacuum in the insulation layer and in the oil channel. To fill up this space one end of the cable was placed in a heated container, which was filled with evacuated hot thin cable oil. By puncturing the lead sheath below the level of the oil, the necessary oil to fill the empty space in the cable was sucked in without any air being able to enter. When mounting there was pressed oil into the channel, which was absorbed by the insulating layer, thus preventing entry of air inte the oil channel. Each cable end distribution box is provided at the top of the insulator with a container for about 110 l oil. The upper part of the container has a gas cushion to allow of expansion of the oil on rise of temperature in the cable. Gauges have been placed at the bottom of the distribution boxes to give readings of oil pressure and vacuum in the boxes.

The cable installation was tested after laying and proved to fulfil all the guarantees undertaken.

New Ericsson Exchanges during 1936

In 1936 the following automatic telephone exchanges on the Ericsson system with 500-line selectors were put into service:

month	town	exchange	lines
Jan.	Tangiers, Morocco		1 500
Mar.	Stockholm, Sweden	private branch exchanges	840
Apr.		private branch exchanges	600
May	México D. F., Mexico	Roma (extension)	1 000
Jun.	Warsaw, Poland	Praga (extension)	1 000
Jly		Żoliborz	3 000
Aug.	Manizales, Columbia		2 500
	Caltanisetta, Italy		1 000
	Schiedam, Netherlands		2 500
	Stockholm, Sweden	private branch exchanges	440
Sep.	Tallinn, Esthonia	Central (extension)	500
		Nõmme (extension)	500
	Gothenburg, Sweden	Drottningtorget (extension)	3 500
	Stockholm, Sweden	Äppelviken (extension)	2 000
		private branch exchanges	290
Oct.	Kokkola, Finland		820
	Warsaw, Poland	Zielna IV	5 000
	Stockholm, Sweden	private branch exchanges	460
Nov.	Stockholm, Sweden	private branch exchanges	200
Dec.	Gothenburg, Sweden	private branch exchanges	250
	Stockholm, Sweden	private branch exchanges	1 190

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

Apr.	Paris	Invalides	8 000
Nov.	Paris	Observatoire	2 500
Dec.	Maubeuge	(system R 6)	700
	Hautmont	(system R 6)	500
	Jeumont	(system R 6)	400

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

Jan.	London	Derwent	2 000
Feb.	Manchester	Trafford Park	2 000
Mar.	Dorking	Holmwood	200
Apr.	London	Uplands	6 000
May	Harrogate	Starbeck	600
	Manchester	Droylsden	600
Jun.	Loughborough	Loughborough	1 100
	Harrogate	Knaresborough	400
Jly	Chelmsford	Chelmsford	1 600
	Chorley	Chorley	800
	Glasgow	Lennox Castle Sanatorium (PABX)	100
Sep.	Berwick-on-Tweed	Berwick-on-Tweed	500
	London	Euston	4 300
Dec.	Kings Lynn	South Wooton	200
	Edinburgh	Balerno	200
	Bristol	Bradford-on-Avon	300
	Bristol	Corsham	200
	Newcastle	East Herrington	200
	Leicester	Narborough	200
	Southend-on-Sea	South Benfleet	300
	Southend-on-Sea	Vange Corner	200
	Dundee	Wormit	200

X 3693

Enskede telephone exchange, Sweden

Ericsson Exhibition

An exhibition was held at Warsaw from August 24 to October 18 this year in order to show the development of the Polish mechanical and electrical industry. About 600 firms took part in this exhibition which was visited by over 650 000 people. The exhibition was held under the patronage of the president of the Polish republic, professor Ignacy Mościcki, and aroused considerable interest in the whole country.

The Polish company, Ericsson Polska Akcyjna Spółka Elektryczna exhibited in the telecommunication hall the first results of the company's manufacture at the Wełnowiec works. The apparatus for electrical interlocking plants for railways and the telephone equipment shown were a matter of great interest, particularly to the representatives of public authorities. Ericsson Polska Akcyjna Spółka Elektryczna was awarded the gold medal of the exhibition in recognition of its merits in the field of activity of the Polish industry.

Further the company managed jointly by the Polish state and Ericsson, Polska Akcyjna Spółka Telefoniczna, showed a model rack of the Ericsson automatic telephone system which is, as known, used in the Warsaw telephone exchanges and the functioning of the systems was demonstrated to visitors. The rack was provided with three bays, one for each selection step, and fitted with two cord circuits; the demonstration of the working of the system was greatly appreciated by the public.

X 5348

Ericsson Technics No 4, 1936

K. Lundkvist: Calculation of the Grade of Service in Automatic Telephone Systems

When calculating the traffic capacity of automatic telephone exchanges no consideration is usually given to the fact that different systems, and even different parts of a system, are working under different conditions. It is generally accepted that in non-register systems — step-by-step or Strowger systems — delays can be neglected, with the result that even in register systems no delays are taken into account. As a matter of fact, delays must exist in register as well as in non-register telephone systems. In the following article it is shown that delays cannot be neglected, and that the same formula for the grade of service is obtained when using combinational calculus as when using the theory of statistic equilibrium.

Ericsson Technics No 5, 1936

A. Holmgren & G. Swedenborg: Influence des réseaux électriques industriels sur les circuits de télécommunication

This paper gives first a general orientation over the nature and causes of disturbances, special attention being directed to the general influence of unbalanced tensions and currents existing in power networks jointly with balanced tensions and currents. Further a few details concerning the production of harmonics by generators, motors and transformers are discussed. A survey of the methods used for the measurement of telephone noise and for checking the form of the tension and current curves in power networks with regard to telephone disturbances is given. The limit values for induced tensions at fundamental frequencies and harmonics fixed by the CCIF are indicated and commented. The screening action of metallic conductors against influence and induction is treated. Finally a few measurements available for use on power networks and telecommunication circuits in order to limit the disturbing influence of the latter already when designing and constructing the installations are mentioned.

Ericsson Technics No 6, 1936

M. Vos & C. G. Aurell: Methods for Increasing Cross-Talk Attenuation between Overhead Lines

In this paper a mathematical treatment of the cross-talk arising between the circuits of overhead lines is undertaken, and the most important methods used for increasing cross-talk attenuation are described in detail. The possibilities of arranging the circuits in such a way in relation to each other that the induction in each cross-section of the circuit will be nil are indicated, and a mathematical expression of the cross-talk attenuation arising between parallel straight-drawn circuits is deduced. The most common methods used for increasing the cross-talk attenuation, *i. e.*, transposition and twisting, are treated in detail, the theoretical increase in cross-talk attenuation being indicated by means of formulae and diagrams. The limitation in improvement attainable in view of the irregularities — inevitable in practice in the placing of the poles is considered. Particular interest has been devoted to the conditions arising with the resonance frequencies inherent to transposed circuits when a close coupling of the circuits increases the line attenuation. The far-end cross-talk attenuation caused by defective matching between the circuits and the apparatus connected thereto is calculated. Finally a short orientation of the methods used in different countries for improving cross-talk condition as well as a schedule for the solution of transposition problems is given.

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