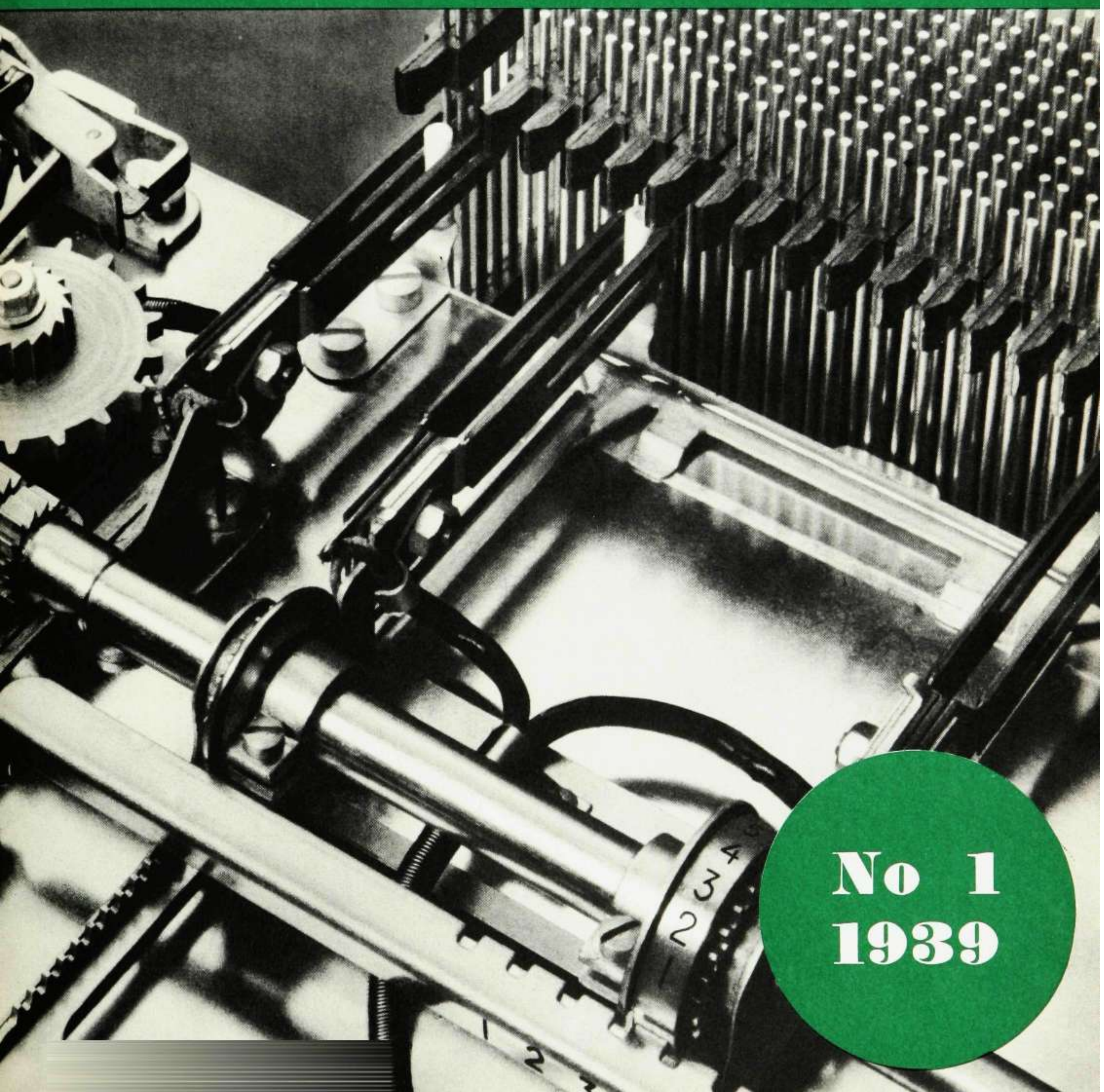
Ericsson Review



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Automatic Private Branch Exchanges, System XY

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On the basis of the new automatic telephone system with 100-line selectors, system XY, as described in Ericsson Review No 1, 1938, Telefonaktiebolaget L.M. Ericsson has designed a series of private automatic branch exchanges, with capacities of from 60 to 180 extensions and 7 to 30 exchange lines respectively. The new exchanges provide all the traffic facilities nowadays demanded of a modern private branch exchange, while a number of practical improvements have been introduced. In design and appearance too the new Ericsson XY-exchanges differ considerably from previous P. B. exchanges.

In the Ericsson series of automatic PABX's the larger ones, as described in Ericsson Review No 3, 1937, are made on the Ericsson automatic telephone system with 500-line selectors, system OS. In view of the great capacity of the selectors this system, which is machine-driven and register-operated, is extremely well adapted for large installations, as is evidenced by the hundreds of installations on this system which are now in service. However, for small or medium-sized installations the new Ericsson system XY is preferable. This is step-by-step driven and works with 100-line selectors of quite new design, though in the main following the same principles as those that have proved their worth for so many years in the 500-line selectors.

The Ericsson PABX's, system XY, meet all demands that may be imposed on modern PABX's. A distinguishing feature, as in the larger exchanges, is that the extension instruments are *quite standard* telephone instruments without any extra keys; the instruments are connected to the exchange over ordinary two-wire circuits without earthing, so that the circuit network is cheap and reliable.

Outgoing calls to the public telephone network are obtained over the exchange lines by dialling *0* on the extension. Incoming calls are dealt with semi-automatically by an operator who attends to one or more operator's sets, these being of the same form as the standard Ericsson telephone instruments though taking up rather more space. When the operator's sets are not attended, the exchange lines are switched over to one or more extensions which then deal with the incoming traffic. The P. B. X. connecting devices for internal traffic are not called into operation either for outgoing or incoming external calls.

By means of a simple re-wiring in the P. B. X. extensions may be barred for outgoing exchange calls or both outgoing and incoming. While an external call is proceeding it is possible for an extension by means of the dial to make an enquiry to another extension or to a subscriber of the public exchange. Following the enquiry the enquirer may transfer the call to another extension, provided it is not barred simply by replacing his handset. Certain extensions, for instance those intended for the higher staff, may be provided with facility of connection even though a call is proceeding. In this way they have preference over other traffic. The P. B. X's may be provided with extra equipments for automatic code calling, conference calls etc.

Design

The Ericsson automatic P. B. X's, system XY, consist of an aluminium lacquered sheet-metal rack welded throughout, of an entirely new construction giving great lightness, in which all the permanently connected devices are mounted and cabled at the factory; the rack encloses the devices and protects them against dust and outside influences. The connecting devices, *i. e.*, selectors and relay-sets, form groups of the plug-in pattern; thus they are easy to put in and take out of the rack. Consequently it is not necessary at the beginning to provide the exchange with a larger number of devices than required for existing needs, but it may, as the number of extensions and the traffic grow, be progressively extended to full capacity. This means that the exchanges can be employed to advantage in installations which when first put in are considerably smaller than the figures of capacity for the exchanges indicate; in this way costly replacement of exchanges at a later date is avoided when enlargement is necessary.

Each rack, Fig. 1—4, consists at the right of a selector panel containing the requisite number of selectors with multiples, and of a relay panel at the left mounted with relay-sets on both sides.

The selectors are four-wire XY selectors with bare wire multiples. They may be inserted in and removed from compartments mounted in the selector panel, these forming a separate unit. The selectors are connected by plugs to jacks in the corresponding relay-sets, mounted at the left of the selectors, or to jacks fitted in the rack between selectors and relay-sets. The selectors are provided with transparent covers through which it is easy to observe the setting of the selectors, and which protect the selectors against dust. All the selectors in an exchange are of exactly the same construction; the relay-set to which a selector is coupled determines whether it shall act as line finder, final selector or exchange line selector.

The bare wire multiple, Fig. 5, belonging to the selector is mounted on the back of the selector compartment in such a manner that good centring between selector and multiple is attained. The multiple consists of a number of multiple frames, each comprising 2×11 bare wires embedded in insulating strips of bakelite, these serving as supports and fixing devices for the frames. The multiple frames are placed parallel to one another, ensuring that the multiple is very stable, takes up small space and is easy of observation. The whole rear of the multiple is covered by a plate, Fig. 2, thus completing the dust protection for selector and multiple.

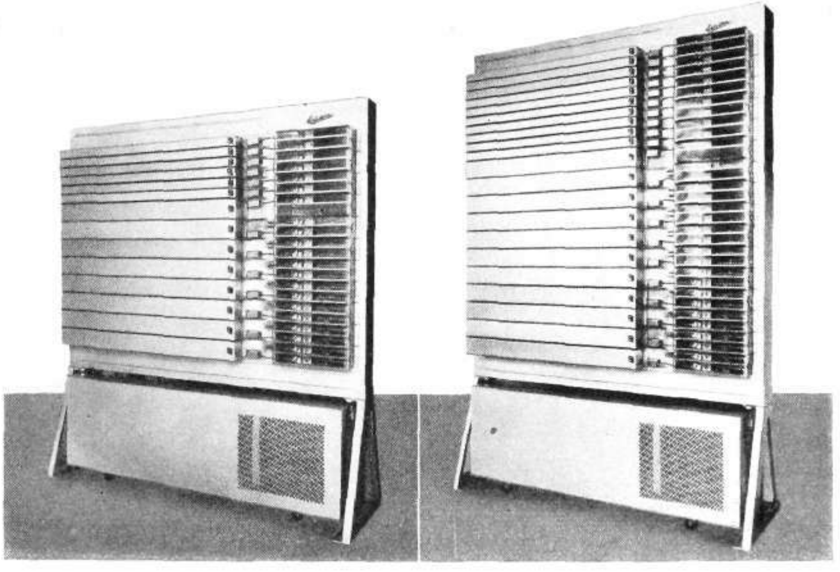


Fig. 1 X 5519

P. B. exchanges, system XY

left, AHD 22 with 60 extensions, 6 links and 7 public exchange lines, right, AHD 24 with 90 extensions, 10 cord-lines and 10 public exchange lines; at the left hand side of the rack the link and public exchange line relay-sets are mounted, with the selectors on the right; beneath the rack is a power plant comprising rectifier and battery, which may be drawn out

The control relay-set for the selectors as also the common relay-sets are detachable and are connected by plug and jack to the rack. They are covered both back and front with hoods as dust protection. They are made single or double row according to the number of relays required. The line relay-sets each comprise line and cut-off relays for ten extensions and are fixedly wired in the rack. They are provided with terminal blocks, the rear of which is used for soldering in the relay-set and the front for furnishing the extensions with various traffic facilities, such as priority, full or semi restriction of public exchange calls etc. The line relay-sets too are protected against dust by covers at front and rear.

The connecting devices are fitted in the rack in such a manner that great accessibility and uniformity of the different types are obtained. At the top in front, see Fig. 3, are fitted the relay-sets for the internal links, and underneath is the auxiliary link with the line finders to the right. By means of this auxiliary link it is possible to obtain an outgoing exchange call even though all internal links are busy. Below the auxiliary link come the relay-sets for the exchange lines with their selectors to the right. The relay-sets for the auxiliary link and the exchange lines are in double rows, each thus taking up the space of two selectors vertically. Consequently the exchange line selectors are only inserted at every other space. The unoccupied selector spaces are utilised for the final selectors of the links, the plugs of which are connected to fixed jacks in the rack between the relay and selector panels, while the other selectors are connected to jacks on the corresponding relay-sets.

At the rear of the rack the line relay-sets for the extensions are mounted above, with a panel of fuses below. They are permanently connected to the rack. Underneath these a number of detachable relay-sets comprising equipment for the common devices and the switching instrument are mounted, and at the bottom of the rack there is a detachable unit comprising ringer and its accessories.

Exchange Types

The Ericsson series of P. B:s system XY, consists at present of five sizes, all of which are uniformly built up and differ from each other merely in respect of height and number of racks. When selecting size, account should not only be taken of the maximum number of extensions but also of the traffic capacity of the exchange in respect of links and exchange lines.

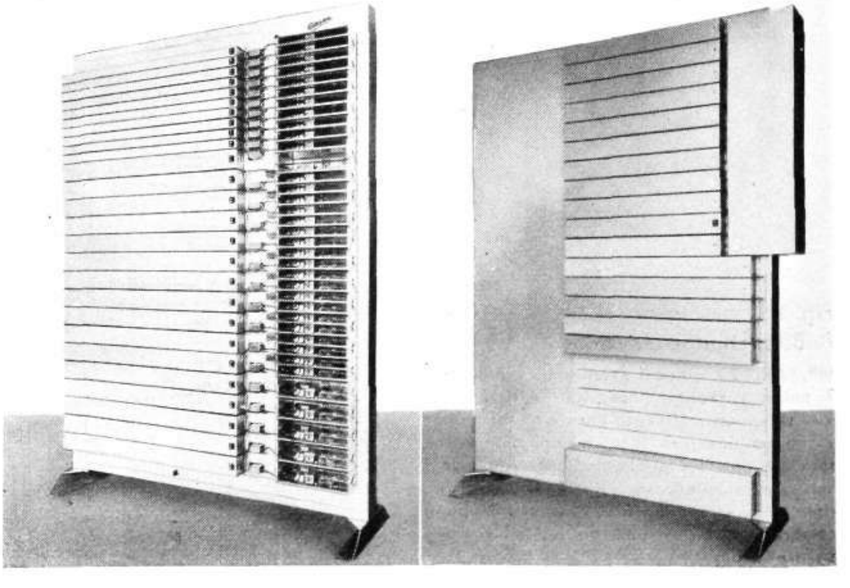


Fig. 2 X 5520

P. B. exchange AHD 26

with 90 extensions, 10 links and 15 public exchange lines; left, the front with link and public exchange relay-sets and their selectors, right, rear view with line relay-sets, distribution and common equipment

ex-change type	capacity			number-ing	dimensions		
	exten-sions	links	exchange lines		height	width	depth
AHD 22	60	6	7	*10—69*	1 600	1 390	330
AHD 24	90	10	10	*10—99*	2 000	1 390	330
AHD 26	90	10	15	*10—99*	2 000	1 390	330
AHD 32	180	20	20	*20—199*	2 000	2 780	330
AHD 34	180	20	30	*20—199*	2 400	2 780	330

Exchange AHD 22, Fig. 1, is made for not more than 60 extensions, 6 links and 7 exchange lines. The traffic requirements in exchanges of this range of size are particularly variable. In some installations the internal traffic is large, while only a few exchange lines are needed. In such case a comparatively large number of line relay-sets with the requisite line finders and final selectors are provided but only a few exchange line relay-sets with the necessary selectors. In another case there may be required a small number of extensions but 5 to 6 exchange lines. In such event the exchange is supplied with a small number of line relay-sets and links. The space for the relay-sets not fitted is filled up with capping plates.

Exchange AHD 24, Fig. 1, is made for a maximum of 90 extensions, 10 links and 10 exchange lines. It is designed for those installations where it is estimated that for some time the extensions will not exceed 90 and the number of exchange lines will not be above 10. For installations with heavy public exchange traffic this PAOX finds employment even with a small number of extensions, since exchange AHD *22*, in view of its small capacity in respect of public exchange circuits is not sufficient for future enlargement.

Exchange AHD 26, Fig. 2 and 3, is made for a maximum of 90 extensions, 10 links and 15 exchange lines. It differs from exchange AHD 24 only in having place for 15 instead of 10 public exchange circuit equipments. Consequently it is employed for installations with exceedingly large public exchange traffic. It may be supplemented with devices for 5 further public exchange circuits for outgoing traffic only, if so required. As a switching instrument has devices only for 10 public exchange circuits, two switching instruments would then need to be used.

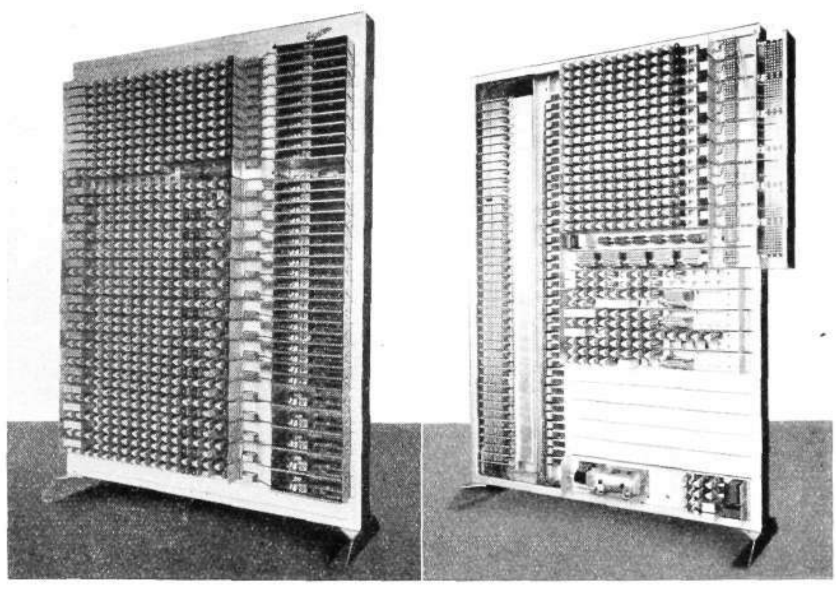


Fig. 3 X 5523
P. B. exchange AHD 26
with covers removed; left, the front, right, the rear

Exchange AHD 32, Fig. 4, is made for not more than 180 extensions, 20 cord-lines and 20 public exchange circuits. It consists of two racks, one of which is a 90-line rack AHD 26, which is equipped only with line relay-sets for the 80 extensions of the first group, however, with the number series 20—99. The other rack holds the line relay-sets for the 100 extensions of the second group, with number series 100—199. Thus in a 180-line P. B. exchange the extensions are divided into two groups, each connected to a line finder multiple. Links numbering not more than 10 belong to each group. The final selectors and the public exchange line selectors belonging to the links can only reach directly the 80 extensions comprised in the first group. For traffic to the second group extensions there is required an extra final selector stage. These final selectors, not more than 18, with their relay-sets are located underneath the second group's auxiliary link, while 15 exchange line equipments are fitted in the first group's rack and 5 in that of the second group. The first group's rack is so constructed that it operates as an independent unit which may subsequently be extended by the second group rack. It is also possible without any great modification to alter a 90-line P. B. exchange AHD 26, when it becomes too small, to a 180-line exchange. In that event the extensions *10—19* must be transferred to the second group.

Exchange AHD 34 is made for a maximum of 180 extensions, 20 links and 30 exchange circuits. It is built up in the same manner as exchange AHD 32, but the rack is 400 mm higher. This provides space for 20 exchange line equipments in the first group rack and 10 in that of the second group. The type is designed for installations having exceedingly heavy public exchange traffic.

If the number of extensions in a 180-line P. B. exchange requires to be *augmented*, yet another rack may be added, containing a third group of extensions. The extensions *20—29* must then be transferred from the first to the third group and the total number of extensions will thus be *270*, with the number series *30—299*.

Operator's Set

The handling of incoming exchange calls is semi-automatic and no special switchboard with cords and multiples is therefore required. Operation is by means of the operator's set, Fig. 6, which in addition to handset and dial

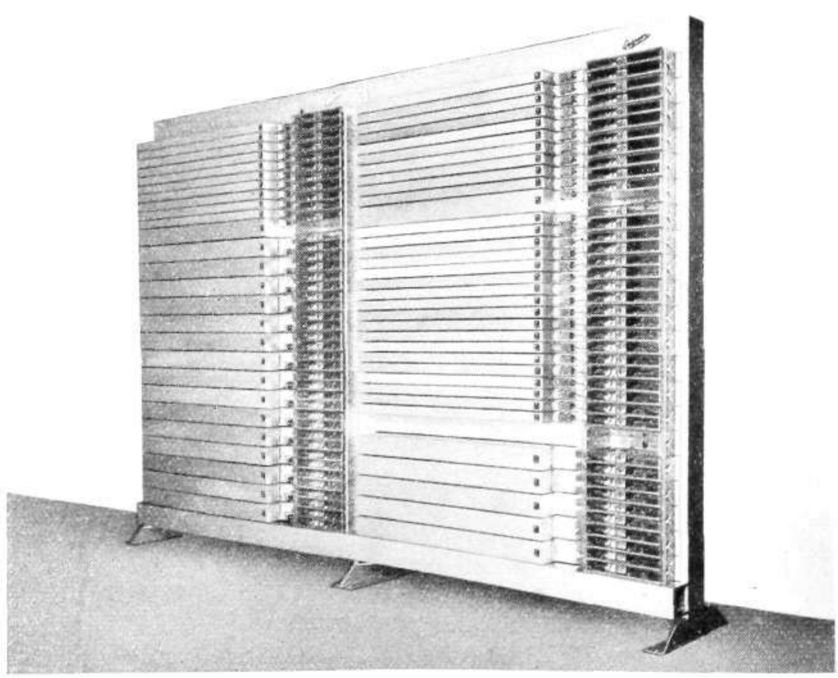


Fig. 4 X 5521

P. B. exchange AHD 32

for 180 extensions, 20 links and 20 public exchange lines; left, rack with devices for the 80 extensions of the first group, right, rack with devices for the second group's 100 extensions

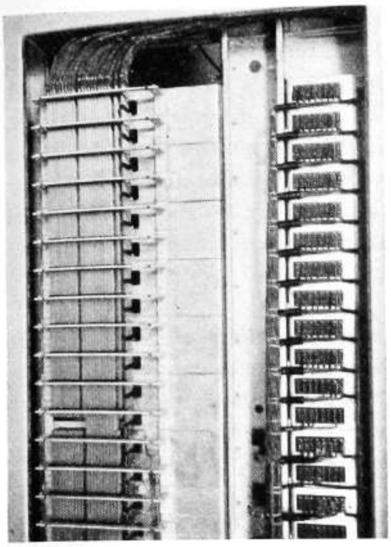


Fig. 5 X 3909
Selector multiple and cabling

comprises separate operating devices for 10 exchange lines together with a keyboard and common keys and lamps. For each exchange line there is a calling lamp, an answering key, a pilot lamp and a series call key. The keyboard facilitates the operator's work and expedites it. The dial is used when the operator is required by an extension to call a subscriber to an automatic exchange; it constitutes a reserve for the keyboard. The operator's set is connected by plug and jack to a wall fitting which contains individual night switches for the public exchange lines.

If the number of exchange lines exceeds 10, two or three operator's sets are provided, each having its own operator for busy periods. When traffic is slack all the calls can be concentrated on a single operator.

Distribution

The line relay-sets of the exchange are provided, at the side of the cover, with screws clamps for connection of extension links. If it is desired to provide the exchange with distribution, as often happens, these clamps are employed as the exchange side in a distribution, Fig. 7, the line side of which is formed of clamps on a special frame, mounted on the outside of the rack alongside the line relay-sets. The jumper wire is drawn direct between the exchange side and the line side clamps. The whole distribution is protected by a dust-tight cover.

Power Plant

All the PABX are constructed for an operating tension of 24 V. They may be provided with a power plant consisting of an accumulator and rectifier with automatic charging control, mounted on a common baseplate resting on light-running castors. The plant is protected by dust-tight covers and is so low that it can be pushed under the racks of the exchanges AHD 22 and AHD 24, which for this reason are furnished with high feet, see Fig. 1. For these two types, therefore, no special space is required for the power plant.

Installation

Special attention has been devoted to making installation on the spot as simple and rapid as possible. The exchanges are sent out from the factory ready fitted with all the permanently connected equipment, such as selector

Fig. 6 X 5522
Operator's set
keyboard in front, individual keys and lamps for 10 public exchange lines, at the back common keys and lamps; to left, wall fitting with night switches

multiples, line relay-sets, jacks etc., together with the cabling pertaining to it. Installation work, therefore, is limited to connecting in the extension circuits, the switching instrument and the power plant.

The connecting of the extension and public exchange lines, constituting the main work of installation, is facilitated by the feature that the terminals for these lines both on the exchange and the line side are on the outside of the rack. In this way the risk of inadvertent disturbance of the P. B. X. devices and the fixed cabling is minimised.

The detachable connecting devices are despatched carefully packed in separate cases. This ensures that disturbance of their adjustment during transport is reduced to a minimum, with the result that time-consuming testing work is not required after the connecting devices have been inserted in their place in the exchange.

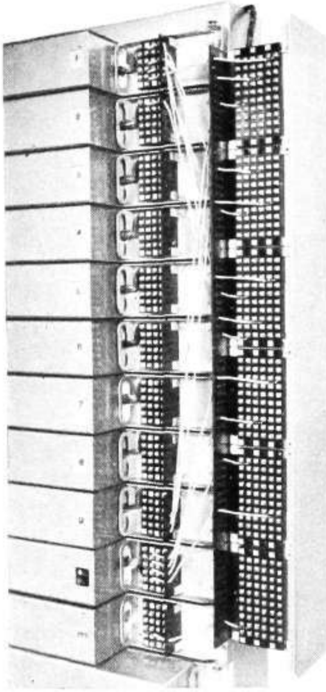


Fig. 7
Distribution

X 3910

Working Properties

The exchanges are so constructed that variation of the operating tension from 22 to 28 V is permissible. The line resistance for the extension links must not exceed 1 000 ohm and the earth leakage resistance must not be below 15 000 ohm. If the line characteristics are more favourable than these limit figures indicate, the exchanges will function with satisfactory reliability with greater tension variations than those given above. The permissible line resistance and earthing resistance for the public exchange circuits are as a rule determined by the properties of the main exchange and therefore cannot generally be given.

The current consumption amounts to approximately 0.25 A for an internal call and appr. 0.45 A for a public exchange call. The operating attenuation of the exchanges at 800 c/s does not exceed 0.06 neper and their cross-talk attenuation is not below 10 neper.

Traffic Properties

The skeleton diagram, Fig. 8, shows the principle of the diagramatic building up of the exchanges with not more than 90 extensions. It is similar for exchanges with 180 extensions and differs only to the extent that a second final selector stage is introduced for traffic to the second group extensions.

Internal Traffic

On calling, the extension obtains connection with a disengaged internal link over its line finder. The extension hears answering tone and dials the required number, whereupon the final selector is set to the required extension. If this is disengaged, periodical calling signal is sent out and the caller hears ringing tone. When a called subscriber answers the call, the ringing signal is cut off and the connection is established.

The two extensions have separate current feed. When one of the extensions replaces his handset the link employed is *immediately disconnected,* on which the extension becomes disengaged and can make a fresh call. The other extension receives busy tone from its line equipment until the handset is replaced. The link is liberated and busy tone is sent out when an engaged extension is called or if the caller does not carry out dialling within a certain time.

Certain extensions, *e. g.*, the instruments of higher staff, may be marked in a special manner, by which they obtain *priority*. When such an extension calls an engaged extension, the link is not released, but it is switched in such a way that the priority extension is connected in to the call going on. There is then

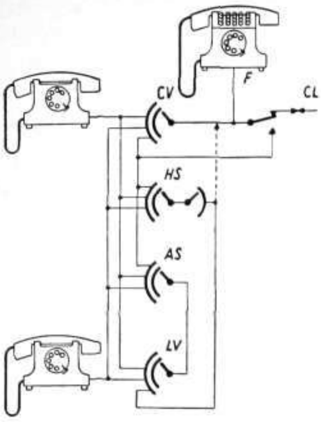


Fig. 8 X 3889

Skeleton diagram for P. B. exchange, system XY

for up to 90 extensions

AS line-finder for link
CL public exchange line
CV public exchange line selector
F switching instrument
HS line finder for auxiliary link
V final selector

emitted a weak busy tone which is audible to the speakers. When the one of these not required replaces his handset, the priority extension is immediately put in normal connection with the desired extension, this being indicated by cessation of the weak busy tone. If, on the other hand, the person wanted should replace his handset in error he is, without further action by the priority extension, rung up in the same way as if it were a normal call.

The links of the exchanges are constructed for *through impulsing*, which makes possible the coupling of the links to other exchanges, automatic devices for conference calls, staff seeking etc. The links may also be made for providing common call number to several extensions. Such a *group number* may be included in each ten. If a group number is called, group hunting proceeds over all circuits; if on the other hand an individual number of the group is called such a hunting does not take place.

External Traffic

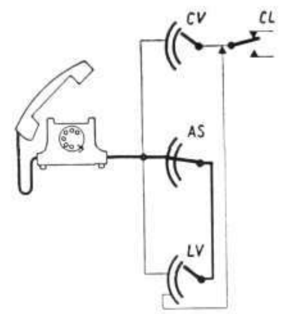
The public exchange equipment is arranged for traffic both ways over the exchange lines. As standard they are made only for connection to automatic or manual CB exchanges, but may be supplemented for connection to LB exchanges as well, in which case they may be used for all three systems. Usually they require no other signal than the calling signal from the main exchange and are blocked for a short interval after the ending of a call, so that disconnection is sure to have taken place before a fresh outgoing call can be made. They may, however, be constructed for operating with clearing signal from the main exchange, in which case the extension is not cleared until disconnection has taken place at the main exchange. In such case the above blocking is not needed at the end of a call.

A simple rearrangement of connections on the terminal strip of the line relay-sets enables the extensions to be made *open*, or *barred* or *semi-barred* to the public exchange traffic. A barred extension is shut off both from incoming and outgoing traffic, a semi-barred for outgoing only. The latter, however, may obtain an exchange call by ordering it through the operator.

Outgoing Traffic

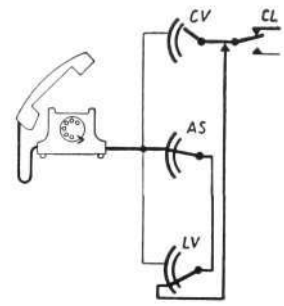
Outgoing calls are obtained by dialling *o* after receiving dialling tone from an internal link. The calling extension is then marked in the public exchange line selector multiple over the link's line finder, see Fig. 9. A disengaged public exchange line selector hunts the extension, whereupon the occupied link is liberated and the extension is connected direct to the public exchange line over this selector. The internal link therefore is only occupied for quite a short time. If the public exchange is automatic, the required number is then dialled in the customary manner after hearing dialling tone from the exchange; if the exchange is manual the number is requested of the operator. If all public exchange lines are occupied the link is liberated and the extension receives busy tone.

To avoid inability to obtain outgoing call when all internal links are occupied though unoccupied public exchange lines are available, the PABX exchanges are equipped with an *auxiliary link* which can only handle outgoing traffic. When all the normal links are occupied the call is connected to this auxiliary link. If the extension dials the number of an extension the auxiliary link is liberated and the calling extension receives busy tone; if, however, *o* is dialled the extension is connected in the ordinary way to the public exchange line, after which the auxiliary link is liberated. In either event therefore it is only occupied for a short period.



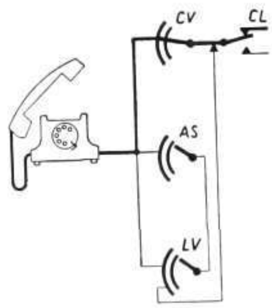
X 3902

an extension calls and is connected to disengaged link



X 3903

an extension dials 0 and is marked in the final selector multiple whereupon a disengaged public exchange line CL is selected



X 3904

a public exchange line selector is set to extension which is connected to the public exchange line CL; link is disconnected

Fig. 9
Skeleton diagram for outgoing external traffic

AS	line finder
CL	public exchange line
CV	public exchange line selector
LV	final selector

Incoming Traffic

On the arrival of a call the public exchange line's call lamp lights up in the operator's set and a signal is heard. The operator lifts her handset, on which the signal ceases, and she depresses for a moment the answering key of the exchange line. The call lamp goes out but the exchange line pilot lamp displays a flickering light to indicate that the exchange line is in process of switching. The operator comes into conversation with the public exchange subscriber. The number of the desired extension is struck on the keyboard, whereupon the public exchange line selector is set to the required extension line. A common connection lamp shows whether the extension is engaged or disengaged.

If the extension is *disengaged*, this connection lamp shines with a fixed light and the extension is automatically rung up. The ringing differs from internal traffic ringing, in that each signal is made up of two short signals close together; this gives a distinctive ring for public exchange calls. The operator informs the calling subscriber that the extension has been rung and replaces her handset, on which the exchange pilot lamp goes over to fixed light, indicating that the calling subscriber is awaiting an answer. It goes out when the extension answers the call.

If the extension is *engaged*, the common connection lamp flickers. The operator informs the calling subscriber that the extension is engaged and disconnects the call. If, however, the calling subscriber wishes to wait until the extension is free, the operator holds the call waiting by laying down the handset. When the extension is unoccupied it is rung up automatically. If it is a matter of an urgent public exchange call, the operator may cut in on the call proceeding and offer the new call to the extension, observing beforehand whether the call proceeding is internal or external. Immediately the operator cuts in to an extension this is indicated by a tick-tack signal. All calls, including also public exchange calls, may be cut off. When a public exchange line is cut off, a new call is obtained which is handled by the operator in the ordinary way. The operator may, while a public exchange line is waiting, connect herself in on it by pressing the answering key and announce that the required extension does not answer. She may then disconnect the call, let the subscriber continue waiting or connect him to another extension.

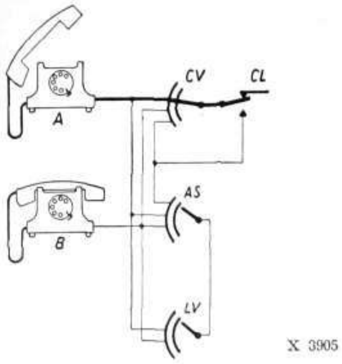
After an extension has answered, the operator is disconnected from the call and the work on the call is completed. No lamp signals are lit up, but by pressing a special key the operator may light pilot lamps for those exchange lines occupied by calls.

If an extension wishes to be connected by the operator to a subscriber in the public exchange, the operator is first called on an extension line proceeding to the switching instrument and the desired call is ordered. The operator depresses for a moment the answering key of a free exchange line, gets connected to the exchange and dials the required number, or asks the public exchange operator for the number as the case may be. The call is switched over to the extension as with incoming calls.

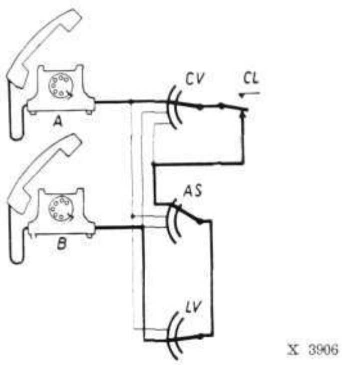
It is not necessary for the operator to lay down the hand-set each time she leaves a public exchange line, she need only depress the answering key of another exchange line to be handled.

Enquiry

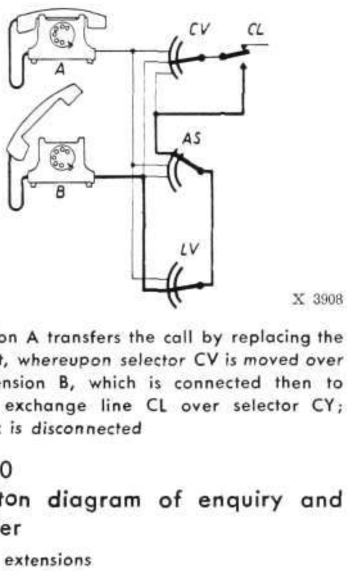
Enquiry is started by the extension taking the first digit of the dial, usually *1*, whereupon the connection between the public exchange line and the extension is broken, but clearing signal does not go out to the exchange, see Fig. 10. The extension is then connected to an internal link, and the desired number



extension A is occupied with external call over selector CV and public exchange line CL



extension A makes enquiry to extension B, whereupon public exchange line CL is disconnected from extension A and the speaking connection between the extensions is obtained over a link (line-finder AS and final selector LV)



extension A transfers the call by replacing the handset, whereupon selector CV is moved over to extension B, which is connected then to public exchange line CL over selector CY; the link is disconnected

Fig. 10
Skeleton diagram of enquiry and transfer

A, B extensions
AS line finder
CL public exchange line
CV public exchange line selector
LV final selector

is dialled. At the close of the enquiry-call connection is re-established with the public exchange subscriber by dialling the *1*. If the enquired person keeps the handset lifted, the enquirer may alternate between public exchange line and the enquired extension by dialling *1* again and again. Enquiry may be made to all subscribers connected to the P. B. exchange, even those which are blocked, and in addition to public exchange subscribers over another line, if so desired. Extensions which have preference or priority in internal traffic have the same privilege for enquiry calls.

Transfer

A public exchange call may be automatically transferred to another extension that is not fully barred. In such case, enquiry is first made; when the enquired extension replies, the call enquiring is transferred simply *by replacing the handset;* it is of no consequence whether the enquirer last had connection with the enquired or with the public exchange subscriber. The public exchange line selector moves so that the exchange line comes into direct connection with the enquired, after which the cord-line occupied is disconnected. Transfer may be repeated any number of times.

Re-calling of Subscriber

If an extension in making enquiry or transfer manipulates wrongly, *e. g.* replaces the handset before the enquired extension answers, the enquirer is not disconnected from the public exchange line but is re-rung and, when he answers, will be in direct connection with the public exchange subscriber, who thus cannot be left hanging without any connection to an extension. Since the extension at fault and not the operator is re-rung, the operator is not troubled with extra work on account of incorrect manipulation on the part of extensions.

Reference to Operator

An extension which is in conversation over a public exchange line may refer to the operator by taking two impulses on the dial, usually *2*, whereupon the exchange line call lamp lights up. The operator answers the call, cuts in to the extension and receives the necessary information. If required the extension may await the operator's answer. It is not necessary for the extension to await the operator's answer, but the handset may be replaced immediately the reference has been made. The extension is then disconnected from the public exchange line. In this case the call is than handled by the operator as if it were a normal incoming call.

Series Calls

If a public exchange subscriber wishes to talk with several extensions in succession, he informs the operator who then presses the exchange line series call key. The result is that the exchange line is not cleared when one call is terminated, but the operator is called again, answering with the answering key.

Night Switching

During that part of the day when the operator's set is not attended all the incoming public exchange lines may be night-switched to one or more extensions. Night switching is done by the operator pressing a night-switch on her set when leaving it. If she should neglect to do so, there is *automatic night-switching* if a call receives no answer within a certain time. In the wall-box of the switching instrument there are 10 separate night-switching keys, so that any public exchange line may be night-switched even during the day while the others are dealt with by the operator. During night-switching an *incoming call* causes the extension to which the public exchange wire is connected to be rung, if it is disengaged. The call is answered in the ordinary way, just as if switched by an operator. By enquiry and transfer the call may be trasferred to any other extension of the P. B. X. that is not blocked. The switching extension enjoys priority when switching a night-switched call, even though it has no priority with ordinary calls. If the night-switched extension is busy when call is made from the public exchange, those talking hear a weak ringing signal. The night-switched extension should then terminate the conversation as quickly as possible in order to receive the ring from the public exchange line.

Manual Telephone Exchanges for CB-System

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

Though automatic telephone exchanges are coming more and more into use it should not be supposed that the manual exchanges have had their day. In small and medium-sized communities particularly, where the subscribers' lines are connected to a single telephone exchange, the manual exchanges hold their own with the automatic. The choice of automatic or manual exchange is dependent on the local conditions and should be considered for each individual case. Among the features in favour of the manual exchange is the fact that the first cost is lower, that there is less demand for technical qualifications of the maintenance staff, that longer lines and lines with poor insulation may be more conveniently connected and that the utilization of junction lines connected may be augmented by means of recording service.

If a manual exchange has been found best suited to the actual requirements, then the choice lies between LB-system and CB-system. The chief advantage of the former system is that it permits connection of even very long lines with poor insulation, while the CB-system is to be preferred in other respects since the telephone instruments will be simpler and cheaper in maintenance and the operation of the exchange appreciably more convenient.

The telephone exchanges for CB-system of Ericsson's make here described are made up of single-position switchboards and have a final capacity of 2 000 subscribers. They are particularly well adapted for the case where in a small town or community it is required to have a simple, cheap and easily operated telephone plant, though they can also be employed to advantage in *e. g.* a large industrial establishment.

A feature of the system is that the microphones of the instruments are fed during conversation from a common battery at the exchange over the windings of a line relay belonging to each subscriber's line. This relay transmits both calling and clearing signals to lamps in the switchboard over local circuits within the exchange. Normally the line relays are so adjusted that they operate for a line resistance, exclusive of instrument, of at least 1 000 ohms or a leakage resistance of 8 000 ohms between the line branches or to earth; however, by means of special adjustment of the line relays the exchange may be made to operate with considerably less favourable conditions of the lines.

In local CB-exchanges it is almost always required that a small number of LB-lines are also connected up, for example trunk and rural lines, *i. e.*, lines to other more or less distant telephone exchanges. Such LB-lines may be connected without difficulty to an exchange of the type here described and differ from a CB-line only to the extent that the line relay is replaced by two relays. To some extent, therefore, it may be said that these exchanges combine the advantages of the LB- and the CB-systems.

The line relays are mounted apart from the switchboards on separate relay racks. This makes the switchboard exeedingly simple in construction besides ensuring that the work of installation and extensions to the exchange is reduced to a minimum.

Execution

A telephone exchange of this system is made up of one or more switchboards ADK 50, with line relay racks, a main distributing frame, a power plant, cables, cable runs and a test instrument.

Each *switchboard,* Fig. 1, has a one position, two panel cabinet of dull dark-stained oak. The board is 1 600 mm high, 632 mm wide and 830 mm deep. The connecting devices for 10 lines, each consisting of a 10-line jack strip and a 10-line lamp strip together with a terminal block, are assembled to a separate line circuit. The jack and lamp strips constitute the answering field. Number pegs, one for each jack, may be inserted in separate holes in the jack strips, thus ensuring satisfactory numbering of the lines. The terminal strips are fitted at the rear of the board and the answering field cables from the line relay rack are then connected direct to these terminals. A switchboard may be fitted with any number of line units up to 200 lines.

A cord-circuit comprises two three-conductor cords with plugs and weights, a cord clip terminal block for connecting the two cords, a double condenser and a speaking and singing key. The cord clip terminal block, the condenser and the key are assembled to a separate unit. Each switchboard may be fitted with any number of cord-circuits up to 19. Both the line units and the cord circuits may also be used without further adaptation for the LB-lines which are to be connected to the switchboard.

Above the answering field of the switchboard space is provided for the multiple jack strips, consisting of 20-line jack strips; in each switchboard there is space for 50 such jack strips *i. e.,* for 1 000 lines. Ordinarily the multiple is installed on a four panel basis, *i. e.* over two switchboards; the multiple capacity will thus be 2 000 lines, which consequently represents the final capacity of the exchange. The multiple jack strips are soldered to 100-strand multiple mats which are provided with spare lengths for future extension. The jack strips are numbered with the figures engraved. The cables from the line relay rack to the multiple jack strips are connected direct to the jack strips in the first four panels.

The common equipment of the switchboard comprises a complete operator's telephone circuit including a black bakelite handset, with four-wire cord and plug connected to a jack in the board. The handset may, if desired, be replaced by a head-phone and breast-plate transmitter. In addition this equipment includes a powerful five-bar hand generator, a ringing back and splitting key, a pilot lamp and a night alarm bell.

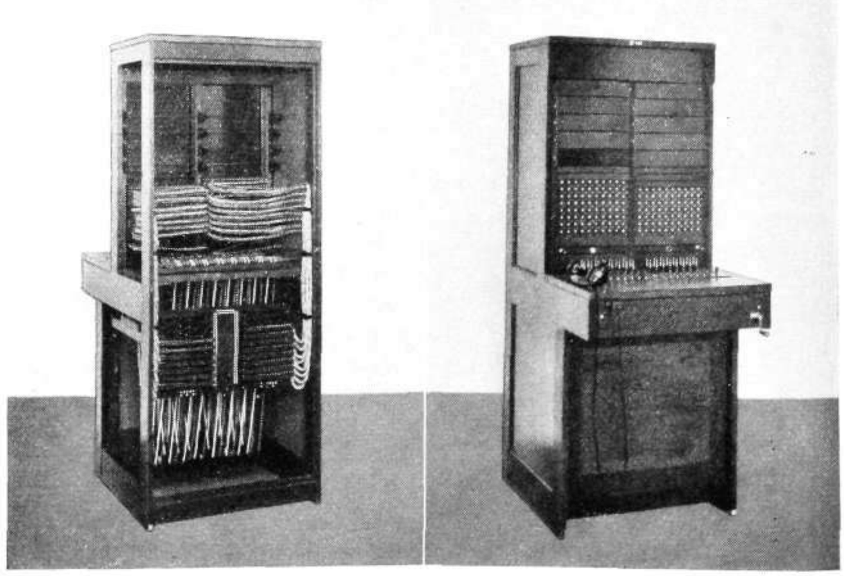


Fig. 1
Switchboard ADK 50

X 5530

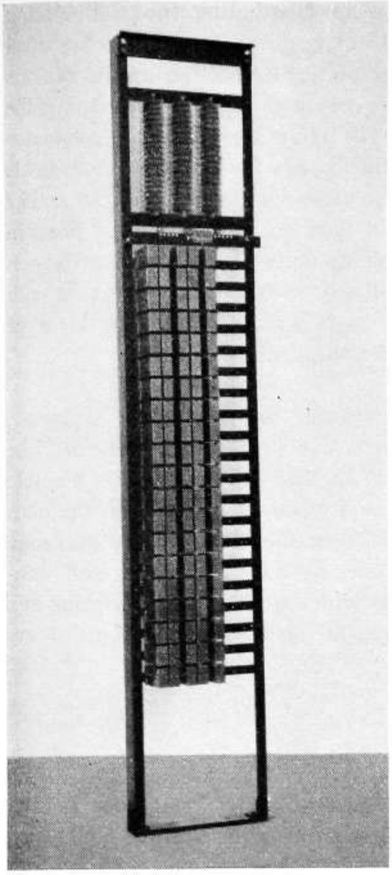


Fig. 2 X 3912
Line relay rack
at the top terminal strips, below relays for 100 CB-lines

To enclose the cables entering the line-up of switchboards a *cable turning section* — of dull dark stained oak to match the switchboards — is required. It is adapted for either left or right hand mounting.

The *line relay racks* are made of black-enamelled steel angles and bars, accommodating up to 200 relays, see Fig. 2. Each rack is 2 200 mm high, 155 mm deep, and 550 mm wide. The relays are wired in groups of 20 to terminal strips, located in the upper part of the rack. To these strips the cables for the incoming lines from the main distributing frame and to the answering and multiple fields of the switchboards will be connected. Each relay group is connected to the plus and minus poles of the battery over a fuse. These fuses are furnished with alarm contacts and are placed on a fuse bar in the rack along with an alarm lamp. There are also facilities for connecting an audible signal device to the fuse bar. The relays for the LB-lines may be mounted on the same rack as the CB-relays but require a different wiring.

The *main distributing frame* is made up of an initial section and a number of extension sections, dependent on the number of lines to be connected. The initial section holds 400 lines and each extension section 300 lines. The sections are made of black enamelled steel angles and bars and are provided with distributing rings for the jumper wires. The racks are 2 200 mm high and 760 mm deep; the initial section is 720 mm wide and each extension section 520 mm.

The line side is equipped with protector strips with carbon lightning arresters, fuses and heat coils for every 50 lines, and the exchange side with test jack strips for every 20 lines. From the protector strips to the test jack strips jumper wires are run for each line. The test jack strips are then connected with the relay racks by cables. From the test jacks it is possible to connect any line to a test instrument or disconnect the line from the exchange equipment.

The *power plant* furnishes all microphone current and signalling current to the telephone plant. The operating voltage of the system is 24 V and the current consumption is very low, so that telephone exchanges of this system are exceedingly economical in operation; for a three minute conversation including normal time for the operator to establish the connection no more than approximately 0.0032 Ah is required.

In general, the power plant consists of a 24 V storage battery, with charging unit, for feeding the subscribers' microphones and the circuits in the switchboards, together with a ringing machine or a pole changer for generating ringing current. The capacity of the battery is calculated so that sufficient reserve is ensured to allow for possible interruption of the charging current. Usually the battery is of such capacity, that it will suffice for the operation of the exchange for three days. The charging unit required depends on the nature of the current available at the exchange. If it is AC, which is the most common, the unit consists of a metal rectifier with regulating devices and an instrument board arranged for continuous charging of the battery. The charging current is regulated to a value corresponding to the average current consumption of the exchange. The instrument board is fitted with voltmeter and ampèremeter, fuses and devices for the distribution of feeding current and ringing current to the various units of the exchange. When only DC is available, a special charging unit is required.

In certain cases the exchange may be equipped with double sets of batteries, charged alternately. If the power supply is unreliable, with possibility of long interruptions of the supply, a charging plant independent of the mains, and consisting of a petrol engine coupled direct to a DC generator may be installed at the exchange. The ringing machine or the pole changer is, as a rule, connected to the battery and starts automatically, immediately a ringing signal is to be sent out.

Fig. 3 X 3913
Test instrument

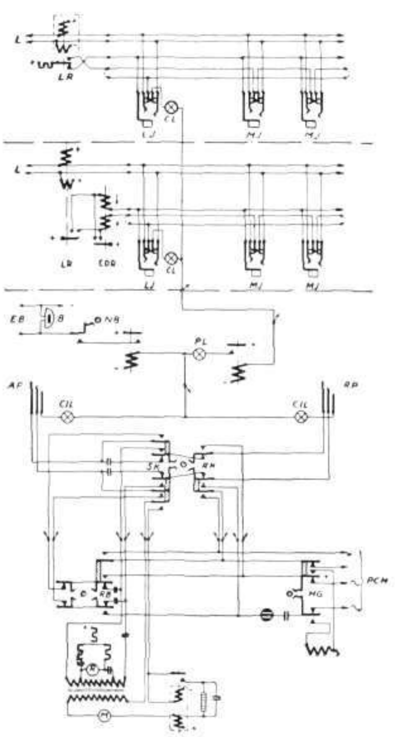


Fig. 4 X 3907
Diagram of switchboard ADK 50
top, CB-line; below, LB-line; bottom, switchboard

AP	answering plug
B	bell
CL	calling lamp
CIL	clearing lamp
COR	cut-off relay for LB-lines
EB	extension bell
HG	key for hand generator
L	line
LJ	answering jack
LR	line relay
MJ	multiple jack
NB	night alarm key
PCH	pole changer
PL	pilot lamp
RP	ringing plug
S-RB	splitting and ringing-back key
SK-RK	speaking and ringing key

The *cable runs* are erected between the main distributing frame, the relay racks and the line-up of switchboards, and are made of black enamelled steel flats and rods. On these runs the cables required for connecting up the various units are laid. For each 20 lines there are required one 42-conductor cable between the main distributing frame and the relay racks, two 42-conductor cables between the relay racks and the switchboards for the answering fields and one 42-conductor and one 63-conductor cable for the multiple field. The total quantity of cable required depends in part on the number of lines in the exchange and in part on how the various units are mutually arranged. The cable has enamelled conductors, insulated with two coverings of silk and one covering of cotton; the cable core is wrapped with one layer of cotton tape, impregnated with wax and lead sheathed.

The *test instrument*, Fig. 3, is employed for testing the lines to the exchange, the good functioning of which is above all dependent on the external line network being maintained in good state. With this instrument it is possible to make insulation tests conveniently and handily and detect faults in the lines and other equipment. It is installed at some convenient spot in the exchange in the vicinity of the main distributing frame. By means of a test cord, connected at one end to the test instrument and with the other end terminating in a plug that fits the test jack strips, the instrument may be connected up to any line desired.

Operation

In the answering field of the switchboard each subscriber has a jack *LJ* and a calling lamp *CL*, see diagram, Fig. 4. Speaking connections are established by means of cord pairs. The method of operation, which is the same for both CB- and LB-lines, is exceedingly simple; in certain conditions an operator should be able to deal with up to 200 lines without difficulty. In cases where the exchange comprises more than 300 to 400 subscribers' lines, *i. e.* with the line-up of switchboards consisting of more than two operators' positions, multiple jacks must be employed. This means that the line jacks must be repeated in the line-up of switchboards often enough for each operator to have access to all lines. In general, the multiple jacks *MJ* are repeated in alternate switchboards.

An incoming call is signalled in the switchboard when the subscriber lifts his handset, causing the line relay *LR* to be actuated, and the calling lamp *CL* to light up. The operator inserts the answering plug *AP* in the calling subscriber's jack *LJ* and throws the speaking and ringing key to position *SK*, which brings her into speaking connection with the subscriber. The subscriber then states what number he desires. If the switchboard is provided with multiple jacks, the operator inserts the plug *RP* into the nearest multiple jack *MJ* belonging to the desired subscriber's line. First, however, she ascertaines if the line is idle by touching the sleeve of the multiple jack with the tip of the ringing plug. If the line is busy she hears a click in her receiver and does not continue with the establishment of the connection; instead, she informs the calling subscriber that the line is busy. If no click is heard, however, the line is idle and the connection will be established. Immediately a plug is connected either in an answering jack *LJ* or a multiple jack *MJ* all other multiple jack sleeves belonging to the same line are indicated busy.

If the switchboard is not provided with multiple jacks, the connection to the desired subscriber's line is made to the corresponding jack *LJ*. In such case the operator can see immediately which subscribers are busy.

After the connection to the desired subscriber has been established, he is called by the operator by throwing the speaking and ringing key to position *RK*. Ringing current is sent out immediately on the throwing of the key if the exchange is equipped with a ringing machine or pole changer; otherwise, the hand generator belonging to the switchgoard equipment must be used also. When the hand generator is used the key *HG* must be depressed. After ringing current has been emitted the speaking and ringing key is restored automatically to home position, and the two subscribers are connected.

Immediately the plug *RP* is inserted in a jack the clearing lamp *CIL* on the ringing cord lights up; it does not go out until the called subscriber has answered. Consequently, the operator is not obliged by repeated listening in to find out whether the caller subscriber has answered, since this is indicated by the clearing lamp. During the conversation the two condensers in the cord circuit are connected in on the speaking circuit, and in this way the connected lines are fed separately over their respective line relays; when the subscribers replace their handsets at the end of the conversation, double clearing signal is obtained on the connected cord pair, i. e., both the lamps *CIL* are lit. The operator then disconnects the cords, whereupon the clearing signal lamps are extinguished.

If necessary the operator may ring over the answering cord by throwing the ringing back key to position *RB,* provided the speaking and ringing key is at the same time thrown to position *SK*. If the operator wishes to speak to a subscriber over the ringing cord she can cut out the answering cord by throwing the splitting key to position *S*. The pilot lamp *PL* lights up whenever a call occurs in the switchboard. A night bell may be switched in by the key *NB,* and it will then give audible signal immediately a calling or clearing signal is registered at the switchboard. A ringing supervisory indicator is actuated while the ringing signal is being emitted, provided the ringing source operates without fail.

Ships' Telephone Plants

E. BERGHOLM & V. SÖDERSTRÖM, TELEFONAKTIEBOLAGET L.M. ERICSSON, STOCKHOLM

Ericsson's ships' telephone plants have in recent years been re-designed in consultation with the naval administrations of several countries, while the new lightweight materials now available have been adopted to a great extent. In this way it has been possible to bring the weight down by 40 %, while at the same time ensuring an appropriate and compact design.
Telephone plants on board ship may be divided into navigation telephone installations designed for transmission of communications for the internal service, and telephone plants for linking to the public telephone services for the convenience of passengers. Here the first-named kind of plant will mainly be dealt with.

The special conditions on board ship are such that the material employed for ordinary telephone plants can only be used to a limited extent. The humidity and saltiness of the air require the line system to be wholly enclosed and the instruments to be watertight and resistant to corrosion. On account of the motion of the ship in heavy sea all parts comprised in the instruments must be fixed so that no oscillation or jars occur on rolling. For war vessels there is in addition the demand for the lowest possible weight combined with insensitivity to the shaking due to gunfire. The great noise in the engine room and such plases, moreover, call for devices which make telephony possible even if sounds are so great that ordinary conversation cannot be carried on. Special arrangements for signalling are also a necessity in such conditions.

In working out the new Ericsson ships' telephones, Fig. 1, these requirements and conditions have been decisive in the shaping of the designs, while the greatest possible simplicity in the connecting principle has been sought to make the system reliable in operation, easily accessible and to facilitate installation and maintenance.

Fig. 1
Ship's telephone post

X 5537

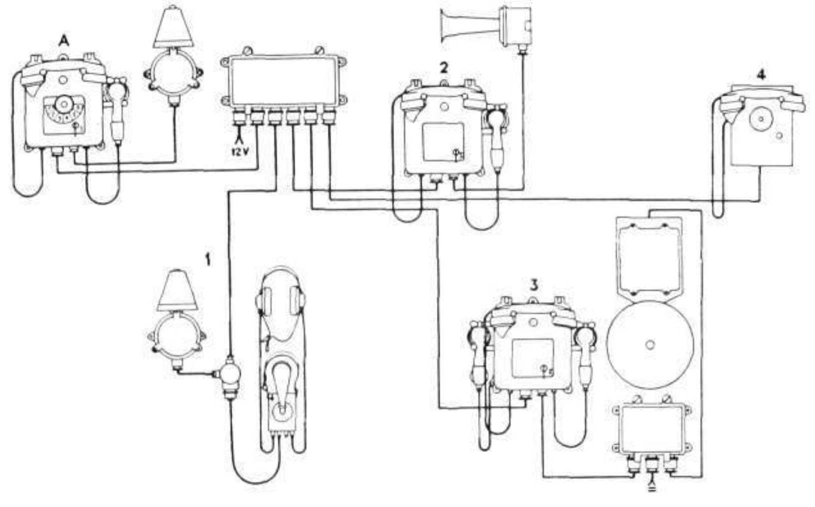


Fig. 2 X 5527
Diagram of navigation telephone installation
on the parallel system
A bridge (main station)
1 fore castle
2 poop
3 engine room
4 engineer's cabin

Navigation Telephone Installations

Side by side with the mechanical or electrical ordering installations, the telephone is being more and more used nowadays to communicate orders and information in ships. While the firstnamed category of order installations — machine telegraph, steering orders and steering position indicators etc. — are restricted to the transmission of certain definite orders respecting speed, course etc., the telephone plant may be employed for every type of order. According to the purpose and employment of the plant differing demands are made respecting its operation, and Ericsson has therefore worked out various types of instruments with a view to being able to offer the arrangement most suitable in all respects for each sphere of utility.

Parallel System

When it is a matter of transmitting orders from the bridge to various parts of the ship, there is mounted on the bridge a main instrument equipped with a selector device, which can call all other instruments; these last can also call the bridge, see diagram, Fig. 2. Direct call between sub-instruments is on the other hand not desirable, as all orders should come from the main instrument and the plant should constantly be available for this purpose. The instrument in the engine room in view of the noise of the engines is equipped with laryngophone and an extra loud bell. As the current required to operate this bell is fairly large, it is connected to the ship's lighting mains and coupled in over an operating relay. The other instruments have diapraghm bells as signal devices, watertight in construction, or if louder signals are required they have electric sirens.

In another plant, intend for intercommunication within the ship, all the instruments are equipped with selectors and may thus call and speak with each other.

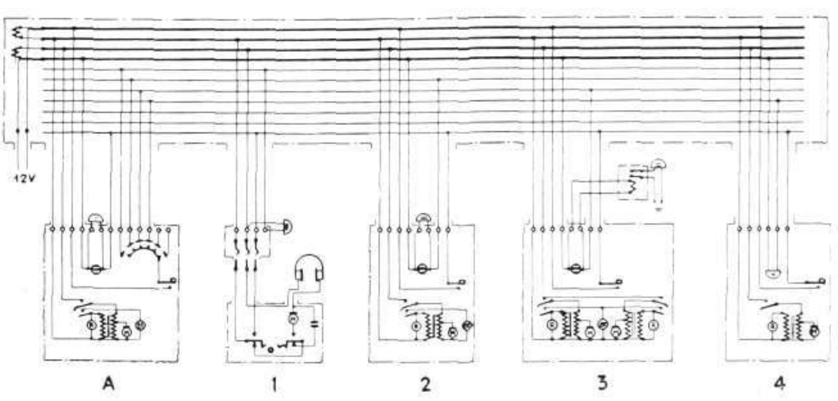


Fig. 3 X 5529
Connection navigation telephone installation

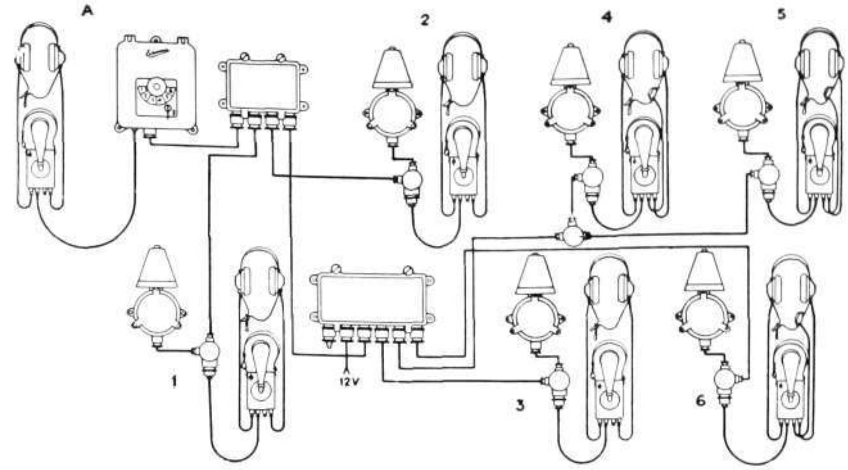


Fig. 4 X 5526
Diagram of fire direction plant

A gunnery officer
1 central gun-directing instrument
2 ship's commander
3 gunnery central
4 anti-aircraft guns
5 aft gun-turret
6 fore gun-turret

The above plants are carried out on the parallel system, the speaking equipment of the instruments being on conversation connected in parallel to two common speech wires, Fig. 3. Thus only one call at a time can proceed and this should be taken into consideration in the selection of the extent and distribution of the plant. Each such installation, then, consists of one unit separated from the others by means of impedance coils, connected into the battery circuit and located in the distribution box of the plant. Up to six instruments may be called from one instrument; if it is desired to utilise this number in several instruments, the plant then comprising more than six instruments, fixed numbering of the instruments cannot be employed. In this case, therefore, the selector positions are designated by the names of the places where the instruments are located.

The advantages of the parallel system are simplicity in design and use and great adaptability to various purposes. The selector does not need to have any answering position and a call may be answered immediately without previous setting of the selector or other corresponding operation. As each installation is divided from the others by means of impedance coils in the speaking branches, cross-talk between the installations will be small. Portable equipment, consisting of breast-plate transmitters and head-gear receivers may be connected, where connection is only required temporarily, *e. g.*, et look-out posts. Several instruments in the installation may be called simultaneously and receive a common order (general call).

Series System

If the special conditions are such that it is required to be able to establish several calls simultaneously, the plant is made on the series system. The speech devices of the instruments are then connected in series with the common battery during conversation.

In such a plant all the instruments can call and converse with each other and several simultaneous calls are possible. This type of plant may be suitable for small vessels where only one telephone plant is installed, which has at the same time to serve several different purposes. The simultaneous call facilities requires the instrument selector being set to answering position when a call is to be answered. Up to five instruments may be called in this system, which does not mean, however, that the number of instruments is restricted to six, but if more instruments are connected then communication may not be had between all of them. In this connection it should be stated that the plant should have at least four instruments if simultaneous calls are to be required. Since there must be a special answering position, all instruments are equipped with selectors. The only exceptions are those instruments which are solely to answer calls and where possibility of calling from the instrument is not required.

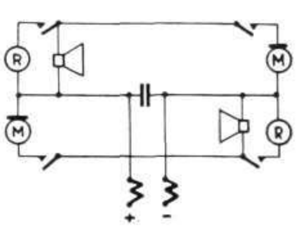


Fig. 5 X 3911
Diagram of loud-speaker plant
on three-wire system

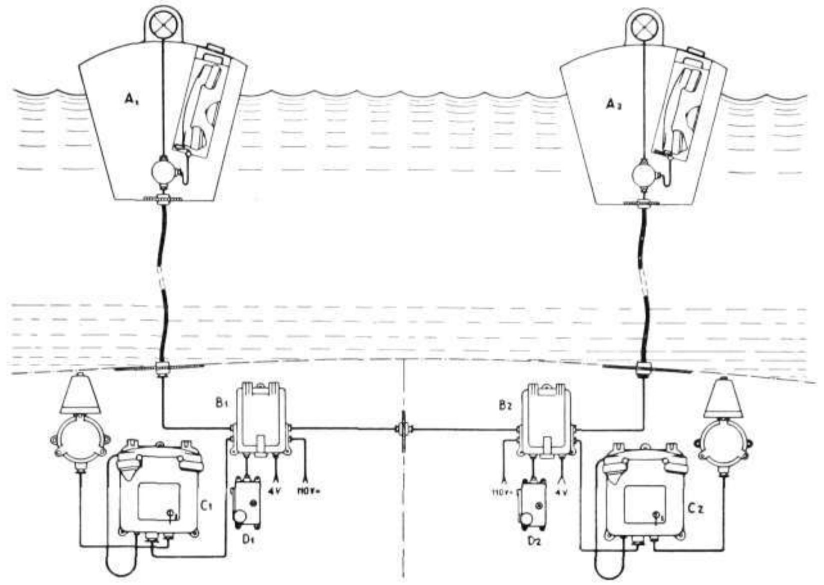


Fig. 6 X 5528
Diagram of buoy telephone plant
A telephone buoy
B switch-box
C telephone instrument
D telegraph sounding key

Several plants on the system above described may be coupled to a common battery without it being possible to overhear calls from one plant to another; common battery lines should be avoided, however, as these in certain cases may cause cross-talk. Within the plants themselves the calls are not secret; an urgent order therefore need never be delayed on account of the instrument called being busy and not in a position to be called, which might be the case if the system were made for secret calls. A secret call system, moreover, would be more complicated and consequently less reliable. No relays or other devices needing adjustment and supervision are to be found in the systems described above. The battery tension, which is normally 12 V, may go down to half this voltage without the speech communication being endangered.

Special Plants

The plants referred to above are such as are required to some extent on all kinds of vessels. On war vessels there are in addition others designed for special duties, in the shaping of which new points of view must be observed. Thus, for example, the modern armament on such vessels, if full efficiency is to be achieved, requires that there shall be a well arranged telephone system for fire direction, observation, aircraft watching etc. Such a system consists as a rule of several distinct plants, each of which fulfils a definite purpose. As these plants are only employed occasionally the instruments are usually not connected permanently but only at the times the plant is to be put into operation. Complete freedom of movement is often required during employment, so that the instruments are made portable in the form of head-gear.

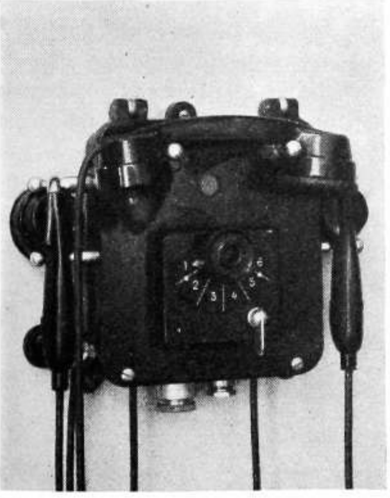


Fig. 7 X 3916
Ship's telephone
with laryngophone to left, handset in middle and extra receiver to right

In a plant for fire direction, observation, etc. the individual observations regarding speed, course etc. of the enemy's force are communicated to a central point where the pointing settings are calculated, taking into account the movements of the vessel herself. From this point there are then directed the laying and firing, over other telephone plants, Fig. 4, to the crews of the different pieces. These plants are executed on the parallel system in view of its great flexibility of operation.

In certain cases the conditions require that loud speakers must be employed for order giving and so on. That occurs when those who are to receive the order cannot interrupt their work to go to the instrument. To ensure the highest possible intensity of sound special apparatus are used for such plants, made on the three-wire system, Fig. 5, by which greater acoustic effect is achieved. The risk of return noise connection and howling is also reduced by employment of this system.

Fig. 8 X 7188
Watertight signal devices
left, diaphragm bell, middle siren, right tolling bell

On submarines there are, in addition to the ordinary order plants, one or more buoy telephone plants, Fig. 6, designed to serve in the event the submarine sinks to put the crew in communication with the outer world to direct the work of rescue. For this purpose buoys are let up from the submarine, equipped with telephone instruments and signal devices. A plant of this kind has been described in more detail in Ericsson Review, No 3, 1935.

Telephone Instruments

A telephone instrument of Ericsson's new construction for ships' plants, Fig. 7, is built into a watertight case, on which are fitted handset, laryngophone and extra receiver. The fixing arrangments for the telephones are so made that no swaying can arise with the ship's motion.

The handset is made of bakelite with moulded-in conductors and is very strongly constructed. The receiver earpiece is provided with a rubber pad which considerably improves its fitting to the ear while at the same surrounding noise is excluded. The transmitter and receiver are made as easily replaceable capsules. The connecting cord is rubber insulated. On account of its light weight this handset is appreciably more comfortable and less fatiguing than those formerly employed for this purpose.

The laryngophone, which to a large extent is of the same design as the handset, is used in the cases where the extraneous noise prevents the use of ordinary handset, *e. g.* in the engine room. The transmitter is replaced by a laryngophone which during use is pressed against the throat and takes up the sound vibrations of it. Sound waves from the air, on the contrary, do not act on the laryngophone.

The extra receiver is furnished with a handle so that it may more comfortably be held to the ear; it too is provided with rubber pad.

Fig. 9 X 3915
Extension instrument for series system

The selector and signal key are mounted on the front of the instrument. If required a visible indicator for marking call to the instrument may also be fitted there. Underneath the instrument are watertight cable terminals for leading the cables into the instrument. The terminal block for these is accessible on opening the cover. Tightness between cover and case is ensured by rubber packing. The cover has adjustable hinges which may be regulated to ensure complete tightness. The contact devices of the instruments are so made that the drop indicator is automatically restored when the handset or laryngophone is lifted.

Fig. 10 X 5539
Speaking set
breast transmitter to left, laryngophone in middle and head-gear receiver to right

In view of the need for the least possible weight in the instruments, particularly for warships, the instrument is so designed that it may be made of light metal, as well as the standard brass. The alloy used is anti-corrosive, which combined with special surface treatment make the instrument even in this construction very resistant to the action of damp and sea water. An instrument constructed of brass weighs 10.5 kg and of light metal 6.25 kg.

Having regard to the varying demands made on the intensity and character of the signalling devices, these instruments are not fitted with bells. The bell is mounted alongside the instrument and connected to it by means of special cable lead. The signal devices in question, see Fig. 8, consist of watertight diaphragm bells or, when a more penetrating signal than a bell can give is required, of signal horns (sirens). In certain cases, *e. g.* in the engine room, where the siren signals in unfavourable circumstances cannot be distinguished because of similar machine sounds, a tolling bell should be employed.

Instruments located at unsheltered parts of the deck, where they are exposed to submersion and ice-formation should be placed in protective cases. It is most advisable to arrange the connections with plug in a watertight wall-box which is sealed by a lid when the instrument is not connected.

In addition to these types of instrument, there are employed in cabins and other places extension instruments of simpler type, Fig. 9. Made for the series system, this type has a two-position switch for calling and answering positions and a bell mounted on the front of the instrument.

The portable equipment, Fig. 10, comprises a transmitter with rubber funnel and also, to allow for noise and use with gas-mask, a laryngophone; this is connected in place of the transmitter by a switch on the transmitter fitting. The speech equipment is connected by plug to a watertight distribution box, Fig. 11.

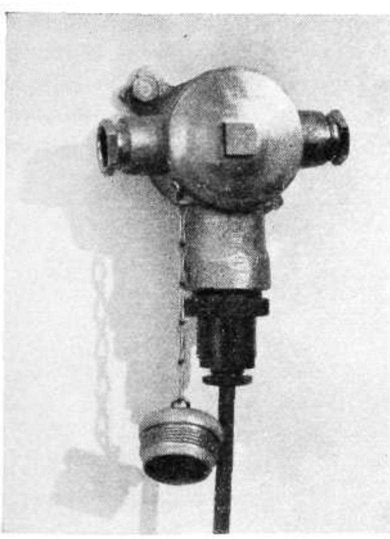


Fig. 11 X 3917
Watertight distribution

The cable network is as a rule carried out with ship's cable having a conductor section of 0.5—1.5 mm². The cables are connected and distributed in sealed distribution boxes, Fig. 12, where as stated the choke coils are placed.

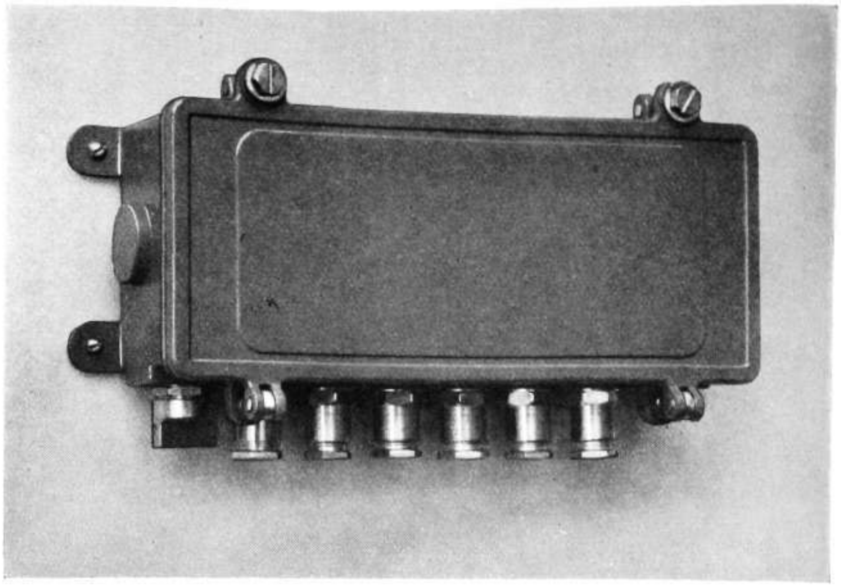


Fig. 12 X 5538
Distribution

The plants are operated from a 12 V battery. The current consumed is low, appr. 90 mA per instrument, so that only comparatively small batteries are required.

Ericsson's ships' telephone instruments comply with the regulations in force for teletechnic plants on board ship (Lloyds' Rules for Electrical Equipments section 13 clause 3).

Public Telephone Installations

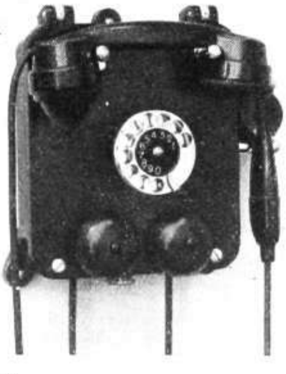


Fig. 13 X 3918
Ship's telephone for automatic system
with extra receiver

On large vessels, both pasenger and warships, there are usually telephone installations for communication between cabins. These are generally automatic, though manual CB-systems are also employed. The installations are as a rule so constructed that they may be connected up to the telephone network on land when the ship is lying in port. In addition they are connected to the ship's wireless station, thus giving facility while the ship is at sea to exchange conversations with the land. The technical execution of the branch exchanges and instruments largely follow the principles above described. Automatic equipment with relays requires spring mounting on board ships with gun armament. Arrangements are provided with the instruments in the cabins, which are of standard construction, to avoid the handset sliding off or swaying to and fro, which would cause disturbing noise. The grip of the handset on such instruments, therefore, is so constructed that as the ship rolls it is caught and held fast by the switch-hook points. Those instruments that may be exposed to damp must be made watertight, Fig. 13. As these installations in other respects differs little in design from corresponding land plants, more detailed description of their functioning is hardly necessary.

Portable 10-Line Telephone Switchboard

ERIK I. ENGQVIST, TELEFONAKTIEBOLAGET L.M. ERICSSON, STOCKHOLM

To meet the demand existing for portable telephone switchboards with a capacity up to 20 lines, Telefonaktiebolaget L.M. Ericsson has designed a new 10-line switchboard, which in an exceptionally satisfactory manner combines handiness with strength and suitability to its purpose. This new switchboard is intended to replace the 10—20 line switchboards described in Ericsson Review No 2, 1936, which on account of their bulk and weight proved less convenient as portable switchboards.

The Ericsson portable telephone switchboard ABH 50 is on the monocord principle, which means that each line in the switchboard terminates both in a connecting jack and in a single cord with connecting plug. This avoids the limitation of the number of simultaneous calls always imposed by the number of cord pairs in an ordinary telephone exchange. Moreover, it provides the facility of arranging simply traffic between two 10-line switchboards and thus making up a 20-line exchange, see Fig. 1.

The switchboard is only intended for establishment of connections between LB-instruments with ringing generator. Naturally both single and double lines may be employed for connecting the instrument to the exchange. The operation of the switchboard requires a special telephone instrument, by means of which calls may be answered and ringing signals transmitted.

Design

The portable 10-line switchboard ABH 50, Fig. 2, is mounted in an oak case, walnut-stained with cellulose finish. All corners subjected to knocks are furnished with metal fittings. The whole of the front is covered by two hinged sheet metal lids which can be fastened by a catch. On the upper lid is fitted

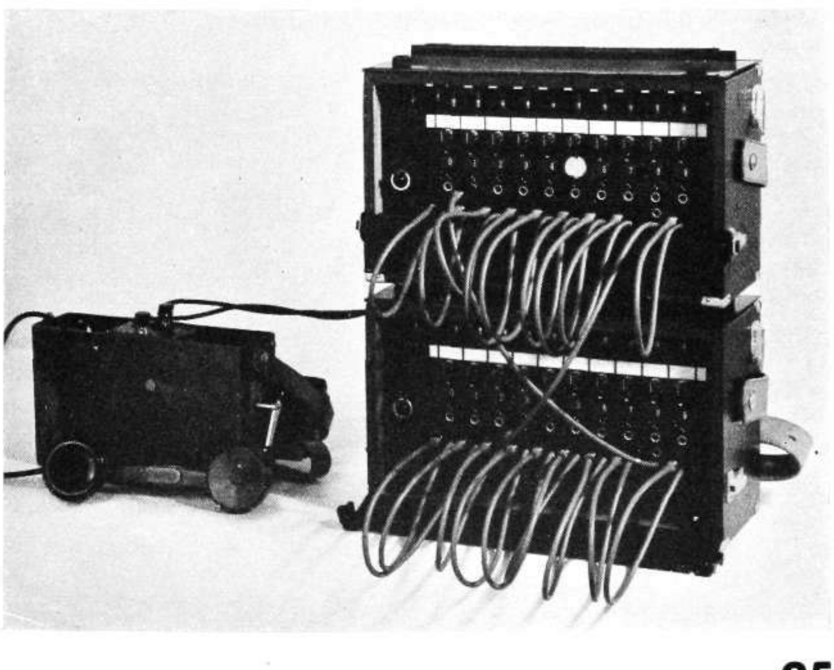


Fig. 1 X 5524
Portable fieldtelephone exchange for 20-lines
consisting of two portable 10-line exchanges coupled together and one portable telephone instrument

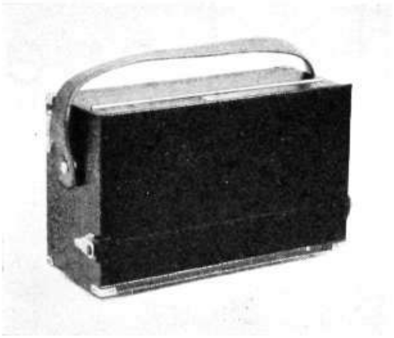


Fig. 2 X 3896
Portable switchboard ABH 50

a bar which prevents the drop-indicator shutters from falling when the lid is shut for transport. On the lid also there are four bowl-shaped hollows placed to correspond to the feet underneath the case and thus facilitating the setting of one switchboard on top of another.

All the parts necessary for the operating of the switchboard are accessible from the front, Fig. 3. The lower part of the case is formed into a compartment to hold the cords during transport. The lower lid may be shut after the cords have been taken out of the compartment. The rear half of the upper part of the case is also made as a lid which opens to display the terminal block to which the lines are to be connected. Inside the case is placed a connecting diagram for the exchange. A strong adjustable leather carrying strap is fixed at the ends of the case.

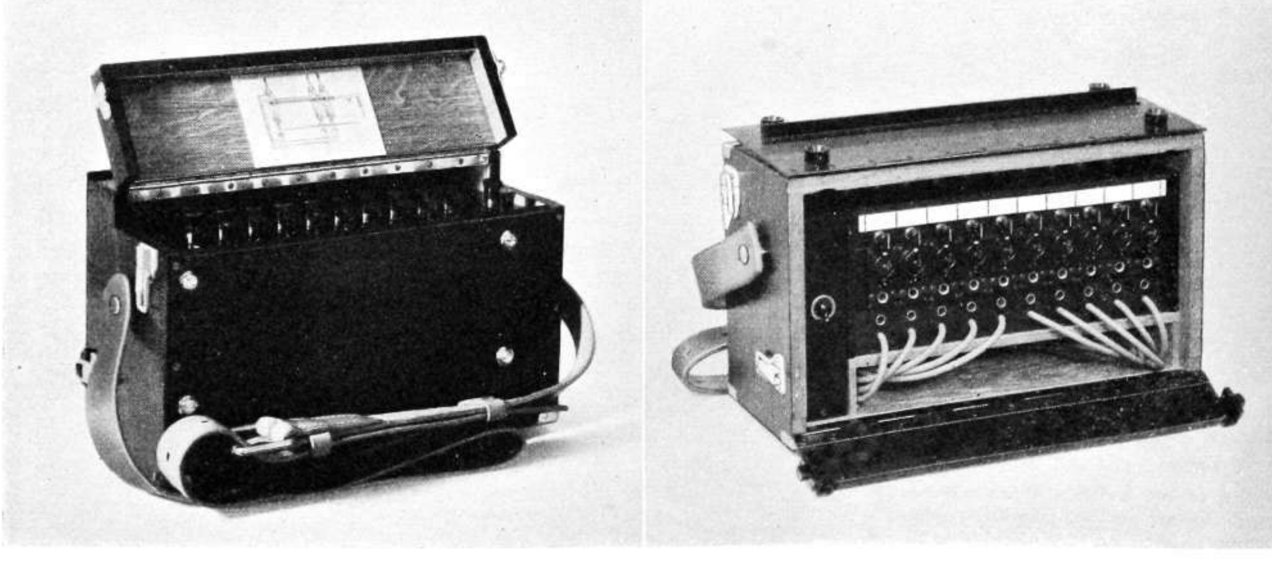
Packed up, the switchboard has the following dimensions: length 346 mm, width 140 mm, height 202 mm. Its weight complete is 9.8 kg.

The *inset* constitutes the telephone exchange itself, the case forming simply a protective cover. It is fixed in the case by means of four screws which cannot be lost. It comprises a rigid frame of metal, on which is mounted the equipment for the 10 lines and the common equipment. The equipment for a line comprises a speaking key, a calling drop indicator, a connecting jack and a connecting cord with plug and finally two line terminals. The common equipment comprises two terminals for connecting the operator's telephone instrument and an alarm device giving audible signal on call.

The *speaking keys* for the 10 lines are assembled on a strip. The contact springs are actuated by pressing the keys which then make a 45° turn, so that it is easy to see whether a key is in working or home position. Above the speaking keys there is a designation strip on which may be noted in pencil the length, designation etc. of the lines connected, the markings being thus easy to remove later with a rubber or a damp rag.

The *calling indicators* and the *connecting jacks* are coupled together mechanically, so that a dropped indicator shutter is automatically restored when a plug is inserted in the connecting jack below. The indicators serve both as calling and clearing signal device and are therefore iron-sheathed to prevent the occurrence of cross-talk. The DC resistance of the indicators is 1 000 ohm and their sensitivity for signal current is extremely great. The indicators are equipped with alarm contacts which are actuated by the indicator shutter when it drops.

Fig. 3 X 7187
Portable switchboard for 10 lines
left, rear with lid open for connecting the lines, right, front open for use



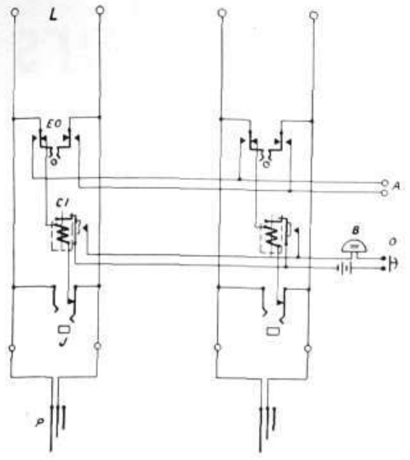


Fig. 4 X 3895

Diagram of portable switchboard

- **A** telephone instrument
- **CI** calling indicator
- **EO** speaking key
- **J** connecting jack
- **L** line
- **O** bell switch
- **P** connecting plug

The *connecting cords* consist of two-conductor rubber-covered cords, fitted at one end with connecting plug and at the other shaped for connecting to the cord terminals of the switchboard. The cords are reinforced at the plug end by a special vulcanising process, thus appreciably reducing the risk of the cord fault at this point. Nor does the plug require to be fitted with protective spirals and consequently the connecting cords are flexible and easy to handle. The rubber insulation of the cord naturally constitutes a particularly effective protection against moisture, which is an important feature in telephone exchanges of this type.

As it is not advisable to allow the cords to hang down freely on an exchange in operation, resting jacks have been arranged, in which the plugs of all idle cords may be kept inserted. These resting jacks are placed in a row immediately below the connecting jacks.

The *line terminals* are of exceedingly strong design and provided with nuts that cannot be lost, covered with insulating material. They are mounted on a plate of insulating material. Right at the left of the plate the terminals for the operator's telephone instrument are located, after which come the ten pairs of terminals for the lines.

The *cord fasteners* are mounted on a block of insulating material, located underneath the inset so as to be easily accessible for exchange of cords. The cords are connected over ordinary screws.

The *alarm device* is fitted in a separate compartment at the left end of the inset. It consists of a bell, a 3 V dry battery and a switch. The dry battery is of the same type as employed in field telephone instruments.

Operation

An incoming signal on a line causes the corresponding calling indicator *CI*, see diagram, Fig. 4., to fall and starts the bell, if it has been connected in by means of switch *o*. The call is answered in the telephone instrument connected at *A*, by pressing the speaking key *Eo* of the calling line. When the order has been received the key is restored and the speaking key of the called line is pressed instead. Ringing signal is transmitted by the hand generator of the telephone instrument *A* and when answer is received this key too is restored, after which the called line's connecting plug *P* is inserted in the calling line's connecting jack *J*. The calling indicator is then restored and the connection is established. The called line's indicator, *i. e.*, the indicator of the line whose plug is used for making the connection, is in circuit throughout the call and drops when clearing signal comes from one of the lines at the end of the call. By depressing the key of one line and listening in on the connection it is possible to determine whether the call really is finished, after which the connection is broken, and the indicator restored.

Circular communications may be transmitted from the telephone exchange by depressing the speaking keys for all lines concerned, at the same time ringing them up, after which the communication can be given as soon as all participating have answered. Conference calls can also be established; for example, if lines *1*, *3*, *5* and *8* are to take part in a conference, plug *1* is coupled in jack *3*, plug *3* in jack *5* and finally plug *5* in jack *8*. In such case the clearing signal is given only by indicator *1*. Two or more conference calls may be proceeding at one and the same time.

Telephone Cable Suspenders

P. PRIKLONSKY, TELEFONAKTIEBOLAGET L.M. ERICSSON, STOCKHOLM

Aerial telephone cable networks in general are at present in a process of rapid development and the problem of designing a suitable device for suspending the aerial cables from the suspension wires has become extremely urgent, since most of the suspender types hitherto employed display various disadvantages which designers have long sought to overcome. Ericsson is now marketing a new stainless steel cable suspender, the design of which constitutes a very successful solution of this problem, as the cables are fully protected against such injuries as formerly often arose through chafing etc. The erection is simple and rapid, provided use is made of certain special methods and tools, which offer an appreciable saving in labour as compared with other aerial cable erection methods hitherto commonly used.

The rapid development of telephone networks throughout the world is resulting in an ever increasing replacement of bare wire lines by cables, chiefly dry-core leadcovered cable.

In areas with a great density of subscribers and limited space, *e. g.*, in large towns or the central sections of small towns, it is customary to lay the cables underground, either direct as armoured underground cable, or unarmoured in conduits. This method of laying provides good protection of the lines against most disturbances as well as against fire, mechanical injury, etc. Also, this is the reason why long trunk cables are generally placed underground. Underground cable lines, however, involve great expense both for new installations and for alterations and — particularly as regards armoured cable — high repair costs when faults occur. Moreover, there often arises risk of corrosion from harmful elements in the soil and of electrolytic injury to the lead covering from stray currents.

In cases where, for some reason, it is out of the question to lay the cables underground, aerial cables can suitably be used, the cost of installation for these being, in fact, appreciably lower than for underground cable, and the repairing of faults being much simpler. On the other hand, when compared with bare wire lines, aerial cables provide considerably greater protection against perturbations and mechanical injury, at the same time ensuring very appreciable saving of space as well as decided æsthetic advantages. Consequently, aerial cables are to be preferred in the outskirts of town and in smaller communities. As it is in just such areas that the number of subscribers shows a very heavy increase at present aerial cable networks are in a state of rapid expansion and the line material required for them is of especial current interest.

The aerial cable is, as a rule, dry-core lead covered cable and is carried by means of a suspension strand or wire. In recent years there have also been introduced self-supporting aerial cables, which are suspended without sus-

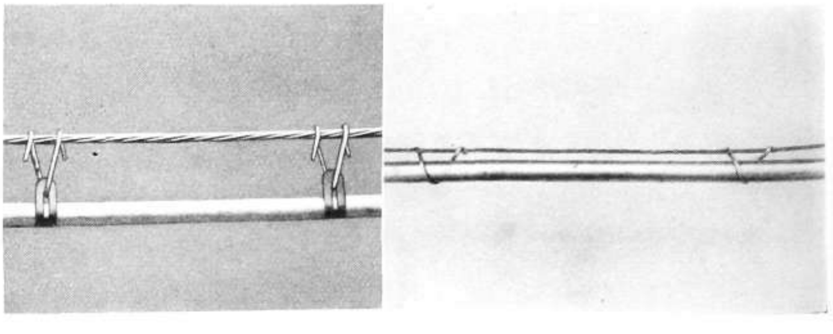


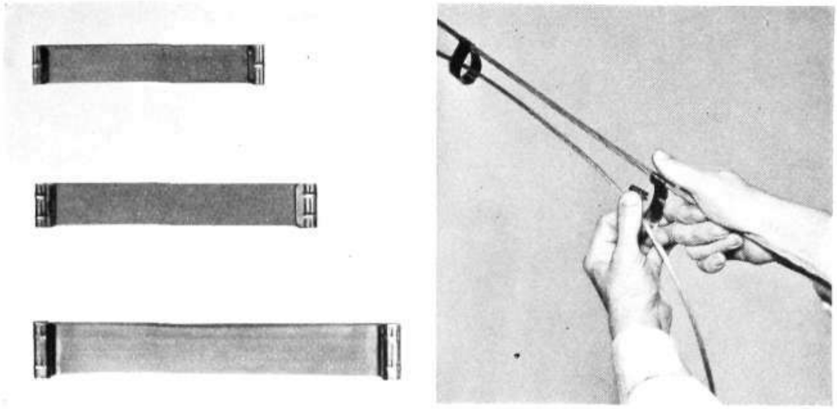
Fig. 1
Cable suspenders,
old types

X 5517

Fig. 2 X 5518

Cable suspender NF 455

left, suspenders for 18, 23 and 38 mm cable diameters; right, clipping suspenders on suspension wire, at the same time inserting the pulling wire



pension wires and thus must themselves bear the pulling stresses. The suspension wire, which is of hot-galvanized steel, is supported and terminated by means of supporting or terminal fixtures, which, in turn, are fitted on supports of various kinds, such as wooden poles, tubular steel poles, walls of buildings, roof standards etc.

Cable Suspenders

One of the most important details in an aerial cable network are the suspenders by means of which the cable is hung from the suspension wire. Several different types of cable suspenders have been designed from time to time in various countries. A distinction may be made between two main groups, *viz.*, the suspenders which grip the cable firmly but are free to move along the suspension wire, and suspenders which grip the suspension wire but in which the cable can move freely.

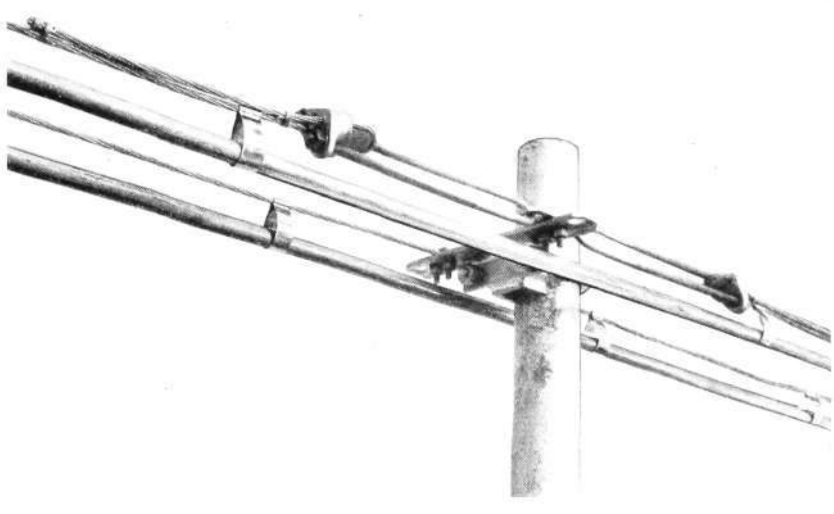
Cable suspenders of the first group are employed in many European countries. They have hitherto constituted the standard type of the Swedish Telegraph Administration as well as of the Ericsson company. This cable suspender NF 400, Fig. 1, consists of a copper strap which is wrapped around the cable and firmly bound to it, together with a hot-galvanized double hook of steel wire which is threaded through slots in the ends of the copper strap and hooked on to the suspension wire, along which it can move freely.

The mounting procedure is quite simple. The suspension wire is first run out and attached to its supporting and terminal fixtures. The cable is then unwound from the drum, fitted with suspenders one after the other and raised up to the suspension wire at the first support of the cable section. A lineman hooks the suspenders on to the suspension wire one by one and pushes the cable along the suspension wire to the next support. There a second lineman is stationed who, as the cable suspenders reach him, unhooks them from the suspension wire on one side of the support and rehooks them on the other

Fig. 3 X 5502

Cable crossarm NE 108/75

on tubular steel pole; the near suspension wire is terminated with stay tighteners NF 1, while the far suspension wire is merely supported by the crossarm



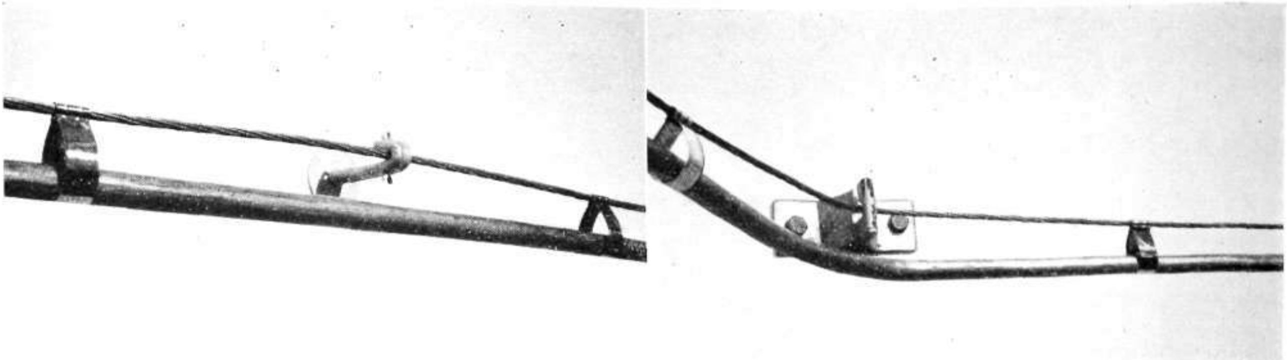


Fig. 4 X 7162
Supporting wall brackets
left, screw bracket NE 2022/3 for running in straight line; right, hook bracket NE 2024/8 for running at sharp bend

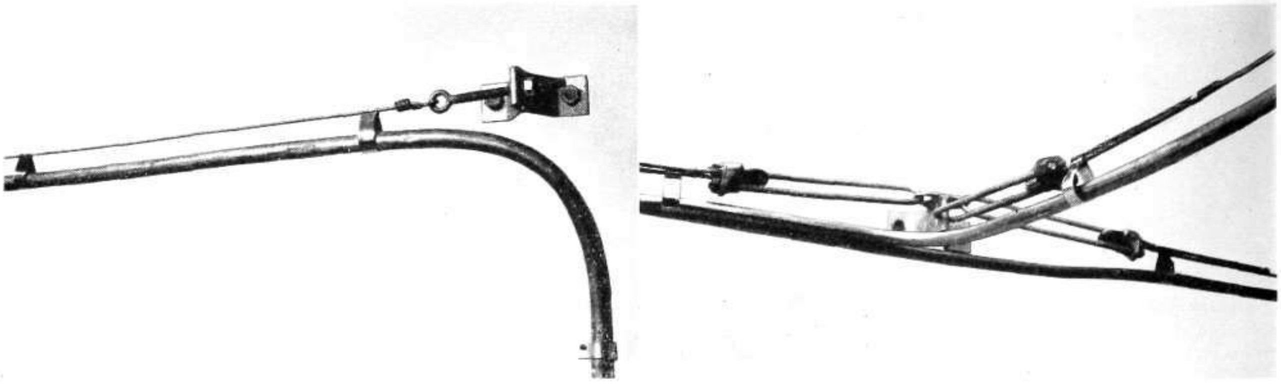
side, at the same time as he assists in moving the cable forward. The same procedure is followed at the third support, where there is a third lineman, and so on. A winch placed at the far end of the cable section may also be employed for pulling the cable.

This procedure is very tedious, however. It requires a lineman at each pole and the friction between the hooks and the suspension wire hampers the running of longer sections. On the other hand, this method has the advantage of being convenient for the running of cables over hilly ground, yards difficult of access, streets with heavy traffic etc., since the cable never requires to be unrolled on the ground but is moved forward at an appreciable height.

Cable suspenders of the second group, in which the cable itself moves freely, are chiefly employed in the United States and other countries outside Europe. This type, see Fig. 1, permits of rapid running of large sections with comparatively few linemen. The cable suspenders are clipped on to the suspension wire from a cable car or, still better, from the ground, for which latter purpose the suspension wire is first run out and temporarily fixed breast high. At the same time as the linemen attach the suspenders the pulling wire is laid in the suspenders. The suspension wire is then hoisted to the correct height, after which the cable is run by means of the pulling wire with the aid of a winch. The low cost of this method, however, has been to some extent counterbalanced by the disadvantages displayed in actual practice by the various designs of cable suspenders hitherto employed.

The cable suspenders are generally in the form of rings of a large diameter and with a rather small cross-section; moreover, the rings are often bent in a spiral. The material is usually hot-galvanized steel, which has a fairly rough surface. Due to the swaying of both the suspension wire and the cable in the wind, however, the cable twists and turns in the rings. Also, the cable moves longitudinally in the rings due to expansion and contraction caused by variations in temperature. These movements against the small bearing surfaces presented by the rings give rise to wear on the lead sheath of the cable and lead particles are deposited on the rings. The lead sheath will then be rubbing against a rough lead surface, which still further aggravates the wear and finally results in the rupture of the lead sheath. Attempts have been made to remedy this condition by providing the cable suspenders nearest the supports — where the heaviest wear has been observed — with broad ring saddles of

Fig. 5 X 7164
Terminal wall brackets
left, terminal bracket NE 2026/3 with eye bolt NF 100/10 for termination of suspension wire; right, terminal wall bracket NE 2028/8 with stay tighteners NF 1 for termination of several suspension strands



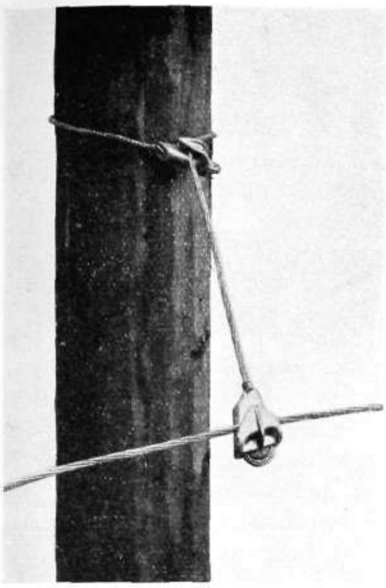


Fig. 6 X 3891
Temporary noose hanger

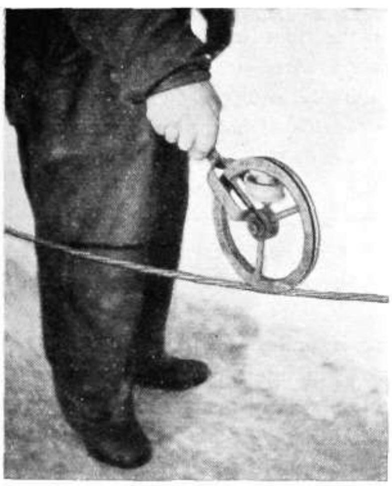


Fig. 7 X 3892
Marking wheel NK 901/50

Fig. 8 X 3893
Mounting of cable suspenders

sheet aluminium, or by replacing these cable suspenders by others, similar to the type which grips the cable. The spiral form of the rings has also been found to cause slight bends in the cable, which finally make it impossible to withdraw it.

Due to the low cost of installation, Ericsson has recently introduced cable suspenders of the second group. These suspenders are of an entirely new design, however, being based — among other things — on the use of high quality stainless steel bands. After most rigorous tests, the new cable suspenders have been adopted by the Swedish Telegraph Administration as the new standard type for the Swedish telephone networks, and they have already aroused considerable interest in other countries as well.

These cable suspenders are made in three sizes — NF 455/18, NF 455/23 and NF 455/38 — for cable diameters not exceeding 18, 23 and 38 mm respectively, see Fig. 2. These dimensions correspond to maximum 50, 100 and 300-pair cables of Ericsson's type EPBL 0.6 mm. The new suspenders are made of bright, stainless, spring band steel with the edges rolled down to prevent injury to the lead sheath of the cable when pulling in the latter. The width of the band steel in the three sizes is 18, 20 and 25 mm respectively. Both ends of the suspender are rolled so as to form sleeves which grip over the suspension wire. It is important that the cable suspenders be used with a size of suspension strand or wire suited to the size of the suspender. Thus the small suspender is intended for 1.5 ton suspension strand NF 202/1.5, 7×1.5 mm or 1.1 ton suspension wire NF 203/1, 4.7 mm; the medium size will fit the 3 ton suspension strand NF 200/3, 7×2.2 mm, while the large suspender is suited for the 6 ton suspension strand NF 200/6, 7×3 mm.

The cable suspenders are supplied flat, this being the most convenient form for packing and requiring very little space for transportation. When being mounted, the two end sleeves are clipped on to the suspension wire, one over the other, so that pear shaped rings are formed, see Fig. 2, through which the cable is then pulled in lengths of about 500 m. No tool is required for clipping the suspenders on to the suspension wire. The suspenders are usually spaced at 0.5 m for small cables and at up to 0.75 m for large cables.

In the new cable suspender, a plane at right angles to the bearing surface of the cable is also at right angles to the longitudinal axis of the cable, the bends in the cable caused by the spirally bent rings as mentioned above being thereby eliminated. Wear is prevented by the great width and the polished, rustproof surface of the steel band, by the shape of the ring formed by the suspender and its small dimensions — which reduce rolling — as well as by the cable's position close to the suspension wire, which reduces the swaying tendency of the cable.

Erection

On wooden poles and tubular steel poles — the types of poles most often met with — the suspension wire is supported on crossarms, Fig. 3. Instead of crossarms brackets may be used on wooden poles, Fig. 9. At the terminating points the same crossarms are employed, these being fitted with punched plates when the cable line continues on beyond the crossarm. The suspension wire is terminated with stay tighteners. For poles of concrete or structural steel etc. appropriate supporting and terminating devices are designed for each individual case.

When the cable is run along a wall, screw brackets, Fig. 4, are used as supporting fixtures if the cable is to be drawn in a straight line or at a slight angle. For sharper angles, the hook bracket, Fig. 4, is used. At the terminating points for suspension wire for a maximum strain of 1.5 tons, and when this is drawn parallel with the surface of the wall, the terminal bracket in Fig. 5, with two $^3/_8$" carriage bolts, is used, the suspension strand or wire being fixed to an eye-bolt. For heavier suspension strands, however, terminal brackets with two $^1/_2$" carriage bolts and stay tighteners are employed for terminating, Fig. 5. Suspension strands (but not single wires) may be spliced in the middle of a span and secured by means of two stay clamps NF 35.

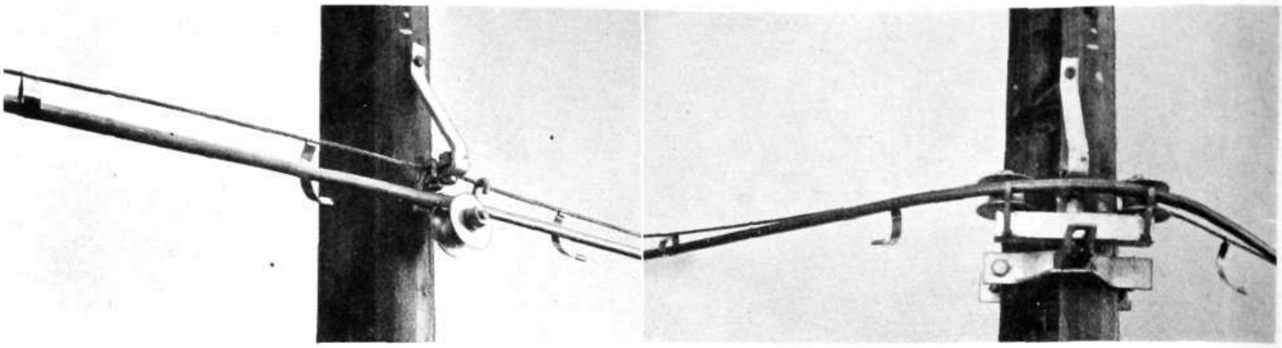


Fig. 9 X 7163
Guiding rollers
left, NK 921/1 for straight cable line; right NK 932 for bend in cable line; suspension wire supported in bracket NE 100

The suspension wire is unrolled on the ground and temporarily run breast-high. Each end, however, is usually attached to a stay tightener at the final height. At the intermediate support, the suspension wire is secured in various ways, according to the nature of the support. With wooden poles, for example, noose hangers made of a piece of suspension and two stay clips NF 15, see Fig. 6, are used. The spacing of the cable suspenders along the suspension wire is marked by running a marking wheel along the wire, Fig. 7. The circumference of the wheel is equal to the suspender spacing. The rim of the wheel is at one point provided with a hole and a paint container, from which marking paint runs out each time the hole makes contact with the suspension wire.

A pulling wire for the cable is then unrolled on the ground; 550 metres of special steel cable NK 590/5, wound on a wooden drum, being recommended for this purpose. The pulling wire is laid in the cable suspenders at the same time as these are clipped on to the suspension wire, see Fig. 8. When performing this operation, the linemen are suitably equipped with cloth bags NK 70/1, suspended from a neck band and capable of holding a few hundred cable suspenders. Suspenders are not clipped on to the ends of the suspension wire that have been raised up to their final elevation. The placing of suspenders on these parts of the suspension wire takes place from a ladder after the cable has been placed. When the pulling wire has been inserted, the suspension wire is detached from its temporary supports, raised up and attached to the regular brackets.

At the beginning and end of the line, guiding-in pulleys are clamped on to the suspension wire to guide the cable, see Fig. 10; at intermediate supports guiding rollers are fixed, different types of guiding rollers being used, depending on whether the line is straight or makes a bend, Fig. 9. The distance from the centre of the roller to the suspension wire is adjusted so as to suit the diameter of the telephone cable. The cable suspenders nearest at each side of the rollers are opened, to be clipped together again from a lineman's ladder after the cable has been pulled in, the rollers being removed at the same time.

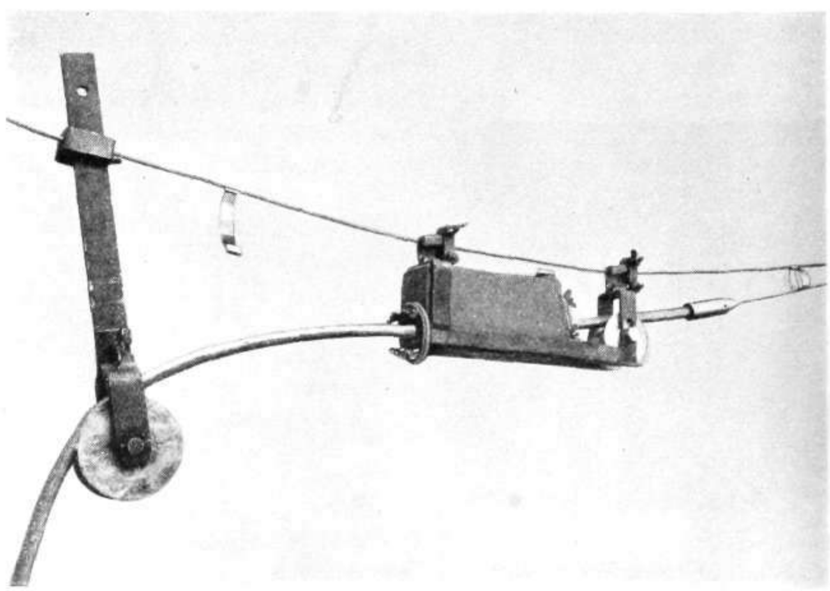


Fig. 10 X 5501
Guiding-in pulley NK 911/1, lubricating box NK 905/1 and cable pulling sleeve NK 30

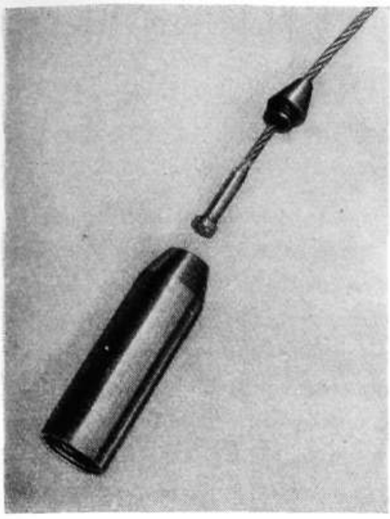


Fig. 11 X 3898
Cable pulling sleeve for cable NK 30

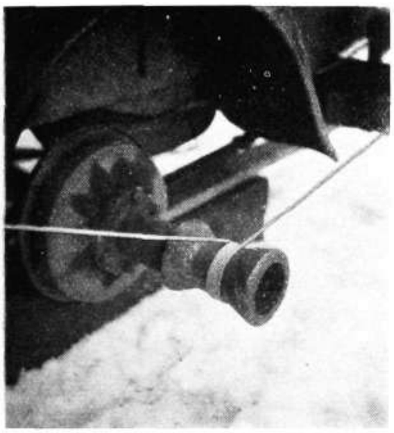


Fig. 12 X 3899
Winch drum
on car axle

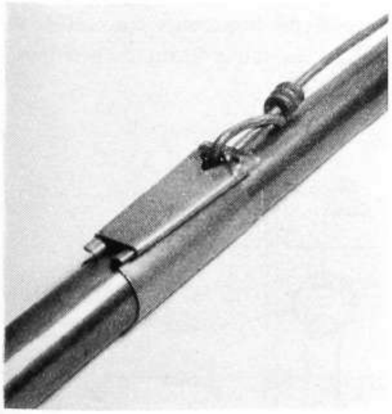


Fig. 13 X 3894
Strain sleeve
for anchoring cable in steep gradient

At the beginning of the line about 0.5 m beyond the guiding-in pulley a lubricating box, Fig. 10 is attached to the suspension wire, the pulling wire being passed through the same and over the guiding-in pulley. The lubricating box consists of a rectangular oil container with inlet and outlet openings for the cable and an opening for filling. The cable openings are provided with rubber packings. When passing through the lubricating box the cable is covered with a film of oil which enables long stretches of cable to be pulled without injuring the lead sheath. While being attached to the suspension wire and during the passing through of the pulling wire, the box should be empty, however, as otherwise the oil would run out through the cable openings, which are not filled by the lighter pulling wire.

The pulling wire is joined to the free end of the lead covered cable by means of a special cable pulling sleeve, Fig. 11. These cable pulling sleeves are made in three sizes to suit the three sizes of cable suspenders, *viz.*, for cable diameters not exceeding 18, 23 or 38 mm. Each cable pulling sleeve consists of a sleeve, a cap and a swivel head. The cap is first slipped over the pulling wire, and then the swivel head, both ends of which are then soldered to the pulling wire. It is most advisable that the pulling wire be equipped with these parts in advance while it is still on the drum, since they may be used for pulling all current sizes of cable, the swivel head and cap being the same for all sizes of cable pulling sleeves. The sleeve, which has a tapered female thread, is screwed on to the end of the cable with such force that the lead sheath just begins to turn, after which the cap is screwed on to the sleeve, see Fig. 10.

At the end of the line, the pulling wire is led over the guiding-in pulley to some simple form of winch, such as a motor-car, for instance, on which one wheel has been replaced by a winch drum, Fig. 12. The pulling wire is wound a few turns around the drum, after which the cable pulling may start. One man should be stationed at the cable drum and one at the winch. With the aid of the winch the cable is first pulled up carefully and slowly through the first guiding-in pulley and the lubricating box, it being advisable to have a man placed on a ladder to supervise the movement of the cable. When the cable end has been pulled about 0.5 m beyond the lubricating box, operations are suspended while the box is filled with some first-class oil, *e. g.*, B oil; in winter somewhat thinner oil may be used, *e. g.*, A oil. The cable pulling sleeve and that part of the cable which has already passed through the box are wiped off with a rag soaked in oil.

The cable pulling then proceeds at the speed of a slow walk (from 1 to 2 km/h), quicker over straight stretches over open ground, slower at bends, through wooded areas etc. Two men should keep pace with the cable end, one of them climbing up the posts at sharper bends as the cable passes in order to make sure that the cable sheath is not injured and, in case of need, to stop the pulling in order to adjust the guiding rollers etc.

When the cable pulling is completed, the lubricating box, guiding-in pulleys and guiding rollers are taken down, any cable suspenders still open or not yet mounted at the ends of the line being clipped together or mounted. A few days later the sags are adjusted, after which the suspension wire is definitely fixed to its supports and the cable ends are spliced to other cables or connected to terminal boxes. If some of the spans should have a steep gradient, so that the cable may be in danger of gliding in the suspenders, the cable is anchored by means of a strain sleeve, Fig. 13, which is attached to the cable about half a metre below the higher support and bound to the same with 3 to 5 mm hot-galvanized iron wire.

For the stringing of about 500 m aerial cable a gang of six men is required for approximately seven working hours. Compared with the method hitherto used for the erection of aerial cable with suspenders NF 400, this quantity of work represents a very considerable saving. This saving can be estimated to amount to at least 25 per cent for sections under 500 m and to at least 35 to 40 per cent for longer sections. Moreover, the Ericsson stainless steel cable suspenders NF 455 offer several decided technical advantages, so that this new method for aerial cable erection may well be regarded as the foremost hitherto devised.

Cable-Finder

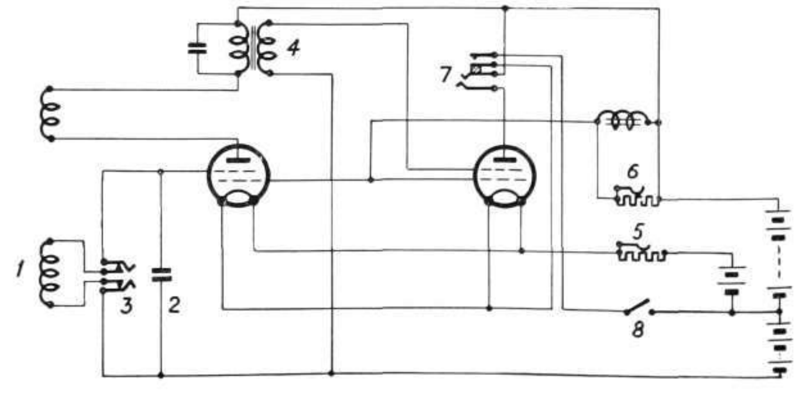
A. OHLSSON, TELEFONAKTIEBOLAGET L. M. ERICSSON, STOCKHOLM

If an earth leakage occurs in a cable it is a question of determining its position as rapidly as possible, which, at least with large circuit areas, cannot be done accurately by means of resistance measurements. This indefiniteness leads to considerable excavation and long interruptions of the current supply. Moreover, in the older installations there are often lacking complete maps of the cable network and consequently a cable repair may be a very time-consuming and expensive proceeding. In addition, there is frequently the question of determining the exact position of underground lines and piping (water and gas mains), e. g. to avoid damage when blasting. If reliable maps are not available such an investigation is exceedingly troublesome. Now, however, Ericsson has designed an apparatus, the cable finder, with which all measurements of the above nature may be conveniently made.

The cable-finder equipment comprises a transmitter buzzer, a cable-finder and a finder coil. The measurement is based on the principal that an electromagnetic field produced by an alternating current in a metallic conductor can be heard in a telephone receiver. From the intensity of the sound the position is determined of the electro-magnetic field and from it the position of the cable, underground line or piping sought.

The cable-finder, Fig. 1, consists of a two-valve amplifier with built-in frame aerial. The antenna *1* is tuned by condenser *2* to 400 c/s. By means of the jack *3* the frame antenna may be disconnected and a finder-coil connected instead. The two valves are provided with space charging grids to enable them to work with low anode tension. In addition to this normal function of the space charging grids they are interconnected, so that a feed-back takes place which compensates the losses in the tuned circuit *4*. In addition there is in the first valve's anode circuit a reaction coil which compensates the losses in the frame circuit. By means of the potentiometer *5* the filament tension of the valves may be varied and by the potentiometer *6* the feed-lack, obtained through the space charging grids, is adjusted to a suitable value. A telephone receiver is connected to jack *7*. Finally there is a switch *8*, for connecting and disconnecting the built-in batteries.

The apparatus, Fig. 2, is built in to a case of light oak, measuring: 217 × × 266 × 160 mm. The total weight including batteries is 10 kg. The case is fitted with a lid and behind this is a panel with the two rheostat-knobs, the switch and the jacks for the telephone receiver and the finder coil. Solid leather handles on the top and bottom of the case make the apparatus convenient to carry both in vertical and horizontal position, a valuable feature when measuring.



X 5533

Fig. 1
Diagram of cable finder

1 frame antenna
2 tuning condenser
3 antenna jack
4 transformer
5 filament rheostat
6 potentiometer
7 receiver jack
8 switch

Fig. 2
Cable finder

X 5532

The transmitter buzzer, Fig. 3, the instrument which transmits the necessary voice frequency current on the cable or piping searched consists of a tuning-fork buzzer *1* for 400 c/s. After the battery has been connected and the switch *2* has been thrown on, the buzzer begins to work. By means of the slow-operating relays *3* an interrupted current is transmitted on the cable through the milliammeter *4* and the rheostat 5. The instrument, Fig. 4, is mounted on an aluminium treated steel panel enclosed in a case of light oak, fitted with a leather handle and a detachable cover. At the top of the panel is a milliammeter and below this are the rheostat, the switch and a key for disconnecting the relays. Further there are two terminals for connecting the 6 V battery and two for the outgoing AC current. The measurements of the instrument's case are 130 × 240 × 150 mm and the weight is 4 kg.

Let us assume that a power cable has developed an earth leakage and the position of this is to be determined with the aid of the cable finder. One end of the cable, *e. g.*, in the nearest transformer cabin, is connected to one AC contact of the transmitter buzzer, while the other contact is earthed. When the battery has been connected and the switch thrown the buzzer begins to work. The interrupted 400 c/s AC current is transmitted along the cable, through the earth leakage into earth and back through the earth connection to the buzzer, Fig. 5. The intensity of the transmitted current is read on the instrument and may be regulated by the potentiometer to a suitable value. There is now created around the cable an electro-magnetic field which spreads out concentrically round the cable. This field is created obviously only around that part of the cable which is between the buzzer terminals and the fault. From the above it is also eviden that there must not be used as earth connection either another conductor in the same cable or the cable mantle, since the spread of the electromagnetic field would thereby be hampered.

The transmitter buzzer is connected and the cable finder started. The cable finder is held vertically and a series of signals which sound something like long Morse signs is heard in the receiver. The intensity of the signals increases and they attain their maximum when the instrument is right over the cable and the cable finder case including the frame antenna is parallel with the cable, see Fig. 6. The amplification is adjusted by the rheostat so

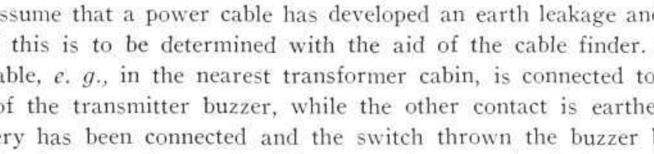


Fig. 3
Diagram of transmitter buzzer

X 5534

1 tuning-fork buzzer
2 switch
3 relays
4 milliammeter
5 regulation resistance

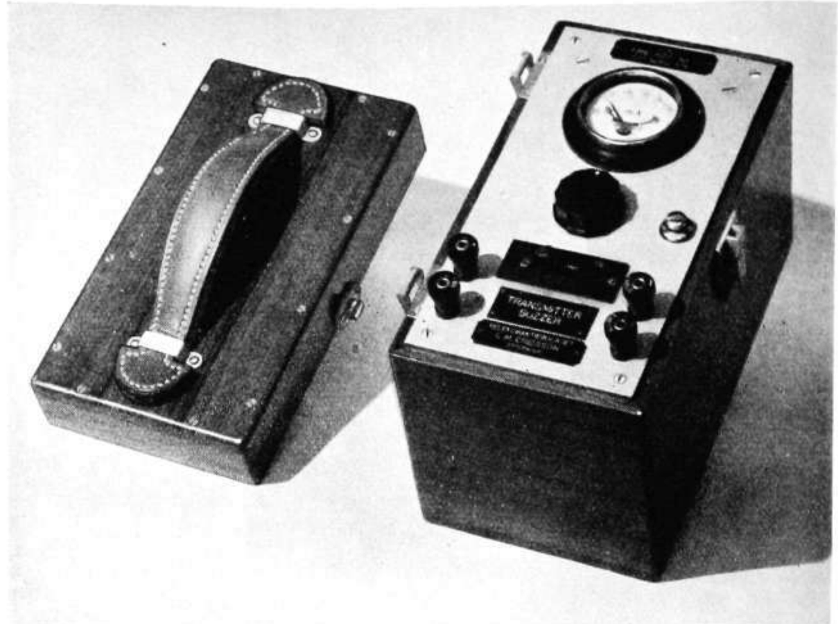


Fig. 4
Transmitter buzzer

X 5531

that the sound is sufficiently loud. The position of the cable in the ground is now fixed fairly accurately. If the cable is very deep underground its position can be determined to within one or two metres. If, however, the cable is near the surface the accuracy of the measurement will be still greater. If it is required to fix the position of the cable with even greater accuracy, the cable finder is held horizontally, lowered to the ground and taken slowly forward over the cable. When it is exactly over the cable there is observable a very marked sound minimum in the receiver. The cable's position is now fixed to within only a few decimetres, which in all cases arising should be more than sufficient. The resulting field in the frame is greatest when it is right over the cable and upright; thus the current in the frame antenna will be greatest here. When the frame antenna lies horizontally over the cable it is seen that the resulting flux will be zero and no current will be flowing through the frame. On either side of the cable the sound intensity rises again and goes through a maximum after which it lessens.

In this way it is possible to follow the cable along its whole stretch to the point of fault, where the sound disappears. The cable is excavated at the point where it is believed that the fault is to be found. Often, however, an earth leakage has arisen without the armouring being injured and therefore it is not possible to see directly, after excavating the cable, where the fault lies. In that event the finder coil, Fig. 7, is employed. This consists of a coil wound on a rectangular iron core, one end of which is removed. The finder coil is connected to the cable finder in the jack provided and the frame antenne is disconnected. The dimensions of the coil are such that the antenna circuit is still tuned for 400 c/s. The coil is then put down over the cable and slowly moved along it. As long as the coil is in the flux from the cable, signals will be heard in the receiver. At the point of fault the flux ceases, so that the fault can be fixed exactly.

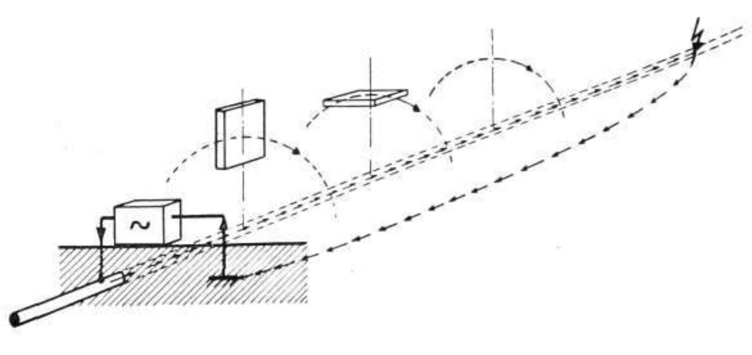


Fig. 5
Principle diagram

X 5535

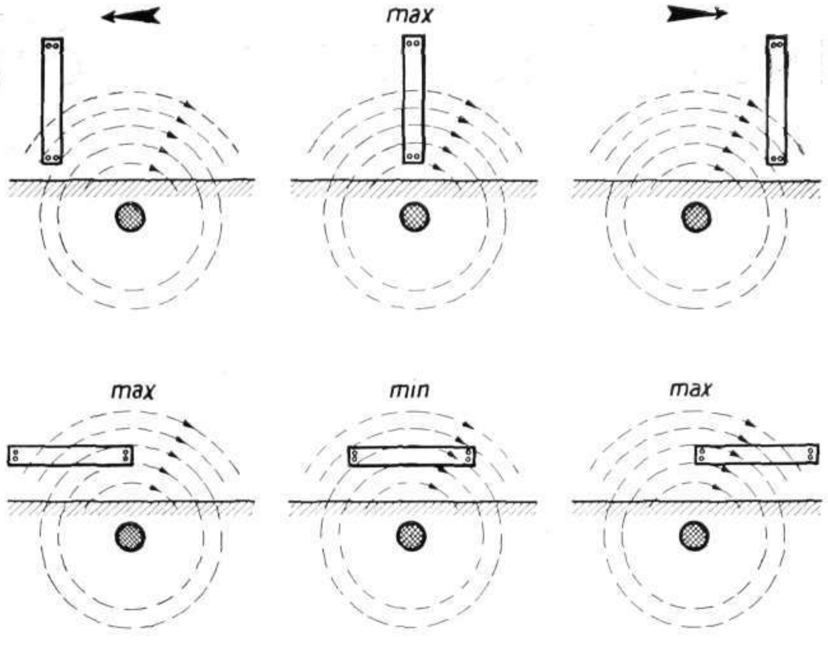


Fig. 6 X 5536
Diagram of measuring procedure

If for some reason it is required to fix the route of a faultless cable, the cable must be earthed at its far end, whereby the circuit will be closed through the whole cable and earth. A low tension power cable without fault dos not need to be set out of operation if its route is to be investigated with the cable finder. The earth lead of the cable sheath is detached at one end of the cable and the one AC contact of the buzzer is connected to the cable sheath. The other pole of the buzzer is as usual connected to earth. If it is feared that some residual tension may persist in the cable sheath, a suitable protective condenser should be inserted between the buzzer and the cable sheath.

When water and gas mains and underground lines are searched for it it should be remembered that suitable choice of earthing for the buzzer is of great importance. As a rule the earth connection, consisting of a metal bar driven into the ground, should preferably be located 25—50 m from the point of connection of the buzzer to the piping. Since a metal pipe or an underground line lies uninsulated electrically in the ground, the AC current naturally goes out into the earth, not as with cables at a single spot but along the whole length of the piping. In consequence the current is reduced and with it the electro-magnetic field progressively along the piping. The stretch along which it is possible to find a watermain with the buzzer connected at a fixed point and the same position of earth connection, is obviously limited by the smallest intensity of field that can produce audible signals in the receiver. With piping having numerous branches, the buzzer and its earth connection will naturally require to be moved more often than is the case with a single unbranched piping. The nature of the ground, its humidity etc. as also the depth of the piping affect the maximum measurement length, but even in very adverse conditions piping lengths of 200—300 m may be measured.

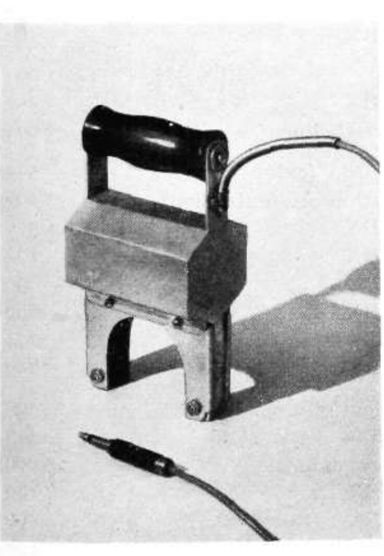


Fig. 7 X 3914
Finder coil

Cable lengths of several kilometres may easily be located with the cable finder, but at times it is necessary to take into account metal objects existing in the vicinity of the cable when judging the results. If, for instance, the cable traverses a railway yard, a maximum of sound intensity is often obtained somewhat to the side of the cable because of the railway tracks. If the cable is adjacent to other cables some of which carry AC, this does not affect the measurements since the cable finder is insensitive to AC of frequencies other than 400 c/s. The strong Morse signals are exceedingly easy to distinguish from other sounds, traffic noise and electric noises of various kinds, and the measurements may therefore be undertaken without trouble even in places with heavy street traffic. A special receiver with sound insulating ear-pads may be used with advantage in such event.

New Ericsson Exchanges in 1938

During 1938 the following automatic telephone exchanges on the Ericsson system with 500 line selectors were put into service:

month	town	exchange	lines
January	Santa Fé, Argentina	(extension)	1 500
	Gothenburg, Sweden	PABX	50
	Stockholm, Sweden	PABX	250
February	Norrköping, Sweden	PABX	90
	Stockholm, Sweden	name call exchange (extension)	4 500
		PABX	250
	Sundbyberg, Sweden		4 000
		PABX	520
	Södertälje, Sweden	PABX	90
	Tureberg, Sweden		3 000
March	Parnahyba, Brazil		200
	Gothenburg, Sweden	PABX	50
	Stockholm, Sweden	PABX	350
	Södertälje, Sweden	PABX	50
	Uttran, Sweden	PABX	90
April	Warsaw, Poland	Praga (extension)	500
	Hagfors, Sweden	PABX	120
	Stockholm, Sweden	Norr	15 000
		PABX	810
	Moss, Norway	(extension)	500
May	Munkfors, Sweden	PABX	120
	Stockholm, Sweden	PABX	250
	Trollhättan	PABX	120
June	Warsaw, Poland	Praga (extension)	1 000
		PABX	400
	Gothenburg, Sweden	PABX	580
	Norrköping, Sweden	PABX	170
	Stockholm, Sweden	PABX	90
	Västerås, Sweden	PABX	90
July	Tucuman, Argentina		5 000
	Warsaw, Poland	Mokotów (extension)	2 000
	Gothenburg, Sweden	PABX	50
	Stockholm, Sweden	PABX	180
	Trollhättan, Sweden	PABX	160
August	João Pessôa, Brazil		1 000
	Stockholm, Sweden	PABX	300
		Kungsholmen (extension)	3 000
September	México D. F., Mexico	Victoria (extension)	500
	Gothenburg, Sweden	Masthugget (extension)	3 000
		PABX	370
	Stockholm, Sweden	PABX	170
	Sundbyberg, Sweden	PABX	90
	Örebro, Sweden	PABX	90
	Cape Town, Union of South Africa	PABX	380
October	Mérida, Mexico	(extension)	500
	México D. F., Mexico	Tacuba (extension)	500
	Gothenburg, Sweden	Vasa (extension)	5 000
		PABX	180
	Gävle, Sweden	PABX	90
	Malmö, Sweden	PABX	120
	Norrköping, Sweden	PABX	100
	Örebro, Sweden		11 000

month	town	exchange	lines
November	Manáos, Brazil		1 000
	São Luis Maranhão, Brazil		1 000
	Rauma, Finland		1 000
	Gothenburg, Sweden	PABX	50
	Norrköping, Sweden	PABX	50
	Stockholm, Sweden	PABX	190
	Södertälje, Sweden	PABX	50
December	Tirrapur, British India		90
	Ferrania, Italy	PABX	160
	Fredrikstad, Norway	(extension)	500
	Haugesund, Norway	(extension)	500
	Kristiansand, Norway	(extension)	1 000
	Gothenburg, Sweden	PABX	150
	Lidingö, Sweden	(extension)	500
	Norrköping, Sweden	PABX	50
	Stockholm, Sweden	PABX	470
	Trelleborg, Sweden	PABX	120
	Västerås, Sweden	PABX	90

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

May	Paris	Central	10 000
		Clignancourt	1 200
July	*Chamalières*	*(system R 6)*	400
December	Paris	Daumesnil	4 000

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

February	London	Larkswood (extension)	1 700
March	Bath	Bath (extension)	800
	London	Stamford Hill (extension)	1 800
	Walsall	Aldrige (extension)	100
April	Folkestone	Folkestone (extension)	100
	London	Derwent (extension)	1 000
		Riverside	5 400
May	Birmingham	Stechford (extension)	500
	Chorley	Chorley (extension)	200
	Cromer	Cromer	600
	Harrogate	Knaresborough (extension)	100
	London	Canonbury (extension)	900
		Wanstead (extension)	900
June	Grimsby	PABX	100
	Manchester	PABX	50
July	Barnsley	Barnsley	1 800
	Birmingham	Acocks Green (extension)	1 000
	Derby	Derby	4 600
		Allestree	400
		Alvaston	300
		Duffield	500
		Mickleover	400
		Spondon	500
	Grimsby	Barton-on-Humber	200
August	Kings Lynn	Kings Lynn (extension)	400
	Loughborough	Loughborough (extension)	200

month	town	exchange	lines
October	Bath	Batheaston (extension)	200
	London	PABX	300
	Manchester	Radcliffe (extension)	200
November	Birmingham	PABX	100
	Chelmsford	Chelmsford (extension)	800
	London	Richmond	4 600
	Walsall	Walsall (extension)	900
December	Barnstaple	Barnstaple	1 200
	Bath	Weston (extension)	300
	Bristol	Bradford-on-Avon (extension)	100
		Corsham (extension)	30
		Winscombe	240
	Edinburgh	PABX	250
	Hereford	PABX (extension)	40
		Euston (extension)	900
	London	Thornton Heath (extension)	1 400
		Uplands (extension)	1 500
	Peterborough	Holbeach	230
		Peterborough (extension)	900
	St. Albans	Wheathampstead	160
	St. Helens	Prescot (extension)	300
	Southend-on-Sea	South Benfleet (extension)	10
	Stoke-on-Trent	Cheadle	240
	Tunbridge Wells	Benenden	200
	Ayr	Maybole	240
	Swansea	Clydach	300
		Pontardawe	240

Ericsson Technics

Ericsson Technics No 1, 1939

L. F. Gandernack & E. Björnstad: Some Measurements on Phase-Opposition Modulation

In the present paper some of the results obtained through practical measurements on phase-opposition modulation are recorded. First the static modulation curve of the output stage is represented for different settings of the side-band valve. The measurements show good agreement with the predictions of the theory of the system. Theoretical and practical results for the phase-inverter follow, showing that a pair of grid-modulated triodes is preferable as regards efficiency.

Measurements of the linearity of a B-set high-frequency amplifying stage, when provided with phase-inverted signals, are then shown. Finally a series of measurements on dynamical modulation are presented, showing the important figures: anode input power, anode efficiency and distortion factor. A close agreement with theoretical results is found in these figures also.

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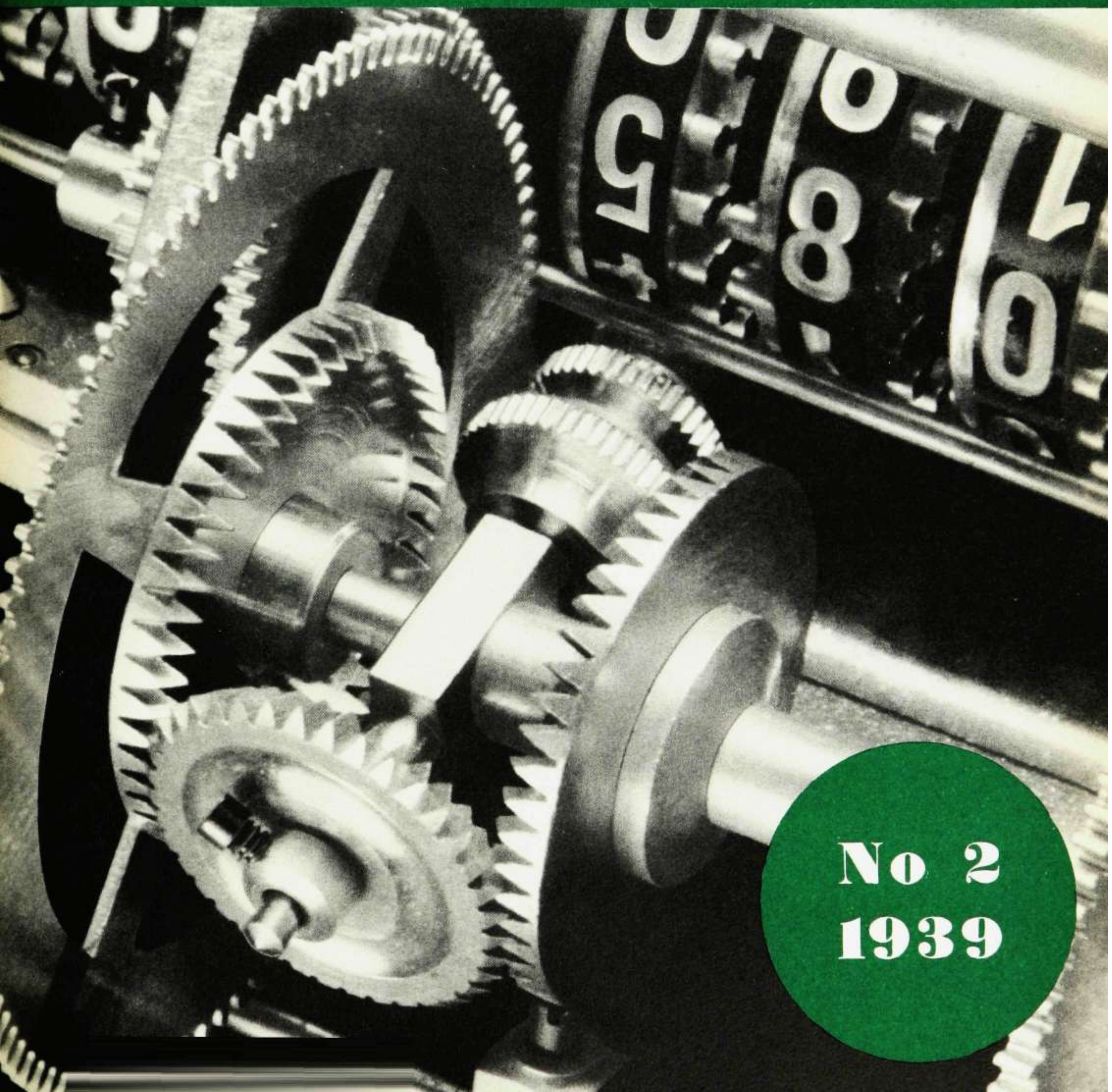
Ericsson Review



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ERICSSON REVIEW

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Multi-Channel Carrier Frequency Systems for Unloaded Cables

R. STÅLEMARK, TELEFONAKTIEBOLAGET L. M. ERICSSON, STOCKHOLM

The intensive work devoted in recent years all over the world to the development of carrier frequency systems for unloaded cables has had the result as far as Ericsson is concerned of bringing out a 16-channel system and a 12-channel system.

The difference between the two systems in principle is to be found in the number of channels and the effective voice frequency band transmitted for each channel. With the 16-channel system the effective voice frequency band transmitted is 220—2 850 c/s on the CCIF definition, while the 12-channel system is constructed entirely in accordance with the recommendations fixed by CCIF at the Oslo meeting in 1938. These provided for channels numbering twelve, situated in the frequency range of 12—60 kc/s with an effective transmitted frequency band of 300—3 400 c/s. Each side frequency would then be the upper side frequency for virtual carrier frequencies 12, 16, 20 and so on up to including 56 kc/s.

The following article will first describe the Ericsson 16-channel system and then give an account of the results attained with the 16-channel system installed on the Mariehamn—Åbo—Helsingfors section.

General Properties

The Ericsson 12 and 16-channel systems are designed to work in four-wire connection on unloaded cables, with one cable employed for each direction of transmission in order to avoid near end crosstalk. The same frequencies are employed in both directions of transmission. On each pair in the cables there are transmitted 16 or 12 calls respectively, this meaning that with, *e. g.*, two 19-pair cables there may be obtained 304 (or 228) possibilities of simultaneous calls. The carrier frequencies are so selected that the side frequencies in a system fall within the frequency range of 12—60 kc/s and so that a frequency band of 3 000 or 4 000 c/s respectively is available for each channel. Fig. 1 shows the diagram for a 16-channel system.

The attenuation in an unloaded cable is naturally considerable at high frequencies such as are in question here, and therefore repeaters must be introduced at distances which are but the third or the half of the usual distance with loaded cables while the attenuation per repeater section may be more than double as great as with four-wire loaded cables. The repeaters, which are of special type, must be capable of amplifying all the 16 circuits of a pair without noise arising from channel to channel because of non-linear distortion. In addition quite special demands must be imposed regarding the cables, particularly as regards crosstalk. In this case the difficulty lies in keeping the far end crosstalk between the different pairs down to the permissible value right up to 60 kc/s. This has involved the developing of methods wholly or partially new for the manufacture, testing, splicing and balancing of these cables.

Despite the difficulties mentioned these systems have gained such a place that it may almost be said that loaded cables will in future mainly be employed for the shorter sections, *i.e.*, for distances up to round about 40 or 50 km.

To begin with the unloaded cables have great technical advantages, amongst others the short transmission time. With these cables there is obtained a phase velocity of about 200 000 km/s, a speed which is attained at around 7 000 c/s,

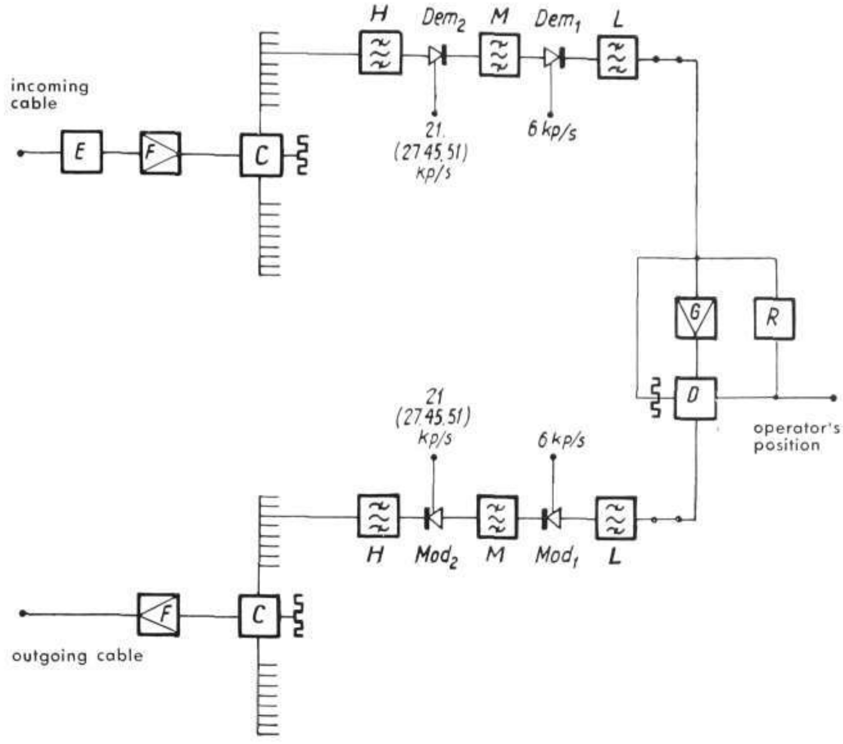


Fig. 1 X 5553

Diagram of 16-channel system

- C compensating network
- Dem_1 intermediate frequency demodulator
- Dem_2 high frequency demodulator
- E equalizing network
- F high frequency repeater
- G low frequency repeater
- H high frequency band filter
- L low frequency band filter
- M intermediate frequency band filter
- Mod_1 intermediate frequency modulator
- Mod_2 high frequency modulator
- R voice frequency ringer

after which the velocity increases only slightly with rising frequency. This velocity is approximately ten times as great as that obtained with loaded cables. At the same time the phase velocity is practically constant in the frequency range corresponding to a channel. It can well be understood, therefore, that the troubles arising with loaded cables at very long distances are in this case eliminated. With loaded cables the phase velocity remains at around 15 000 to 30 000 km/s—according to the intensity of the loading—while it varies within the voice band, so that the different frequencies are transmitted at different velocities. If a retardation of 250 m/s were permitted in the speech coming through then with the new system a distance of some 50 000 km could be bridged if account were taken only of the *cable's* transmission time. This distance is equivalent to more than the earth's circumference at the equator. Even if the transient period in the repeaters and the terminal equipment is taken into consideration, it is evident that the system is exceedingly well suited for transmission over all distances that may come into question on our earth.

The question whether the indisputable economic advantages of the unloaded cables should be regarded as taking first or second place may be left out of account. The fact remains, however, that the system is successfully competing economically with older transmission systems even for comparatively short transmission distances and with a moderate number of circuits, which proves that in such cases the above cited technical superiority was not the deciding factor.

Modulating Systems

Different ways may be used to ensure that the side frequencies of the different channels take up their correct positions in the frequency spectrum. In the 16 channel system there is available for each channel a frequency space of 3 000 c/s, which means that if the frequency band transmitted without appreciable linear distortion is to be 300 to 2 700 c/s, then within 600 c/s on either side of these cut-off frequencies the attenuation in the filters screening off the different channels should have risen to a sufficiently high figure that crosstalk does not arise; at the same time the sum of the attenuation in a filter for two adjacent channels should amount to the same figure in the frequency range between them.

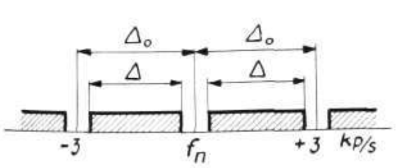


Fig. 2 X 3927

Ratio between effectively utilised frequency band and distribution

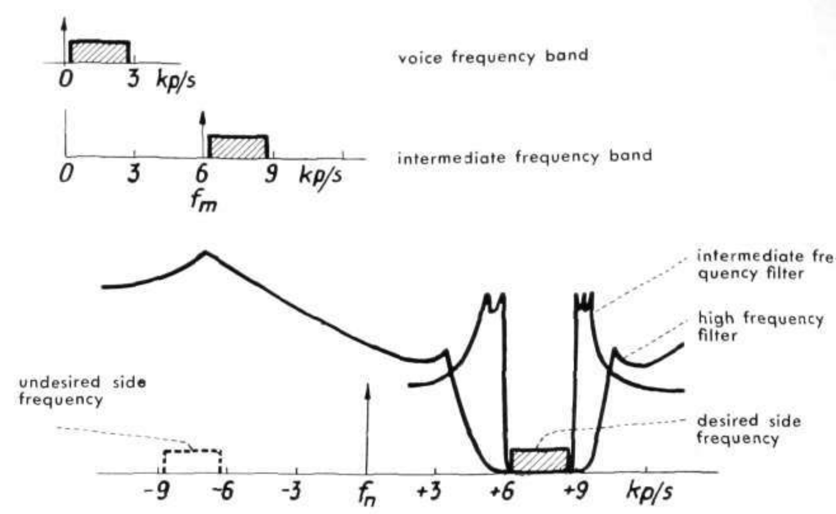


Fig. 3 X 5551
Attenuation process and modulating procedure for 16-channel system

Fig. 2 shows the relation of two side frequencies to a carrier frequency f_n. The lower channel stretches from f_n—300 to f_n—2 700, while the other occupies the frequency range f_n + 300 to f_n + 2 700. The apportionment for each channel has been designated by Δ_0 and $(f_n + 2\,700) - (f_n + 300) = \Delta$. It is evident that the greater the fraction Δ is of Δ_0, the greater will be the requirements imposed on the filters, since their attenuation must rise sharply outside the range Δ. A fairly good approximation would be to say that the attenuation requirements on the filters of all channels may be expressed by one and the same function of $\frac{\Delta}{\Delta_0}$. Moreover the demands on the matching and future stability of the filters will increase with higher frequencies in accordance with the function $f\frac{f_{00}}{\Delta}$, where f_{00} represents the mean frequency for the filter in question. This means that stability and matching accuracy are required about five times greater in the filter for the channel with the highest frequency than for that with the lowest frequency. Now, if the whole of the attenuation necessary to ensure satisfactory crosstalk figures between two adjacent channels is dependent on the high frequency filters, then it will be found with the highest frequency channels that the alteration, *e. g.*, of the filter coils, that may be anticipated on account of their temperature coefficient and ageing, will be near to the limit of tolerance.

To overcome this difficulty Ericsson has made use of the double modulation principle. The idea with this is, by means of a premodulation at a low intermediate frequency, to provide the possibility of obtaining sharp filtering of the desired side band and then by further modulation at a higher frequency to transfer the intermediate frequency side band to the required position in the frequency spectrum. The advantages of such an arrangement are obvious. With the first modulation by the intermediate frequency carrier band f_m there is obtained a side frequency band which is limited by the intermediate frequency filter, the attenuation process of which is seen in Fig. 3. This filter has its main attenuation close to the borders of the band, the attenuation falling off at greater distances from the band borders. In the second modulation, when the frequency band obtained after the intermediate frequency filter is modulated by the carrier frequency f_n, there is obtained the final frequency band which is taken out over a high frequency filter, whose absolute through passage area is wide in proportion to that of the intermediate frequency filter, while at the same time its attenuation rises slowly outside the band borders.

In this way the intermediate frequency filter can take care of the attenuation close to the band borders and the high frequency looks after the attenuation further distant. In the Ericsson system the intermediate frequency is 6 000 c/s, which means that the demands on the intermediate frequency filter will be about ten times less than on a high frequency filter which should have the same properties for 60 000 c/s and direct modulation. The main object of the high frequency filter is to suppress the undesired side frequency band. This,

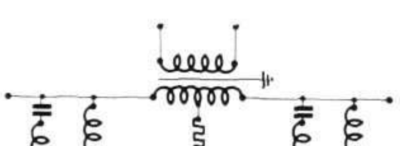


Fig. 4 X 3923
Diagram of compensating filter
filters for channels with odd numbers connected at left, for even numbers to right

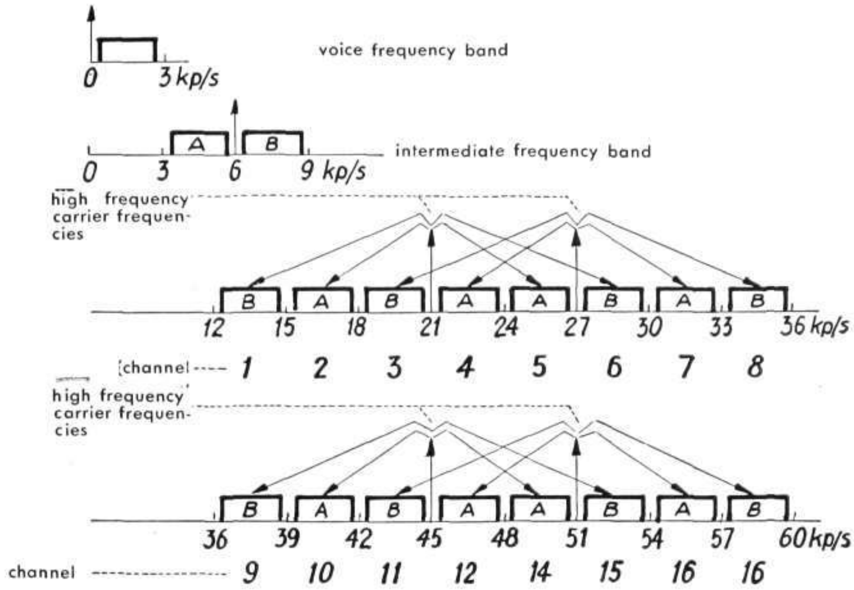


Fig. 5 X 5552
Modulating principle for 16-channel system

however, lies at such a distance from the carrier frequency, that no difficulty is experienced. In addition the properties of the filter must be such that it can be connected in parallel with the other 15 filters belonging to a 16-channel system.

The connection in parallel has been carried out on the same principle as is employed in Ericsson's older carrier frequency systems for overhead lines X 28. Filters are connected alternately to either side of a differential transformer, Fig. 4. In this manner there is obtained a gap of 3 000 c/s between the filters connected in parallel on either side, which facilitates parallel connection and allows of the high frequency filters having a through passage area which is greater than the partition 3 000 c/s. On either side of the differential transformer there is inserted a reactance network to compensate for the action on each other of the filters connected on the same side. Naturally the filters connected on opposite sides do not affect each other.

Carrier Frequency Oscillators

The double modulation procedure has also provided the possibility of reducing the number of carrier frequencies necessary for the production of the sixteen side frequency bands. With the first modulation at 6 000 c/s two side frequency bands are obtained, the one roughly located between 3 000 and 6 000 c/s and the other between 6 000 and 9 000 c/s. For one channel, of course, the lower may be used and the upper be attenuated, while for another channel the lower band is attenuated and the upper is passed through the intermediate frequency filter. In the second modulation stage too it is possible to obtain an upper and a lower side frequency band, but since two different bands have arisen with the first modulation, it is possible with a single high frequency carrier to form four different high frequency side frequency bands, Fig. 5. With proper selection of the carrier frequencies it has been found that all sixteen side frequency bands may be obtained with only four carrier frequencies and 6 000 c/s. The four high frequency carriers are 21 000, 27 000, 45 000 and 51 000 c/s.

All the carrier frequencies are multiples of 3 000 c/s and are produced in separate oscillators, these as regards frequency being so controlled that exact multiples are obtained of the basic frequency of 3 000 c/s, produced in an oscillator with stable frequency. The 6 000 c/s to control the intermediate oscillator is obtained by doubling in a copper rectifier bridge. A further doubling gives 12 000 c/s which is fed into a valve which has two parallel circuits in the anode circuit, one tuned for 24 000 c/s and the other for 48 000 c/s, these frequencies being afterwards modulated with 3 000 c/s, thus giving 24 000 ± 3 000 c/s, *i. e.*, 21 000 and 27 000 c/s, and 48 000 ± 3 000 c/s, or

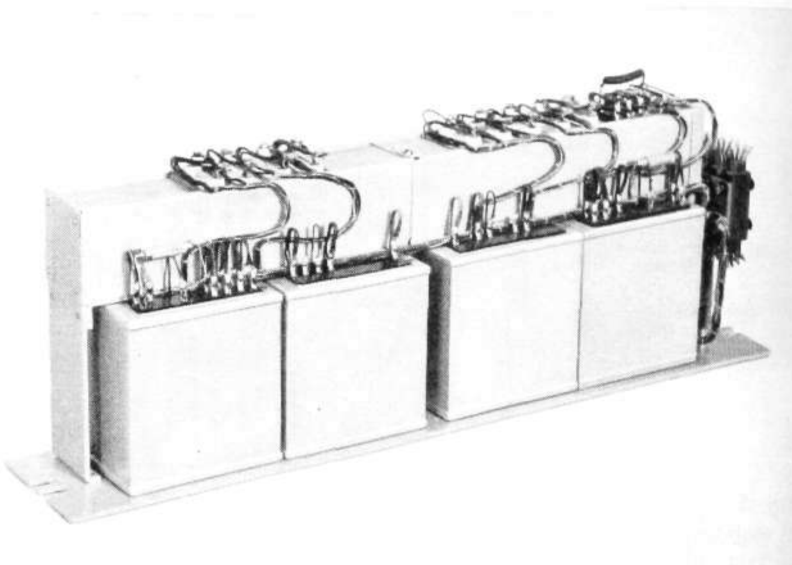


Fig. 6 X 5567
Intermediate frequency filters

45 000 and 51 000 c/s. These frequencies are subsequently employed for synchronising the individual oscillators with corresponding frequencies. The main oscillator for 3 000 c/s is so constructed that if desired it may be driven from a standard frequency plant for 1 000 c/s. It is frequently advisable to have exactly the same carrier frequencies at each terminal station, *e. g.*, when the system is to be employed for the transmission of telegraphic pictures. In such event there is transmitted from one station 6 000 c/s, 3 000 c/s or 1 000 c/s, according to the frequency most convenient to suit the case, to drive the 3 000 c/s oscillator at the other station. In fact, an oscillator may be driven not only with its own frequency, though this of course is best, but also with sufficiently good results by higher or lower harmonic frequencies.

Filters and Modulators

The cost of the terminal equipment will naturally be the decisive factor as regards the economical working of the plant. Since the filter equipment constitutes an appreciable amount, some 30 to 35 %, of this cost it has been necessary to devote particular care to the design of the filters, both as regards the amount of material and the possibility of easily producing and adjusting them. By the utilisation of double modulation it has been possible to make the filters with standard coils and capacitors without any trouble arising in the work of matching them. The attenuation close to the edges of the high frequency band is delivered at a relatively low frequency by a filter which thus requires no particular matching accuracy; and by making the high frequency filter considerably wider than it needed to be for the frequency band transmitted this too calls for no exceptionally high degree of precision. A slight shift in a resonance frequency is not noticeable since it only very slightly affects the shape of the overall attenuation curve or the crosstalk attenuation.

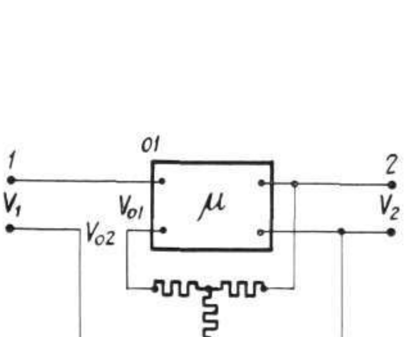


Fig. 7 X 3924
Diagram of repeater with negative feed back coupling

The filters have been made with toroidal iron dust coils and mica condensers. The dust coils have a loss factor that is less than 0.4 % (at certain frequencies less than 0.3 %), equivalent to a magnification factor of more than 250. In addition they have extremely low hysteresis losses so that the harmonics and intermodulation products, preferably of the third order, that may arise even at points where the highest level occurs are more than 11 neper below the basic frequency level.

The modulators and demodulators are of the metal rectifier type now practically exclusively used, connected as ring modulators. Their properties are so well known that no detailed description needs be given here, except to mention their — as far as can be judged up to now — practically unlimited life and the small space taken up; they may without modification be built in to a small case of the same shape as that used for the condensers and mounted along with these on a simple rack, Fig. 6.

High Frequency Repeaters

Exceptional demands must be imposed on the high frequency repeaters for these systems, particularly as regards low non-linear distortion coefficient and high stability. Both these demands may be met by the employment of negative feed back coupling. The first to show that such repeaters could be made practicably was the American *H. S. Black*.

In the repeater, Fig. 7, the amplification is taken as μ neper between the terminal pairs *01* and *2*. There is introduced in series with tension V_1, the tension to be amplified, a further tension V_{02} assumed to be 180° phase shifted in relation to V_1 and attenuated β neper in relation to V_2. The resulting tension at the terminal pair *01* will then be

$$V_{01} = V_1 - V_{02}$$

but according to the figure

$$e^{\mu} \cdot V_{01} = V_2$$
$$e^{\beta} \cdot V_{02} = V_2$$

From which, after elimination

$$V_1 = V_2\ (e^{-\mu} + e^{-\beta}) = V_2 \cdot e^{-\beta}\ (1 + e^{-(\mu-\beta)})$$

Now, if the dimensions of the repeater are made so that

$$\mu = 12 \text{ neper}$$

and the attenuation device in the feed back connection circuit has the attenuation

$$\beta = 7 \text{ neper}$$

it will be seen that the term

$$e^{-(\mu-\beta)} = e^{-5} = 0.0067$$

is small in proportion to 1, and the amplification between terminals *1* and *2* will be

$$^{e}\log \frac{V_2}{V_1} = \beta$$

The amplification, therefore, will be independent of μ, so long as it may be taken that $e^{-(\mu-\beta)}$ is small in relation to 1. This implies that variations in μ due to changes in the valves of the repeater, the anode and feed tensions etc. do not affect the amplification, so long as $\mu-\beta$ is sufficiently large. Condition for stability is satisfied with ease. Moreover, another quality of value is obtained. Since the amplification is dependent entirely on β it will be constant for all frequencies if is made up of purely ohmic resistances. For like reason it can be understood that β may be given the same execution as a correcting network, by which the amplification may be made to follow its attenuation.

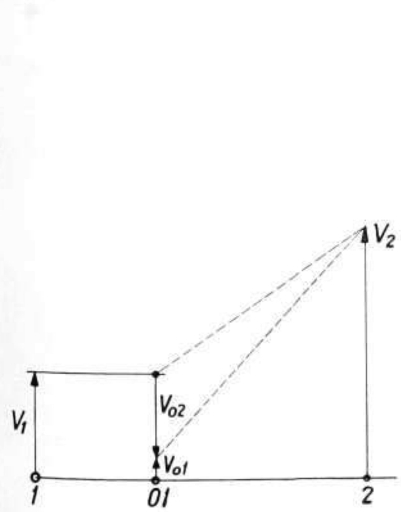


Fig. 8

Tension diagram of negative feed back coupled repeater

It is clear that the non-linear distortion coefficient will likewise be smaller than if the repeater were not negative fed back, from the following abridged reasoning. Let us assume that a harmonic arises in the output stage so that a psophometric potential difference $V_{2}s$ exists at the output terminals of the repeater. We will assume the psophometric potential difference's magnitude to be a certain percentage of the main tension and suppose it to be reduced to the repeater's input terminals *01*, where it is $p \cdot V_{01}$. If the repeater were not negative fed back its non-linear distortion coefficient would be p. By negative fed back coupling we get the following equalising conditions

$$V_{01} - p \cdot V_{01} = V_1 - V_2 \cdot e^{-\beta} - V_{2s} \cdot e^{-\beta}$$

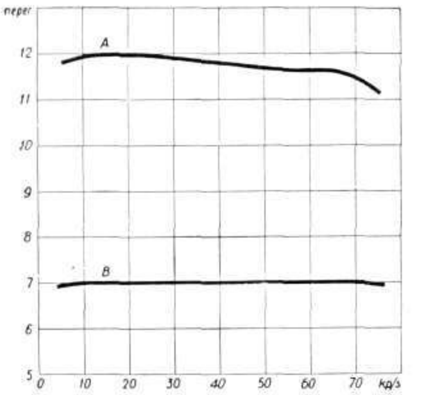


Fig 9 X 3926

Amplification as function of the frequency

A without negative feed back
B with negative feed back

but, according to the above we had

$$V_{01} = V_2 \cdot e^{-\mu}$$
$$V_1 = V_2 \cdot e^{-\mu} + V_2 \cdot e^{-\beta}$$

from which we get

$$V_2 \cdot e^{-\mu} - p \cdot V_2 \cdot e^{-\mu} = V_2 \cdot e^{-\mu} - V_{2s} \cdot e^{-\beta}$$
$$\frac{V_{2s}}{V_2} = p \cdot e^{-(\mu-\beta)}$$

From this it may be seen that the non-linear distortion coefficient through improved negative feed back coupling is improved by $e^{-(\mu-\beta)}$. If the non-linear distortion coefficient of the repeater without negative feed back coupling is $p = 2\,\%$ and $\mu - \beta$ is 4.6 neper, then with negative feed back coupling there is obtained a non-linear distortion coefficient which is 0.02 %. It should be observed that the output capacity of the repeater is kept at the same figure in both cases. It is not the output that is reduced, but it is the input that is increased to compensate for the fed back voltage, Fig. 8.

From the above it will be seen that the principles are very simple when treating the idealised case. This implies among other things that μ is independent of the frequency for phase. This, however, in actual practice is not the case since consideration must be given to unavoidable phase shifts by means of compensating devices, so that the negative fed back coupling is prevented from changing over for any frequency to positive fed back coupling and thus causing self-oscillation. How this problem has been solved, particularly the very complicated calculations on which the solution is based, is outside the scope of this article.

The repeater has been made with three valves, high frequency pentodes and all equal. The reduction of gain due to fed back, Fig. 9, is 4.5 to 5.0 neper and with an output capacity of 700 to 800 mW there is obtained a non-linear distortion coefficient that is around 0.02 %. The repeaters, Fig. 10, are so made that they work with normal 130 V anode tension, but since the valves are indirectly heated the 24 V battery is also utilised, so that the effective anode tension will be 154 V. Each repeater is tested, in addition to the amplification as function of the frequency and the harmonic distortion, also for dependence on anode tension. On changing of this tension from 90 to 240 V the change in amplification should be 0.01 neper at the most.

Equalisation of the Cable Attenuation

Two methods may be employed for equalizing the cable attenuation: either there may be connected in to the negative feed back coupling lead of the repeater an attenuation which reproduces the cable attenuation, or there may

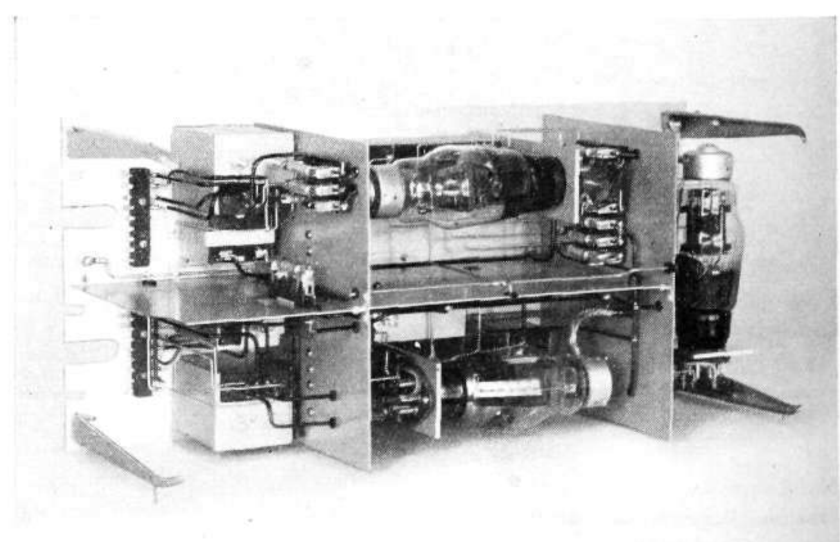


Fig. 10 X 5568

High frequency repeater for 16-channel system

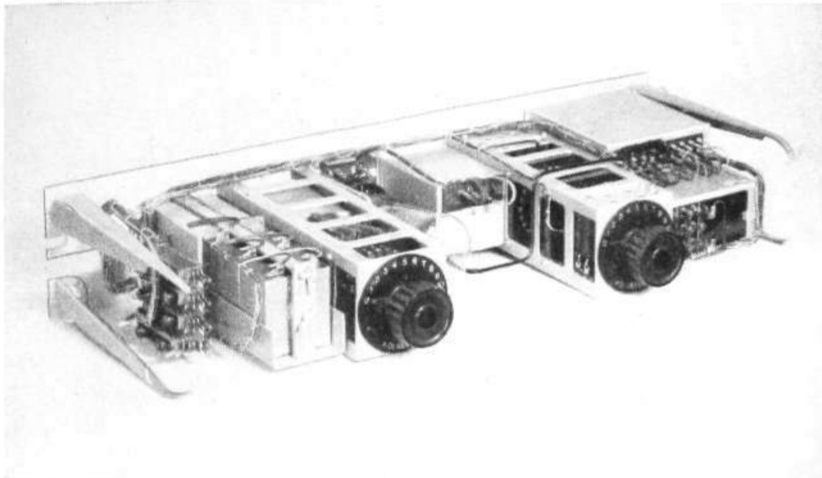


Fig. 11 X 5569
Tuning fork repeater

be inserted an equalizing network before the repeater. Both methods have their advantages and disadvantages that are maybe of equal weight, but Ericsson has decided on the second method. This allows of all the repeaters being made exactly the same, while the construction of the equalizer will be governed in each case by the construction of the cable and the length of the repeater section. Thus the cable and the equalizer form a unit which has always the same attenuation, with the result that replacement of a repeater may be done without the need of any adjustment of the level being carried out.

Four-Wire Termination Sets

The four-wire terminations comprise repeaters for the low frequency voice currents coming from the receiver filters, differential transformers for transition to two-wire system and signal repeaters. The repeater, Fig. 11, displays nothing of special interest; still it is worth noting that the differential transformer is built in and that the repeater may be regulated in ten stages of 0.1 neper, while an attenuation set with the same regulation is to be found on the side of the differential transformer connected to the transmitting filter.

The voice frequency signal receiver, Fig. 12, is built on the system of voice frequency signalling employed by Ericsson since 1928. The main principle still applies, but a number of simplifications and improvements have been made, some rendered possible by the introduction of the metal rectifier. The voice

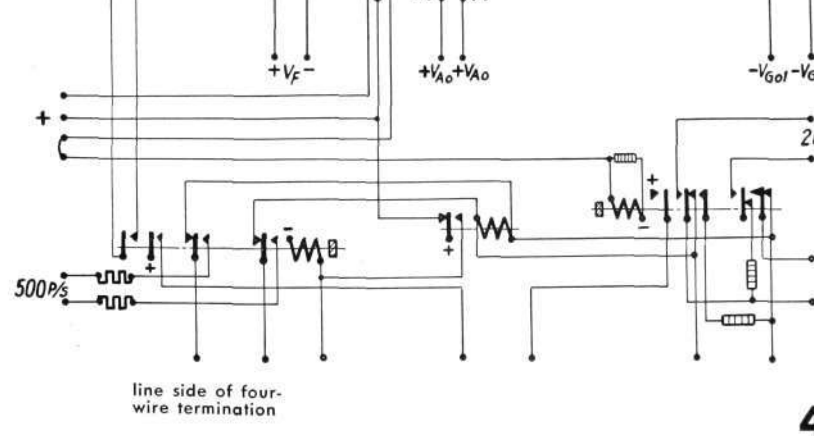


Fig. 12 X 5548
Diagram of voice-frequency signal receiver

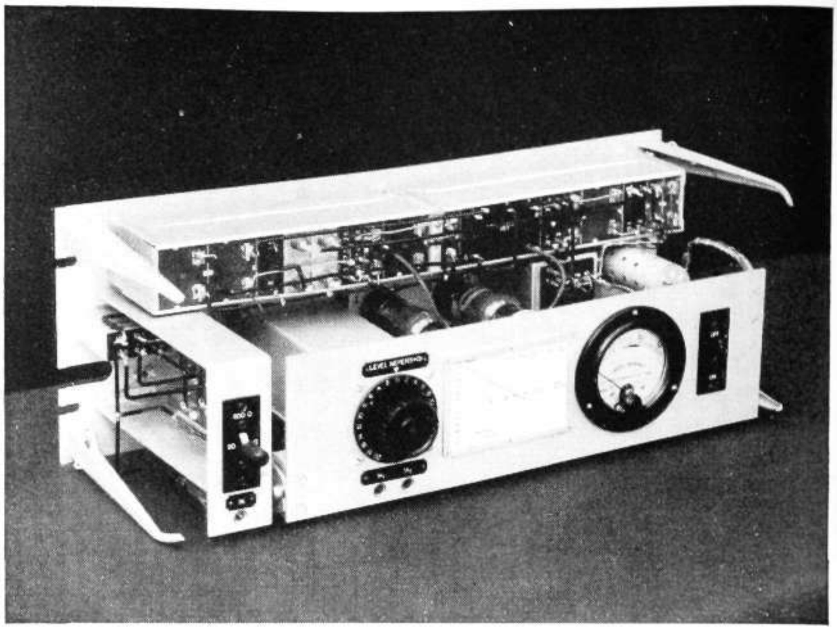
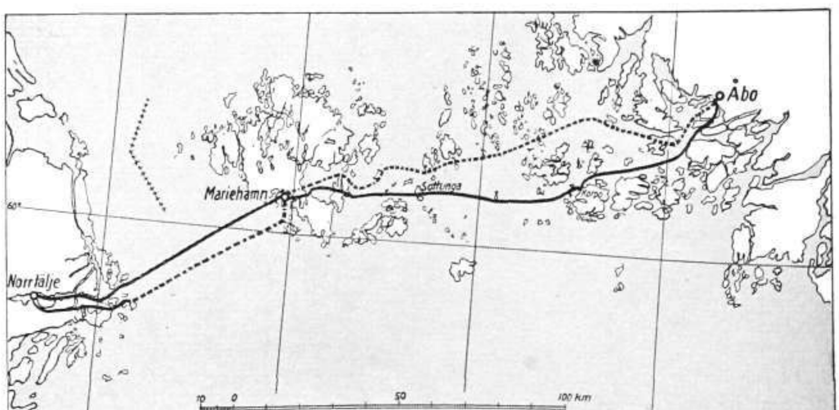


Fig. 13 X 5570
Level measuring set for 16-channel system

frequency signal receiver also contains the relays required for conversion of the 500 c/s signal current to 20 c/s ringing current and vice versa.

As may be seen, the voice frequency signal receiver has only one valve, which serves at the same time as repeater valve and indicator. In its anode circuit there are two tuned circuits coupled in series for the same frequency, 500 c/s (or 1 000 c/s), one of them a series circuit and the other a parallel circuit. The tension over these circuits is rectified separately for each by means of two metal rectifiers, delivering their tension to two resistances connected in series. These resistances in turn are connected in to the grid circuit of the valve. When a tension with pure frequency 500 c/s (or 1 000 c/s) is delivered to the input terminals a high tension arises over the parallel circuit, while the tension over the series circuit is practically zero. The rectifier for the parallel circuit is now so directed that the direct tension over the resistance connected behind it tends to carry the grid tension of the valve to higher positive values. This causes the anode DC current to rise and a polarised relay in the anode circuit is operated and gives a signal. On the other hand when a tension with frequency other than 500 c/s is fed to the input terminals there obviously arises little or, according to the sharpness of resonance, practically no tension over the parallel circuit, while the series circuit displays high impedance and takes up the whole tension. The rectifier of the series circuit delivers a direct tension over its resistance, this tension being of opposite polarity to the direct tension from the parallel circuit. Thus it gives a stronger negative grid bias to the valve and the mobile contact of the signal relay remains unenergised. Now speech contains a whole spectrum



------ 1928
—— 1938

Fig. 14 X 5561
Map of the cable route

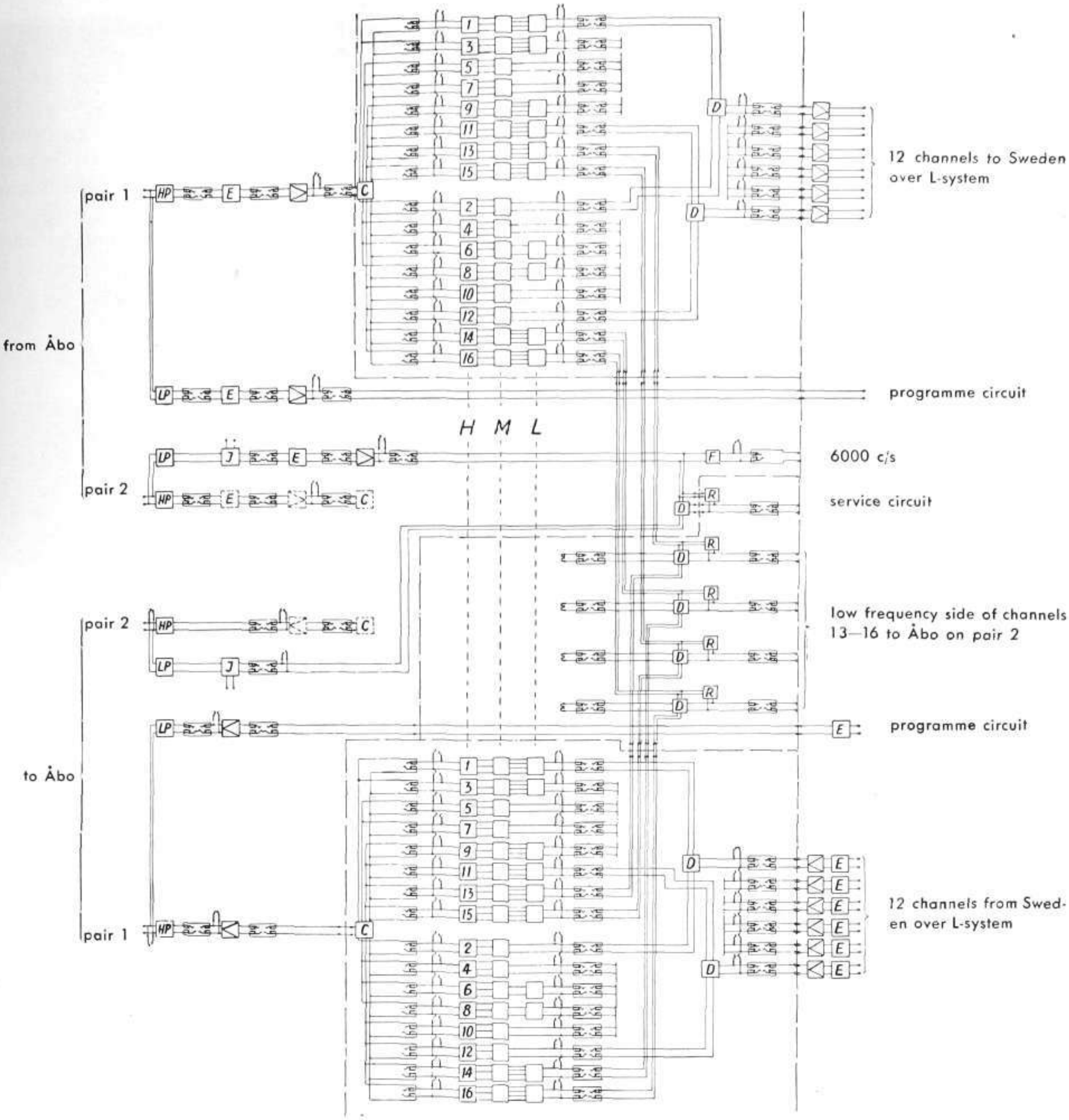


Fig. 15 x 5550

Diagram of the Mariehamn exchange

C compensating circuit
D differential transformer
E equalizing network
F filter for 6 000 c/s
H high frequency band filter
HP high pass filter
J impulse filter for remote control
L low frequency band filter
LP low pass filter
M intermediate frequency band filter
R voice-frequency signal repeater

of frequencies, in which of course 500 c/s may occur, but the presence of the frequencies different from 500 c/s has the effect that the signal receiver cannot give false signal while conversation is proceeding. For this reason it is clear that the exchange oscillator for production of 500 c/s signal tension must not deliver harmonics of 500 c/s to such a degree that the signalling is blocked by them. No more than 1 to 2 % should be permitted.

To ensure that the grid tension is not displaced to zero or even to positive values, a rectifier is connected in such a manner that the grid bias cannot be displaced more than to a certain fixed value, no matter how much the signal tension rises above the amount corresponding to this displacement. This gives two advantages: it saves the valve and there is always obtained a constant current increase on signal that is independent of the signal tension in wide limits. This latter feature is particularly valuable with dialling, since the impulse ratio will be constant.

Test Instruments

At each exchange there are DC instruments for checking feed tensions and anode currents etc., together with a transmission measuring set, Fig. 13. This

Fig. 16 X 3937
Section of the Mariehamn exchange equipment

latter has been specially developed for use in conjunction with these systems, but is quite well adapted for other purposes too. It comprises an amplifier with negative feed back coupling, which has appreciably simplified both the construction and the operation of the instrument. A DC instrument with metal rectifier is used as indicator. The scale on the instrument is graduated from —1.2 to + 0.6 neper. The testing range is extended by a variable attenuator of 20×0.2 neper covering the range —3.2 to + 2.6 neper. The instrument's input impedance may be adjusted for 20 000 ohm, 600 ohm or 150 ohm. The first value is employed for measuring through level and the others when it is desired to terminate the object of measurement. The second figure 600 ohm corresponds to the impedance of the terminal equipment on the low frequency side, while the 150 ohm represents impedance of the cable. This last figure is adapted in each individual case for the cable concerned.

The transmission measuring set may be used in the frequency range of 200 c/s to 100 000 c/s, within which it is correct to within ± 0.02 neper. The instrument is fitted with a curve which gives the actual level when it is used for measuring the level over an impedance different from 600 ohm. Deviation to zero neper on the instrument corresponds to 0.775 V at its input terminals and therefore represents zero level only over 600 ohm impedance.

The Mariehamn—Åbo—Helsingfors Carrier Frequency System

When planning the 16-channel system installed on the new Mariehamn—Åbo—Helsingfors cable connection, account had to be taken of quite a number of considerations and demands due to the conditions, in many respects quite special, under which the system was to operate. The section Mariehamn—Åbo consists for the most part of marine cable and the total section amounts to about 153 km, see map Fig. 14. Two repeater stations have been provided, one on Sottunga and the other on Korpo, two islands in the Finnish archipelago. The repeater distances are: Mariehamn—Sottunga 44 km. Sottunga —Korpo 53 km and Korpo—Åbo 56 km.

The following conditions formed the bases for the shaping of the installation: between Åbo and Mariehamn equipment was required in the first stage of construction for twelve communications and a further twelve in the second stage, designed to be connected at Mariehamn to a loaded cable to Sweden designed for the L-system. Between Åbo and Mariehamn there were required four circuits for local calls and likewise between Åbo and Korpo four local circuits. Between Åbo and Mariehamn there were required two circuits capable of operation simultaneously for programme transmission, one in each direction. These should also be joined to special wireless broadcast pairs in the loaded cable to Sweden. Four of the circuits from Sweden must be carried over to Helsingfors without demodulation at Åbo. A service circuit was to be arranged between Åbo—Korpo, Korpo—Sottunga and Sottunga—Marie-

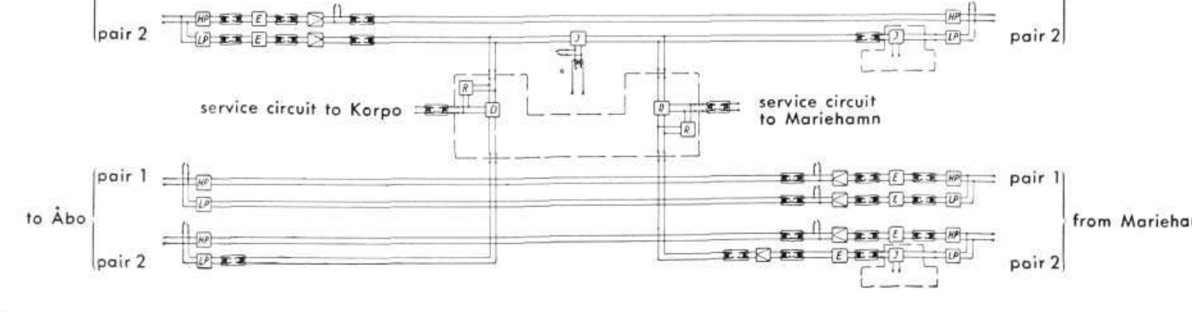


Fig. 17 X 5549
Diagram of Sottunga station

- D differential transformer
- E equalizing network
- HP high pass filter
- J impulse filter for remote control
- LP low pass filter
- R voice frequency signal repeater

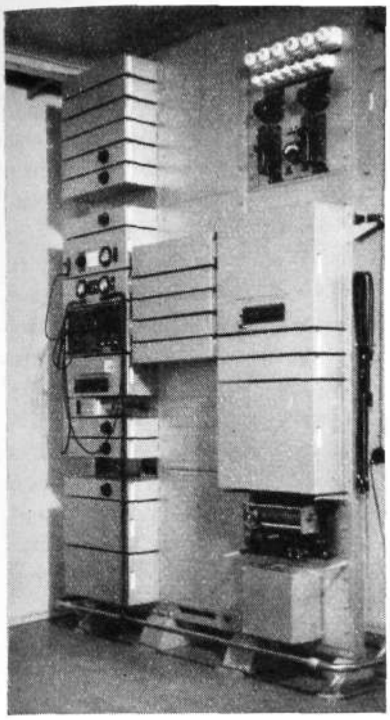


Fig. 18 X 3938
Equipment at Sottunga station

hamn, which when required could be connected through between Åbo—Mariehamn. The repeater stations on Korpo and Sottunga, where electric power was not available, should be constructed for remote control from Åbo and Mariehamn respectively and thus capable of being left unattended.

To provide these circuits two cables have been employed, one for each direction, each comprising two pairs on which the 16-channel system is applied. A marine cable is comparatively expensive and for this reason these possibilities have been utilised to the utmost.

On *pair 1* in the cables there operates one 16-channel system with the twelve lowest channels reserved for the Mariehamn—Åbo through traffic, while the four highest channels are employed for local connections between Åbo and Mariehamn. In the frequency range below 12 000 c/s on the same pair there is equipment for broadcast programme transmission.

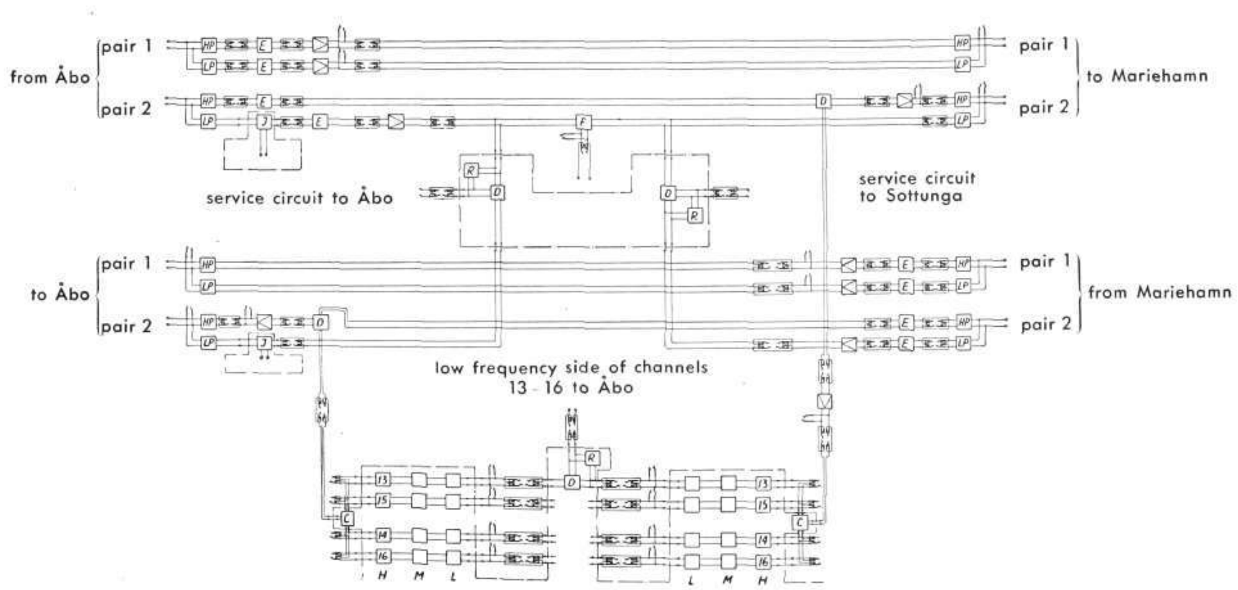
Pair 2 in the cables have the equipment for the twelve circuits of the second stage of construction, arranged on the twelve lowest channels of the second 16-channel system, the four highest channels being used for the service between Åbo and Korpo. Thus Korpo serves not only as repeater station but also comprises terminal equipment for four carrier frequency channels. The service circuits are arranged as low frequency circuits in the range 200—2 700 c/s on the same pair and the remote control carried out with DC impulsing is placed in the frequency range below 100 c/s. Finally the second pair transmits 6 000 c/s from Åbo for synchronising the carrier frequency oscillations in Korpo and Mariehamn.

At Åbo the overhead circuits are connected to the high frequency repeaters over differential transformers. The differential transformer has the overhead circuit connected at one side and the terminal equipment filters on the other. The high frequency repeater and its balance are connected at the two upper terminal pairs. The four lowest channels in the first 16-channel system have been employed for this purpose, the terminal equipment for these being located at Helsingfors. This is a temporary arrangement with the object of obtaining these circuits at once, without waiting for the new carrier frequency cable at present being built between Helsingfors and Åbo.

Remote Control

In view of the small number of wires in the cables it was necessary to arrange the remote control by means of DC impulsing in order to obtain as many control possibilities as possible. The impulses are transmitted on the cables

Fig. 19 X 5554
Diagram of Korpo station
C compensating circuit
D differential transformer
E equalizing network
F filter for 6 000 c/s
H high frequency band filter
HP high pass filter
J impulser for remote control
L low frequency band filter
LT low pass filter
M intermediate frequency band filter
R voice frequency signal repeater



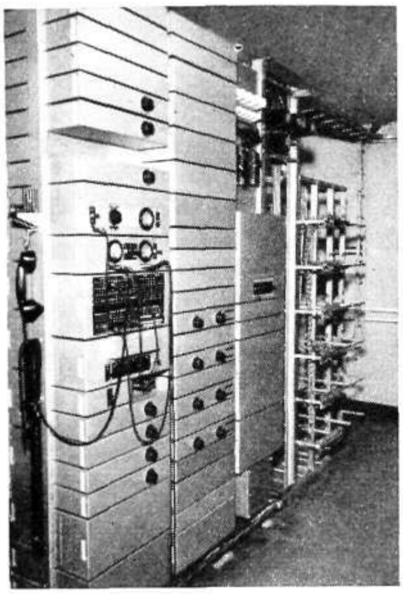


Fig. 20 X 3939
Equipment at Korpo station

over special filters, in order not to interfere with the circuits operating on the same pair. In both parent and sub-stations the equipment comprises a relay set and two selectors. Each selector position answers to a definite function: thus eight positions have been reserved for the like number of starting and stopping facilities, seven positions for different DC measurements, one position to call for a signal and indication of the situation at the sub-station and seven positions for the emission of various signals from the sub-station.

For the proper execution of an order it is necessary that the two selectors have taken up the same positions at both main and sub-station. In this case there is a check since the selectors operate each other successively, the selectors at the main station being the first and last in the chain. If these two have taken up the same position one knows that the sub-station selectors are also in correct position. When the selectors have taken their positions for a certain order and the switching has been done properly, a lamp lights up to indicate that the ordering may be carried out. This is done by a special switch which only operates when the lamp is lit. It is always possible to see by a lamp panel which parts of the sub-station are in or out of operation. The sub-station may also be operated manually. Each change executed manually is, however, reported to the parent station.

Exchange Equipment

The Mariehamn exchange, Fig. 15, presents particular interest on account of the change-over there from the 16-channel system to the L-system on loaded cable from Sweden. The L-system, is a system in which a carrier frequency band is super-imposed on the low voice frequency band 300—2 700 c/s as lower side frequency for a carrier frequency of 6 000 c/s. The band therefore lies between 3 300 and 5 700 c/s. The system is four-wire and the low frequency and carrier frequency bands on one pair are transmitted in the same direction, being amplified in common repeaters. As will have been seen from the description of the modulation procedure, after the high frequency demodulation there is obtained on half the number of channels of a 16-channel system an intermediate band which lies between 3 300 and 5 700 c/s and for the other half a band which lies between 6 300 and 8 700 c/s. Obviously the former band may be sent out direct on the loaded cable as the carrier frequency band for the L-system, while the latter is demodulated in the customary manner, giving a low frequency band 300—2 700 c/s which is then transmitted on the loaded cable along with one of the 3 300—5 700 c/s carrier frequency bands. The carrier frequency and the low frequency bands might naturally be paired together in arbitrary manner, but in this case channels *1, 2, 3, 4, 5, 6* and so on up to including *11* and *12* of a 16-channel system have been combined together to form the two bands of the L-system. The filters for one high and one low frequency band have been connected up by means of a differential transformer.

In addition, there is at Mariehamn terminal equipment for four circuits to Åbo, amplifiers for programme transmission in both directions, amplifiers for the service circuits and devices for remote control of the amplifier station at Sottunga. The whole equipment is accommodated on five racks, Fig. 16. When fully installed with apparatus for the final capacity with twelve further circuits the number of racks will be raised to seven.

The intermediate repeater stations at Sottunga, Fig. 17 and 18, and at Korpo, Fig. 19 and 20, have nothing new to offer in principle compared with earlier descriptions, with the exception of the power plants which are designed for automatic running. At each station there are two 26 V storage batteries. The tension delivered by these is regulated by carbon pressure regulators to 24 V, which is used as feed current to the valves. Anode tension 130 V is obtained from one of two rotary converters, driven by the regulated 24 V tension. The batteries are charged by two petrol engine units which have voltage

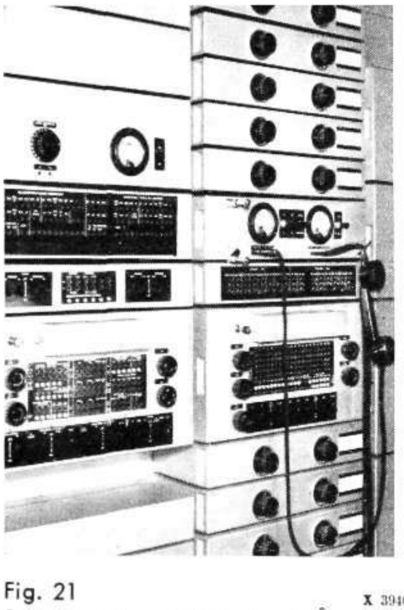


Fig. 21 X 3940
Section of equipment at Åbo exchange

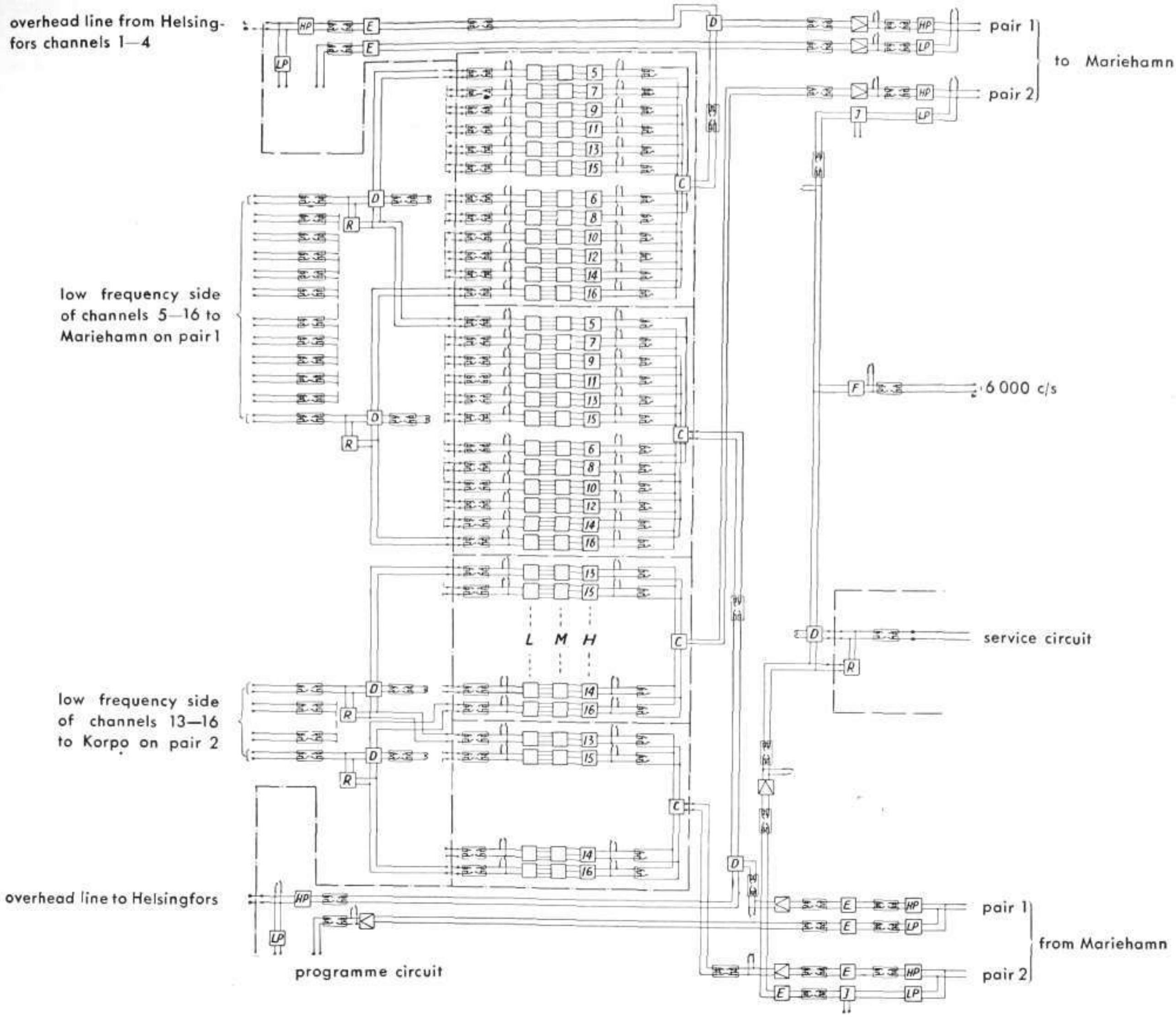


Fig. 22
Diagram of Åbo station

X 5560

- C compensating circuit
- D differential transformer
- E equalizing network
- F filter for 6 000 c/s
- H high frequency band filter
- HP high pass filter
- J impulser for remote control
- L low frequency band filter
- LP low pass filter
- M intermediate frequency band filter
- R voice frequency signal repeater

relays so adjusted that the petrol engine, built in with a generator for 24—26 V DC, starts up and begins charging when the tension in a battery falls to 24 V. Charging is maintained until the tension of the battery has risen to 36 V, when the relay once more operates to cut off the charging.

The batteries are large enough to ensure a reserve period of 24 hours if both charging units should break down at once, though this must be regarded as exceedingly improbable.

The Åbo exchange, Fig. 21 and 22, at present comprises terminal equipment for 18 telephone circuits to Sweden and four to Mariehamn and Korpo respectively. When complete there will be equipment for six further telephone circuits to Helsingfors.

At Helsingfors there is up to now equipment only for four telephone circuits, Fig. 23 and 24, but at the close of the present year all the 24 circuits to Sweden will have their terminal exchange at Helsingfors, while three further channels above the twelve channels in each system will be utilised for the section Helsingfors—Åbo, the section in this way obtaining six new circuits. The 16-channel system will then be completely developed on all sections, with the exception of one pair 1 between Mariehamn and Korpo where there will still be possibility of arranging three further circuits if required.

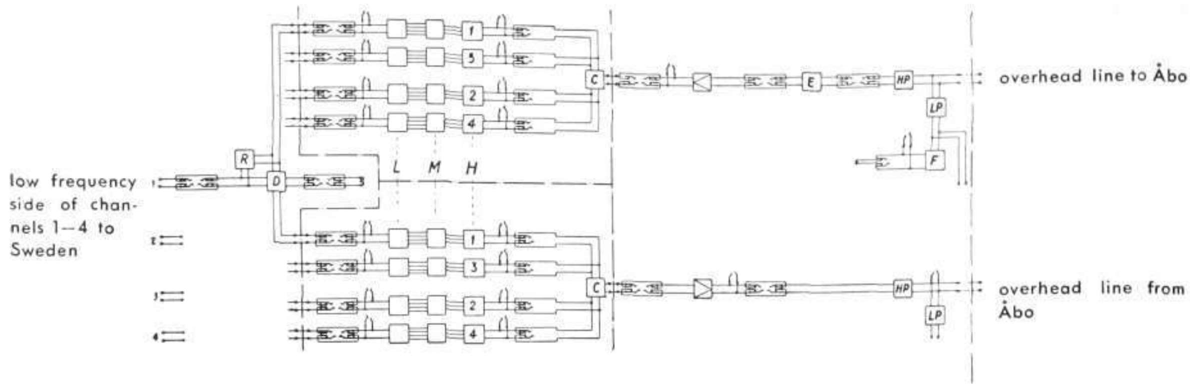


Fig. 23 X 5559

Diagram of Helsingfors exchange

- C compensating network
- D differential transformer
- E equalizing network
- F filter for 6 000 c/s
- H high frequency band filter
- HP high pass filter
- L low frequency band filter
- LP low pass filter
- M intermediate frequency band filter
- R voice frequency repeater

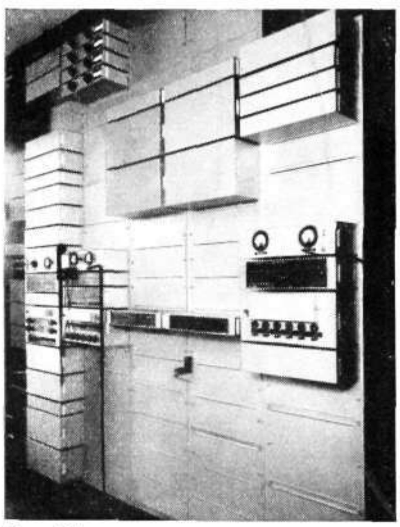


Fig. 24 X 3941

Section of Helsingfors exchange equipment

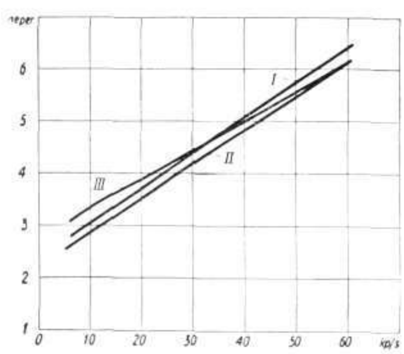


Fig. 25 X 3928

Attenuation at high frequency on the cable sections

- I Åbo—Korpo 56 km, 1.7 mm
- II Korpo—Sottunga 53 km, 1.7 mm
- III Sottunga—Mariehamn 44 km, 1.4 mm

Test Results

The cables, made by Finska Kabelfabriken and spliced by Telefonaktiebolaget L.M. Ericsson, proved on final test to be far better than the guarantee figures prescribed. The attenuation curves for the three sections are shown on Fig. 25 and 26. *Near end crosstalk attenuation* between pairs of the same cable had been guaranteed to be greater than 6.1 neper at 3 000 c/s, 5.75 at 40 000 c/s and 5.4 neper at 60 000 c/s. As may be seen from Table I these guarantees were fulfilled with more than 3 neper margin. The same applies to *far end cross talk attenuation* between pairs in the same cable, see Table II. According to the guarantees the level difference at the far end in the tension on the disturbing and the disturbed pair should be at least 7 neper. It should be observed that the cables were so good in themselves that no balancing network for equalisation of far end crosstalk required to be employed.

The impedance and phase angle for a pair in the Åbo—Korpo cable, measured at Åbo, are shown in Fig. 27.

The *attenuation equalisation* on the whole section Åbo—Mariehamn is shown by Fig. 28, giving overall attenuation for cable, correcting network and high frequency amplifier in the kc/s 12—60 range. It will be seen that the error is less than 0.1 neper. Fig. 29 shows equivalent figures for the programme

Table I

Values as measured and as guaranteed for near end crosstalk attenuation between pairs in one cable

frequency	near end crosstalk attenuation		
	lowest individual figure	mean figure for 24 measurements	minimum guaranteed figure
kc/s	neper	neper	neper
10	9.9	11.0	—
30	9.8	10.6	6.1
60	9.0	9.8	5.4

Table II

Values as measured and as guaranteed for far end crosstalk attenuation between pairs in one cable

frequency	far end crosstalk attenuation		
	lowest individual figure	mean figure for 24 measurements	minimum guaranteed figure
kc/s	neper	neper	neper
10	10.0	10.8	7.0
30	8.7	9.5	7.0
60	8.3	8.9	7.0

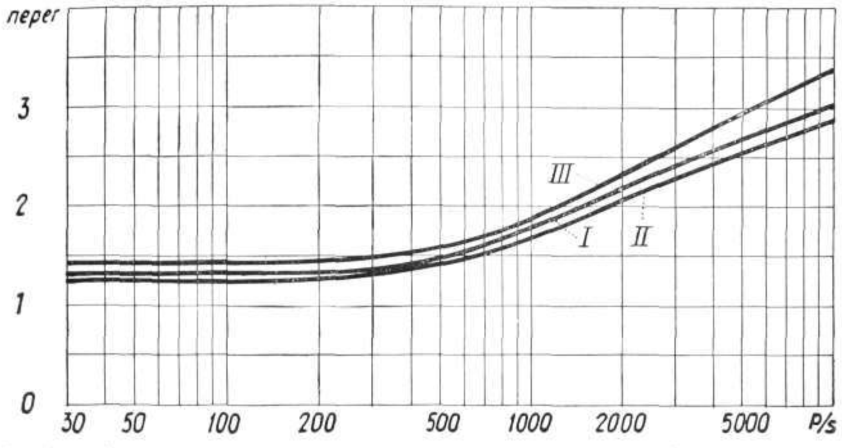


Fig. 26 X 5555
Attenuation at low frequency on the cable sections
I Åbo - Korpo
II Korpo—Sottunga
III Sottunga—Mariehamn

circuits with their repeaters and correcting networks on the Åbo—Stockholm section. The repeaters for the programme circuits have also been made on the principle of negative feed back coupling, thus ensuring great stability and small non-linear distortion coefficient. The repeaters have two valves and can deliver 200 mW with a non-linear distortion coefficient in the neighbourhood of 0.1 %. Fig. 30 gives the amplification as function of the frequency. The effect of frequency on the overall attenuation with a carrier frequency channel is shown on Fig. 31, which also gives the guarantee figures.

The *near end crosstalk* between the different channels was in general in excess of 12 neper, see Table III. The *far end crosstalk* between channels in the same system is shown by Table IV. The figures give the level difference between disturbing and disturbed channels, when all channels have been matched for the same overall attenuation. In measuring a buzzer is employed as tension feed. The figure for far end crosstalk attenuation between two channels of same frequency in different systems will be seen on Table V, giving the results of measurements at Åbo between channels *13—16* belonging to one system (circuits with Mariehamn) and the same channels in the other system (circuits with Korpo).

The *psophometric potential difference* was measured with a psophometer, calibrated in conformity with the CCIF. No potential difference could be observed in any of the channels, though the instrument is adapted to indicate an EMF of 0.05 mV. The potential difference was measured at a point with the relative level of —0.4 neper. The psophometric potential difference pro-

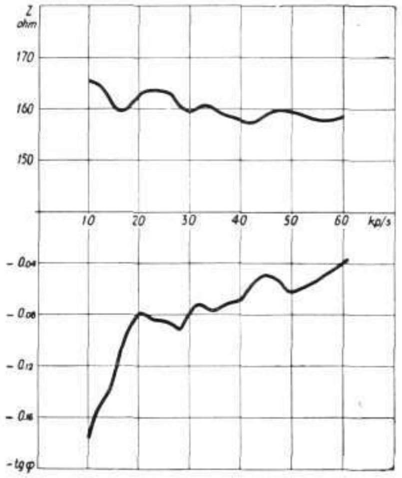


Fig. 27 X 3942
Impedance of 1.7 mm cable

Table III
Values measured in neper for near end crosstalk attenuation between channels in one system

disturbing channel	channel disturbed											
	5	6	7	8	9	10	11	12	13	14	15	16
5		11.7	—	—	—	—	—	—	—	—	—	—
6	11.5		—	—	—	—	—	—	—	—	—	—
7	—	11.8		11.0	—	—	—	—	—	—	—	—
8	—	—	11.0		—	—	—	—	—	—	—	—
9	—	—	—	—		9.5	—	—	—	—	—	—
10	—	—	—	—	10.1		—	—	—	—	—	—
11	—	—	—	11.0	—	—		10.8	—	—	—	—
12	—	—	—	—	—	—	10.8		—	—	—	—
13	—	—	—	—	—	—	—	11		10	11.1	10.9
14	—	—	—	—	—	—	—	—	10.5		11.5	11.4
15	—	—	—	—	—	—	—	—	—	11.4		10.0
16	—	—	—	—	—	—	—	—	—	11.0	9.0	

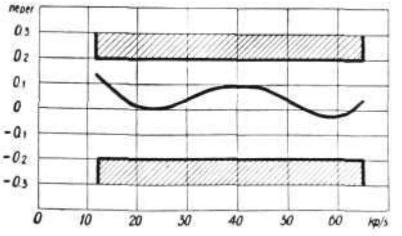


Fig. 28 X 3929
Overall attenuation as a function of the frequency
in cables, correcting network and amplifiers on the whole section Åbo—Mariehamn

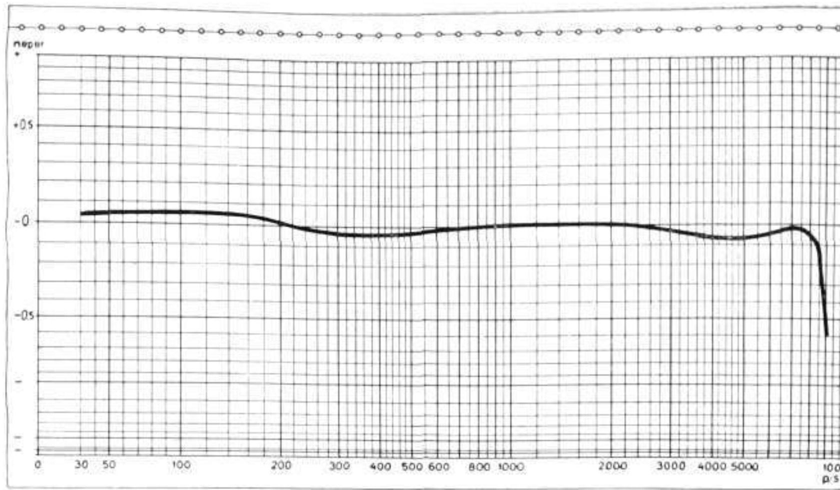


Fig. 29 X 5557
Overall attenuation as a function of the frequency in the programme circuit Åbo—Stockholm

duced when speaking on the channels, due to linear crosstalk over the filters and non-linear distortion in the common repeaters, was likewise measured. Eight persons were connected to speak on separate channels at Stockholm, while the psophometer readings on connecting in the channels not used were taken at Åbo. The figures thus not only apply to the 16-channel system but comprise also the whole circuit Stockholm—Åbo. The figures of Table VI are reduced from —0.8 to zero neper reception level and are given both for normal and for very loud speech.

The *phase velocity* was measured with a transmission recording set in the usual way by measuring impedance on the two-wire side of a channel with

Table IV
Values measured in neper for far end crosstalk attenuation between channels in one system

disturbing channel	channel disturbed											
	5	6	7	8	9	10	11	12	13	14	15	16
5												
6	9		8.7	—	—	—	—	11	10.7	10.7	9.2	9.9
7												
8	10.0	9.6	8.6		8.6	10.1	10.2	10.9	9.9	9.8	9.8	9.8
9	—	—	11.0	8.4		8.4	9.4	9.4	9.7	9.7	9.7	9.9
10												
11	10.3	10.4	11.0	—	10.6	9.8		8.4	8.9	8.9	8.8	9.8
12												
13	—	—	—	—	—	—	—	8.6		8.6	9.0	—
14	11.0	9.9	9.5	9.0	8.8	9.0	9.0	8.6	8.0		8.6	10.0
15	—	—	• 9.8	9.8	—	9.4	10.0	9.0	9.3	8.3		8.3
16	—	—	—	11.0	—	—	—	—	10.2	10.0	8.6	

Table V
Values measured in neper for far end crosstalk attenuation between two channels with the same frequency belonging to different systems

disturbing channel in system 2	disturbed channel in system 1			
	13	14	15	16
13	10.0	—	—	—
14	—	10.0	—	—
15	—	—	9.8	—
16	—	—	—	9.4

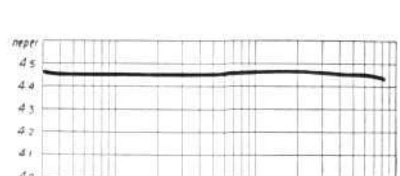


Fig 30 X 3929
Amplifications as a function of the frequency in the programme repeater

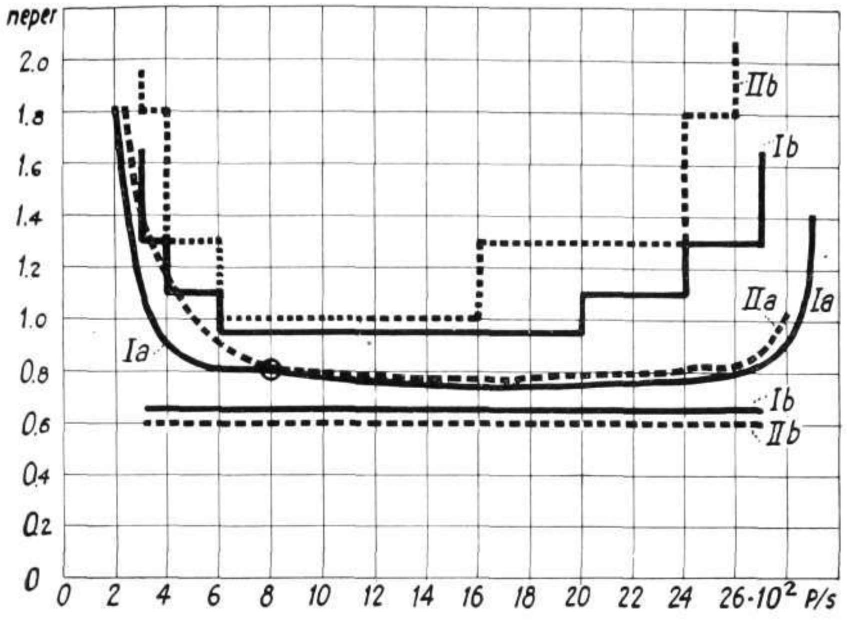


Fig. 31 X 5573

Overall attenuation as a function of the frequency in one channel

I a Åbo—Mariehamn

II a Åbo—Mariehamn—Stockholm

I b figures guaranteed by Ericsson for Åbo—Mariehamn

II b figures recommended by CCIF for four-wire circuits

the two-wire balance at the other terminal station shortcircuited and the line side open. The propagation time was about 2.5 ms. The greater part of this time consisted of building-up time in the terminal equipment filters, see Fig. 32.

The frequency stability in the oscillators was investigated in respect of the anode tension. Reduction of the anode tension from 129 to 118.5 V changed the frequency by 0.63 c/s in 100 000 c/s and on raising from 129 to 142 V the change was 1.7 c/s in 100 000 c/s. The guaranteed figure was ± 6 c/s in 100 000 c/s.

Types of Valves and Current Consumption

For the high frequency repeaters three Marconi Osram N43 high frequency pentodes are used, with filament tension 4 V and filament current 2 A. The two repeaters for the different directions in one system are connected in series to the 24 V exchange battery, thus taking 2 A together. The anode current per amplifier is 35 mA.

The programme repeaters have two valves of the same type as the high frequency amplifiers.

The tuning fork repeater and the voice frequency signal receiver each contain one valve, Marconi LS7, made for 4 V, 0.15 A. Two tuning fork repeaters and two voice frequency receivers may be connected in series to the 24 V exchange battery. The anode current consumption in each is 4 to 7 mA.

Use has been made of LS7 and LS8A valves for the oscillators. The total power consumption for the oscillator plant is 0.6 A at 24 V and 0.16 A at 130 V. The total current consumption for a 16-channel system, exclusive of oscillator plant but including tuning fork repeaters and voice frequency receivers, will then be 3.4 A at 24 V and 0.24 A at 130 V.

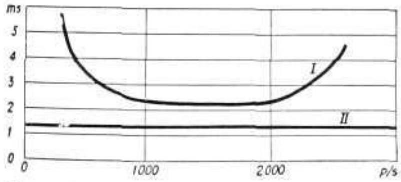


Fig. 32 X 3931

Transmission time as a function of the frequency

I for a channel on the Åbo—Mariehamn section

II for cable alone

Table VI

Values measured of disturbance tension in mV EMF for simultaneous speech on channels 1—6, 9 and 10 with a receiving level of zero neper

disturbed channel	disturbance tension							
	7	8	11	12	13	14	15	16
with normal speech	0.22	—	0.45	—	0.11	0.11	—	0.2
with loud speech	0.4	—	0.6	—	0.5	0.5	—	0.3

Distribution of Costs when Fixing Rational Electricity Tariffs

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After the Copenhagen Municipal Electricity Works had for a long period of years almost exclusively applied a tariff system having no fixed charge beyond a small meter charge, but in general based on various unit rates per kWh for different uses (mainly for lighting, motors and heating), it was decided at the close of 1935 to carry out a thorough investigation of the various items of expenditure in the production of electricity with a view to revision of tariffs. Some of these investigations and the results arrived at were presented to the World Power Conference at Vienna in 1938 and will be given in this article.

Production Costs of an Electricity Works

At Copenhagen the major part of the production takes place at the big steam and Diesel power plant of the *H. C. Ørsted* Station.

It is fairly generally known that the expenses of production and distribution of electricity may be roughly divided into the following three categories:

kWh cost A, directly governed by the size of production. Under this are included cost of fuel and a portion of the amounts paid in wages.

kW cost B, dependent on the maximum load occurring during the year, but otherwise independent of the size of production. The heaviest items for this are charges for depreciation and interest on the production and distribution plant. In addition it includes the greater part of maintenance costs and a considerable part of wages and management expenses.

Metering cost C, which is entirely dependent on the number of consumers but is quite independent of the amount of electricity taken by individual consumers. Under this come the costs of installing, maintaining and reading the meters, expenses of invoicing and collection and a number of other administration expenses.

The ideal tariff would be a form of tariff which comprises these three elements and with which each consumer pays the expenses in each category that are caused by him, *i.e.*, it should be capable of expression in the formula

$$\text{payment} = a \cdot \text{kWh} + b \cdot \text{kW} + c.$$

Before drawing up a tariff system on this basis it is necessary to investigate how the total costs are distributed over the three categories and to what extent the individual consumer groups contribute to the costs within each of the three categories.

Provided accounting is specific and well ordered, it is comparatively simple to divide up the total annual costs into three figures: kWh cost A, kW cost B and metering cost C. It is moreover easy enough to fix the cost a per kWh, since it is obtained by division of the figure A by the total of kWh sold. The cost c per meter per year is obtained by distributing the total metering cost C over the total number of electricity meters, the more complicated meters that are more expensive to buy and maintain being charged with a larger portion of the cost than the simple kWh meters which are cheaper and cost less for upkeep.

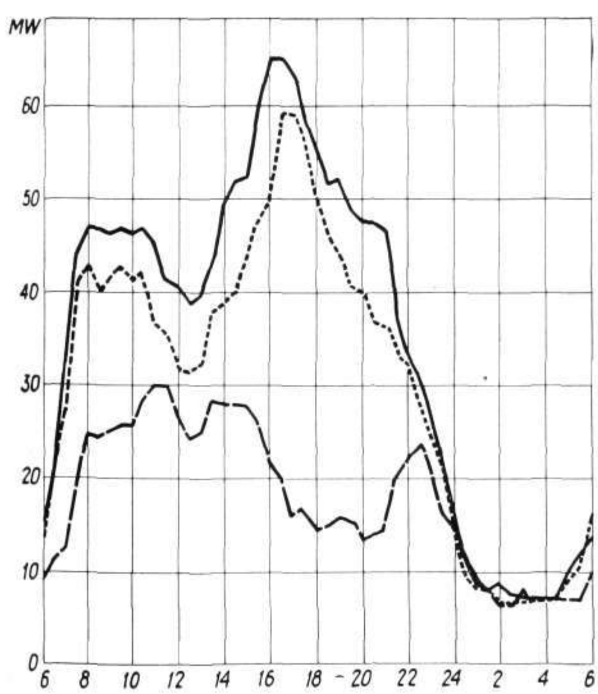
It is, however, considerably more difficult to arrive at a correct estimation of the share of individual consumers or separate consumer groups in the kW cost *B*, that is to say the share of individual consumers or separate consumer groups in the maximum load of the undertaking. The reason is that as a rule there are not meters indicating how intensively the individual installations are utilised during the peaks; still occasional tests and recording can give some basis for an estimate. A somewhat more reliable picture may be obtained if as regards the load actually metered at the station it is possible to decide the shares of the different consumer groups in it.

Individual Consumer Groups' Share in the Maximum for the Year

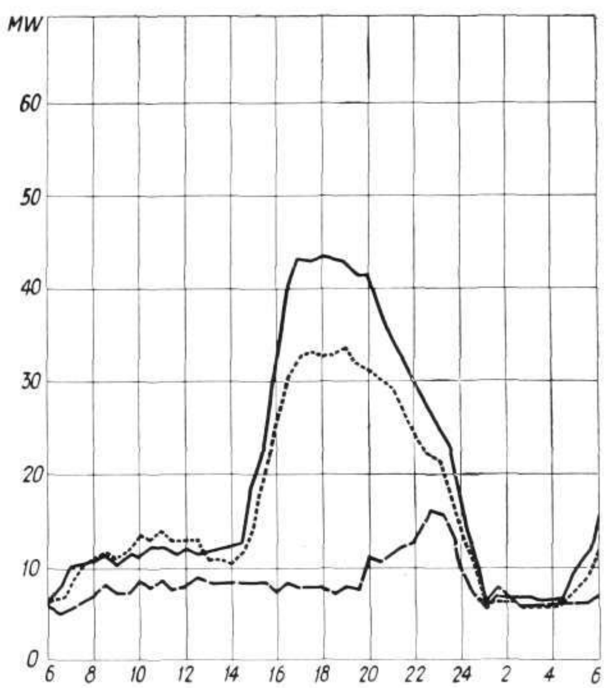
At most large electricity works there is noted daily on a diagram how the load has varied throughout the day. With such load curves for typical days as a basis it is possible, as will be described below, at least as concerns some of the consumer groups, to obtain quite a good idea of their share in the undertaking's maximum supply for the year. It should be observed that at Copenhagen up to now electricity has only been employed to a very small extent for cooking and heating purposes. Further it should be noted that, on the diagrams below, the production of electricity for associated plants, for railways and tramways and for street illumination has been deducted, so that the diagrams refer only to normal consumers.

On Fig. 1, in addition to the curve for 18th December 1935 giving the maximum for the year, there are shown curves for two normal weekdays at different seasons of the year, *viz:* Tuesday, 10th December, and Friday, 21st June. It will be seen from the normal December curve that the consumption in the forenoon hours is quite constant, consisting of motor consumption for workshops and factories and of lighting for numerous purposes; further it is seen that the load rises in the hours after noon, to attain a very marked peak of short duration as darkness falls. The load then diminishes as the factories, offices and other establishments close. The load peak is undoubtedly due to increased lighting consumption with the coming of darkness. The

Fig. 1 & 2 X 7201
Load curves
left, year's maximum and two normal weekdays; right, three Sundays



year's maximum 18th December
Tuesday, 10th December
Friday, 21st June



Sunday, 22nd December
Sunday, 8th December
Sunday, 23rd June

curve for a light summer weekday has its maximum in the forenoon, at which period the most of the load is due to motors and other industrial purposes. By taking the difference between the loads at 5 p.m. on the summer and winter curves there is obtained a figure which gives an approximate expression for *the lighting load's share in the maximum.*

On Fig. 2 are given curves for three typical Sundays, a summer Sunday, a winter Sunday at the beginning of December when establishments may be using light for publicity and window display and a Sunday immediately before Christmas when all establishments are open and are doing large business. It may be seen that up to dusk the load is almost the same irrespective of the time of the year. This load may therefore be regarded as the measure of an electricity consumption (in industry and the like) which is taken year in year out, both weekdays and Sundays, while the difference between the forenoon load on a summer weekday as on the curve, Fig. 1, for Friday, 21st June 1935, and a summer Sunday as the curve, Fig. 2, for Sunday, 23rd June 1935, may give the expression for the size of the load in *factories and workshops on a normal working day.*

Comparing the loads of Fig. 2 for the two typical Sundays in December there is obtained an expression for how large *the actual share in the maximum the lighting of business establishments* will be at the very least. If now a comparison is made between these curves and the curve of Fig. 1 showing the maximum for the year, then one will be in a position to arrive at quite a reliable distribution of the different consumption groups' share in that maximum. The uncertainty of this method may be assumed to be less than the inaccuracy arising, for example, from the fact that interest and depreciation increase sharply on large extensions of producing machinery. It is, of course, always the fact that immediately prior to any large extension the charges for interest and depreciation will be quite small, while on the other hand they are relatively high just after an extension and will continue to be so until the supplementary power thus obtained is utilised to the full.

The results obtained from the load curves may be checked and supplemented on the basis of information from the installation departments of the electricity undertaking. In these departments there is usually kept more or less detailed statistics of the load amounts installed in the separate consumption groups (their installation values). These groups, however, contribute in extremely varying degree to the building up of the maximum for the year and the question is, therefore, whether it is possible to estimate the proportion they comprise of the total maximum. This may be done with a certain closeness by making a series of investigations into the maximums and coincident factors for characteristic installations and including these results for the groups concerned as a whole. Where there is AC supply with transformer stations exclusively supplying either residential districts or industrial districts it is possible, by installing a simple recording instrument covering several consumers, to make an investigation of a large number of similar consumers. This last method has the advantage over investigations of individual consumers in that deviations from the average which are always liable to occur are eliminated automatically.

On the basis of the above-named investigations, the maximum load on 18th December 1935, in all 65 200 kW, of the actual consumers has been subjected to analysis, Table I. It may be observed in the table that the group »large industrial undertakings» constitutes but a small part of the maximum; this being due to the application to these consumers of a special tariff with a power charge for energy taken out between 4 p.m. and 7 p.m. in the period 1st November—10th February; the power charge for these is reckoned on the basis of recordings by maximum meters with 15 min recording period.

Considerations Respecting Tariff for Business Establishments' Lighting

After the share in the maximum of the different consumer groups had been determined the task was to draw up tariffs built up in such a way that each individual consumer would pay an annual charge proportional to his share in the maximum. Of course, on practical grounds, it is not possible to do this on the basis of a metering during the electricity undertaking's maximum, and therefore as a rule the tariff must be worked out in such a way that each individual consumer pays a yearly charge which is proportional to his own maximum load, though this maximum may not necessarily coincide with the maximum of the electricity works. Since the different consumer groups, as stated above, contribute in extremely varying degree to the maximum for the year of the electricity works, there is justification for taking this into account when fixing the annual charge.

The object was in the first place to draw up a tariff for the lighting of business establishments which would ensure that there was paid a fixed charge proportional to the power utilised, while fixing this charge in such a manner that consumers with long utilisation time were favoured.

The most direct method of metering a maximum, namely with the aid of *maximum meter* or thermic *maximum indicators*, cannot be regarded as appropriate for this purpose, as it may be liable to give rise to many complaints from consumers, either alleging that the maximum meter may have given an incorrect reading or that the maximum recorded has only been utilised on a single occasion, which would make the charge disproportionately high.

A very simple method is to impose *an annual charge governed by the size of the business premises.* Such a charge, however, may not be particularly appropriate since establishments with the same floor space and even in the same line of business may utilise a very different amount of power according to the location of the establishment, the nature of the show windows and various other things. A rather better approximation is obtained with a *fixed charge per installed kW*. This tariff, however, has the disadvantage that frequent control over the number and power of the consumer's lamps is necessary; yet an abundant and appropriate lighting may not of necessity be the reason for a correspondingly large part in the maximum. A particularly thorny problem with such a tariff is the extent to which plug connections are to be reckoned in.

Employment of the very common *general double tariff* where a high kWh price is paid for the hours of the day when the electricity works is most

Table I
Distribution of the shares of the various consumer groups in the year's maximum

	lighting					large factories or consumers	public institutions	motors	total
	dwellings	large businesses	small businesses	offices, workshops etc.	total lighting				
installation value kW	116 800	5 800	11 400	39 900	173 900	35 100	13 300	86 500	308 800
millions kWh sold	29,2	8,4	16,0	9,9	63,5	37,3	9,7	35,0	145,5
estimated share in kW max.	14 300	5 100	9 500	15 600	44 500	2 000	4 200	14 500	65 200
resulting simultaneous factor during kW max.	0,12	0,88	0,83	0,39	0,26	0,06	0,32	0,17	0,21
utilisation time for share in kW max. in hours	2 042	1 647	1 684	635	1 427	18 650	2 310	2 414	2 232
utilisation time for installation value in hours	250	1 448	1 404	248	365	1 063	729	405	471

heavily loaded and a lower kWh rate for other hours of the day was left out of account because of the expense associated with the providing of the meters and the necessary contacts and relay circuits; besides it was not considered reasonable that electricity should be dear just at the time when there was most use for it.

Demand Limit Tariff of Business Establishment Lighting

Basing on these considerations it was decided as regards lighting electricity used in business establishments in Copenhagen to introduce a subscription tariff — demand limit tariff — based on special double tariff meters — demand limit meters or *subtraction meters.* This subscription tariff, already in use at Stockholm and other places, is based on a certain annual charge, at present 200 Kr./kW; when — see Fig. 3 a — there is taken out electricity at a demand not exceeding the subscribed figure, payment is made at a low kWh rate, now 8 Øre/kWh, while for loads exceeding the subscribed demand limit there is charged the higher rate of 30 Øre/kWh for the excess consumption (the shaded area on the figure), but only for the excess. Certain electricity undertakings employ a subscription tariff where the higher rate is charged for the whole electricity consumption over the period when the subscribed demand is exceeded (the shaded portion of Fig. 3 b). Since however, consumers might take the attitude that in paying the subscription charge they have already contributed to the overhead costs and therefore become entitled to take out electricity at any time at the lower price for loads within the subscribed limit, it may well be anticipated that debiting in accordance with Fig. 3 b might justly be criticised from the standpoint that they will thereby be making contribution twice over to the overhead costs immediately the load goes beyond the subscribed limit. In Copenhagen therefore the charging has been introduced in accordance with Fig. 3 a.

Recording of Consumption for Demand Limit Tariff

For the purpose of accounting there are used special electricity meters with two counters, as stated, called subtraction meters. For practical reasons the meter is so designed that the one counter records total consumption and the other the excess consumption; only the excess consumption recorded by the second counter is paid for at the difference between the high and the low kWh rates. The meter may be arranged in such a manner that it consists of two metering elements, mounted in a common meter case, one being a normal kWh meter while the other is braked by an anti-rotation force corresponding to the subscribed demand in such a way that the counter operates

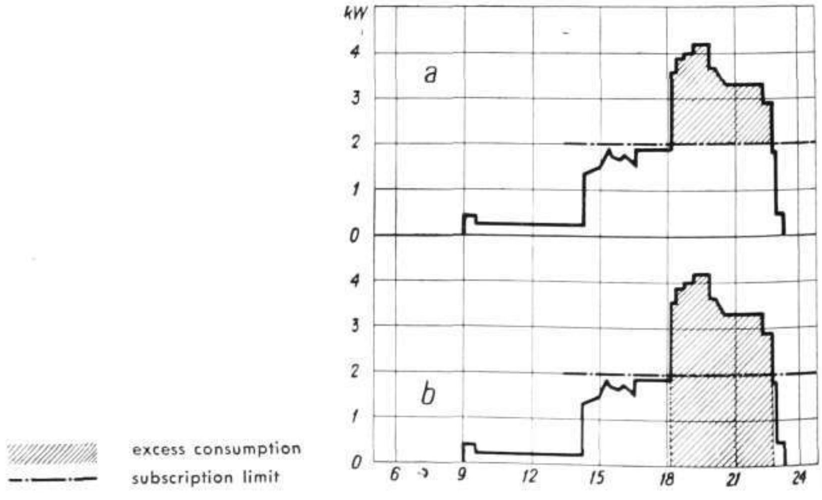


Fig. 3 X 5572
Different accounting methods for excess consumption

only for loads higher than this demand. The constant braking is effected either by spring mechanism or magnetically. On account of the employment of two metering elements subtraction meters on this principle, with the exception of single phase AC meters, are exceedingly bulky. The use of two independent meters, an ordinary kWh meter and a special peak load meter, takes up still more space but is unavoidable where DC kWh meters have to be employed.

Most of the newer types of subtraction meters are made with a single metering mechanism, utilising a differential gear. The rotating meter system drives the total consumption counter and, in addition, one pinion in a differential gear. The other pinion in this gear is driven round at a constant speed corresponding to the subscribed demand limit. A counting mechanism actuated by the planet wheel of the differential gear thus records the excess consumption. For AC current the constant speed referred to is attained easily enough by means of a little Ferraris motor or, in case there is frequency control at the station, a synchronous motor; meters of this kind are made by several of the leading meter manufacturers. As regards DC, as far as we know, it is only by Telefonaktiebolaget L.M. Ericsson, that a simple solution of the problem has been found, the constant rotatory motion being attained by means of an escapement, ingeniously maintained in oscillation by the meter's own rotation.

Application of the Demand Limit Tariff in Practice

At Copenhagen consumers may choose whether they wish to come under the demand limit tariff for lighting electricity for business houses or whether they wish their consumption to be charged at the general unit rate of 30 øre/kWh with some reduction for large consumption and no other charge beyond a small meter charge. The smallest subscription that may be taken on the demand limit tariff is 300 W; other subscriptions rise by 200 W up to 1 500 W and thereafter by 500 W. The lowest limit is fixed at 300 W, partly because smaller subscriptions were not found to be of practical interest and partly because reliable subtraction meters for DC at nominal current of 5 A are not made for subscription limits below 300 W. It may be observed that of the business establishments in Copenhagen numbering some 20 000, between the time of the introduction of the tariff in October 1936 and the 31st December 1937, about 4 200 went over to the business establishment tariff. The size of these subscriptions altogether amounts to 4 230 kW with a total installation figure of 7 440 kW (approximately 40 % of the whole business establishment group). As it might prove difficult in certain cases for the consumer himself to decide on the most favourable size of subscription, the electricity works has introduced a comprehensive service with experts at disposal on all occasions to give guidance, while in addition electricians who act as intermediaries between the electricity works and the consumers have received full information for use in advising their customers.

Shaping of the Domestic Tariff

When working out a tariff for domestic electricity, particular attention must be given to having a tariff that is simply made up and easy to understand, so that the consumers may themselves be able to grasp it without trouble and realise what its application to them means. Moreover it would be well that the tariff should be so shaped that there is no necessity to change the meters installed for consumers, which would mean either that the electricity works would be faced with a big outlay all at once or that only a small number of consumers could change over each year to the domestic tariff. Consequently the employment of the wellknown double tariff meters dependent on time must therefore be considered as not suited for this purpose. Moreover a tariff based on this meter will always be unpopular, since in any case in a large town with a big working class population it will have the effect that electricity is expensive just at the moment when there is special requirement for it.

In Copenhagen, where previously no domestic tariff had been employed, consumption of electricity for cooking and heating purposes was comparatively small. The charge for these purposes was made on special kWh meters at the same price as for motors. Since it was not permitted to take lighting current at this rate, those consumers who employed electricity for domestic purposes had to have two meters and two sets of wiring, which was expensive and troublesome for the consumer and therefore hampered any large extension of electricity for this purpose.

As a series of enquiries had shown that the consumption of lighting electricity in private houses varied very closely in proportion to the number of rooms, the tariff for electricity for domestic purposes was drawn up on basis of a fixed annual charge of 8 Kr./room and a price for the electricity consumption of 8 Øre/kWh; the fixed charge is applied only to actual living rooms, and bedrooms and kitchens. Such a tariff can be applied in most large towns; on the other hand in rural districts and for distinctly residential districts it is necessary to allow reduction of the fixed charge per room, when the number of rooms goes beyond a certain figure.

The Telephone in the Service of the Railways V

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

In Ericsson Review No 4, 1937, and No 1, 2 and 3, 1938, a number of telephone systems employed on railways were described. By appropriate combination of these telephone systems it is possible for the railways to benefit by all the advantages that rationally arranged telephone service can give. In addition to the telephone systems already described, the railways also require a system specially designed for train dispatching where all the telephone traffic on a circuit along a certain railway section is controlled by a train dispatcher, whose duty it is to direct and control the train traffic along the railway section in question. Two such systems, developed by Ericsson, are described here.

Train Dispatching Telephone

The idea of ordering and controlling railway traffic by telephone, especially for goods traffic, from a central point on a railway section first arose in USA at the beginning of the present century. Train dispatching by telephone has since then been introduced into other countries and is nowadays applied by many railway administrations throughout the world.

The centralisation of train dispatching to a single point on a railway section means considerable saving for the railways, since by concentrating the supervision of the whole train traffic along a certain section to a single person there is obtained better utilisation of the track, of the rolling stock and of the train staffs. This improved utilisation is due to the fact that the train dispatcher is able to survey the traffic at any moment, rapidly arrange modification of time tables for trains delayed or special trains, easily work in the goods trains between the passengers trains without affecting the time tables of the latter, reduce the running empty of trucks etc.

Principle

The two Ericsson train dispatching systems are designed on the same principles as the Ericsson selective calling telephone system for decentralised selection, see Ericsson Review No 1, 1938. Thus, each extension is equipped with a selector set the main parts of which are a selector and two rectifiers, Fig. 1. The one rectifier is connected in series with the selector magnet and the other in series with the speaking set in the telephone instrument; as regards the line branches, the two rectifiers are connected for opposite directions. The selector magnet is connected to the line in such a manner that the rectifier in series

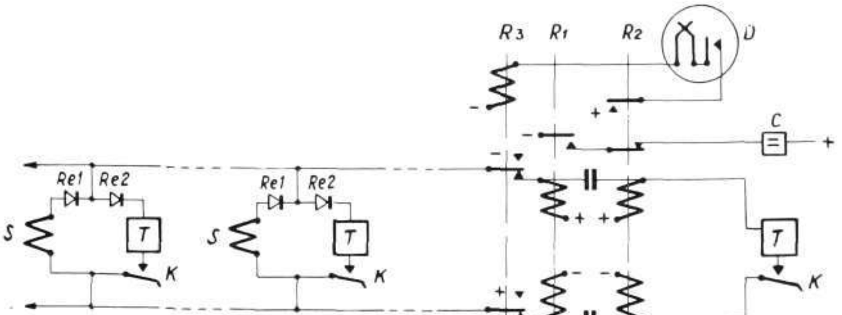


Fig. 1 X 5544

Calling and impulsing circuits in the Ericsson train dispatching system

C	buzzer
D	dial
K	switch hook
R1	call relay
R2	feed relay
R3	impulse relay
Re1, Re2	rectifiers
S	selector magnet
T	speaking set

with the magnet does not pass current in the direction of the »off normal» voltage. When call is made the contact *K* in the telephone instrument switch hook is connected and a loop is formed between the instrument and the rectifier connected in series with it. This connects the line current, and the line relay *RI* is energized. This relay forms part of a relay set common to the line and located at the train dispatching instrument, and it closes a circuit to a calling device, usually consisting of a buzzer. When the train dispatcher answers the call the buzzer is disconnected and he comes into communication with the calling extension.

If the dispatcher wishes to call an extension he lifts his handset and dials the required two digit call number — or presses the keys for it if the equipment is made for keyboard operation. The relay *R3* then operates in time to the impulses and transmits on the line a corresponding number of impulses. As may be seen on Fig. 1, the operating impulses have a polarity opposite to that of the »off normal» voltage, with the result that the selector magnets step forward the selector wipers, in time to the transmitted impulses, to the call position for the wanted extension. In this position the bell of the extension is connected and a signal is given. The conversation may begin immediately the extension handset is lifted. Internal calls between two extensions may be carried on, but ringing up must always be done by the train dispatcher.

As may be seen, the principle for the Ericsson train dispatching systems is exceedingly simple. Both calling and impulsing are done by DC over the two line loop circuits, without the utilisation of an earthing circuit. The selector line »off normal» tension is but 24 V. For the operating impulses to the selectors, however, a higher tension of 150 to 200 V is employed, the tension being determined by the number of selectors and the electrical properties of the selector line.

In the Ericsson selective calling telephone systems all operating relays and the whole power plant are concentrated at a single spot on the selector circuit, while the extension instruments are of very simple design and have no power supply. This is of the utmost utility for a railway telephone system where it is important that the central equipment be located at the spot where the train dispatcher is stationed and where usually maintenance staff is available, while the extensions are located at spots which are entirely without expert technical staff. As a result of the principle of design employed by Ericsson, the system provides the greatest operating reliability possible.

The fundamental element in the Ericsson train dispatching system is the *selector*, a little selector so designed that it can be operated direct by the impulses transmitted over the selector line. The selecting mechanism of a selector is so light-acting that the current intensity of the operating impulses need not be more than 1.5 mA. Each extension along the selector line is equipped with such a selector and all these selectors are connected in parallel with one another. The purpose of the selector is, when in a certain position corresponding to the call number, to close a circuit over which the calling device — bell or the like — of the instrument pertaining to it is actuated.

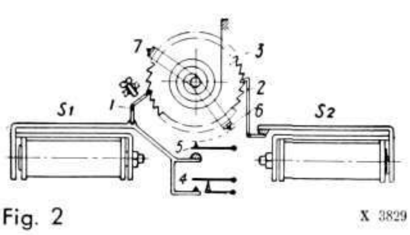


Fig. 2 X 3829

Diagram sketch of two-magnet selector

S_1 stepping magnet
S_2 holding magnet
1 driving pawl
2 holding dog
3 step wheel
4, 5 contact springs
6 wiper for individual call
7 wiper for general call

The selector consists of two magnets, a step magnet *S1* and a blocking magnet *S2*, these two acting on a step by step mechanism, Fig. 2. The step magnet acts on a driving pawl *1*, a contact spring *4*, which closes a circuit to the blocking magnet's winding, and another contact spring *5*, which closes the ringing current circuit. The holding magnet, which is connected in when the step magnet is operating, acts on a holding dog *2*. When the step magnet has been brought to operate and release alternately, a step wheel *3* is moved forward; when *3* has reached a certain position, the calling position of the selector, the wiper *6* attached to the wheel acts on the contact spring *5* so that the ringing current circuit is closed. The ringing signal is produced by the last impulse from the central relay equipment being automatically prolonged

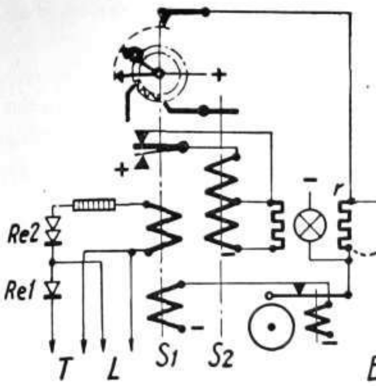


Fig. 3
Diagram of selector set

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

to 3 or 4 s, during which time a galvanic bell is rung. The step magnet has two windings, Fig. 3, one of which is connected to the selector line and receives the impulses which move the step wheel forward step by step. The other winding transmits part of the ringing current inductively to the selector line, which enables the train dispatcher to hear that the ringing signal has actually been transmitted. The holding magnet also has two windings, which are connected in such a way that the magnet is delayed acting, with the result that it remains energized when the step magnet is released in the intervals between impulses. This delayed action is due to the fact that one of the holding magnet's windings is short-circuited when the step magnet is released. When an incoming train of impulses actuates the step magnet a local current circuit is closed from a 4.5 V dry battery to the holding magnet, so that this is energized whereupon the step wheel moves forward. The step wheel is provided with a spiral spring which seeks to restore the wheel to home position, this being prevented, however, during impulsing by the holding dog *2*. In this way the selector moves forward the number of steps corresponding to the number of impulses.

All extensions are called by two-digit numbers, this being possible because the step wheel is automatically held in a certain position depending on the call number, so that it is prevented from returning to home position in the intervals between the two trains of impulses. The mechanical holding device consists of an adjustable stud on the step wheel, which in one position holds the holding magnet's armature energized, in spite of the magnet winding being without current. Thus, if the call number for an instrument be *76* then after the first train of impulses the step wheels are held in all instruments with a first digit *7*, while all the other step wheels return to home position. When the subsequent train of impulses is sent out by the line equipment all the selectors are stepped forward further, but only instrument for *76* is rung. After ringing signal all the step wheels are restored except those which had been held after the second train of impulses. These selectors are disconnected by a special clearing impulse.

It is frequently required to call a whole group of extensions or all the extensions simultaneously. Such calls are designated group call and general call respectively. For this purpose the step wheel of the selector is provided with still another wiper *7*, Fig. 2, which connects a calling circuit when the extension group number or the general call number is dialled.

Systems

Train dispatching plants are utilised in very different manners by different railway administrations and to meet varying requirements Ericsson has produced two distinct systems.

In the more simple of the systems, ATA 50, Fig. 4, the extensions are called by means of an ordinary dial in the train dispatcher instrument; there is no

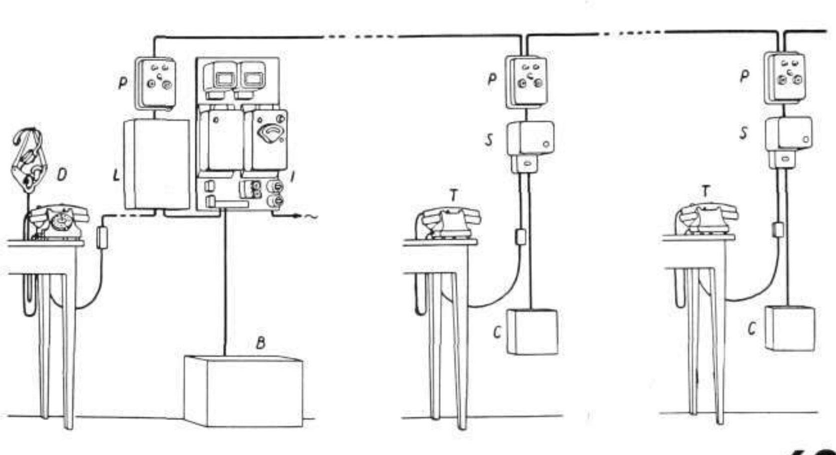


Fig. 4
Train dispatching plant ATA 50

left, equipment at the train dispatcher station, right, equipment at two extensions
B, C batteries
D train dispatcher's instrument with speaking set
I power panel with rectifier, relays, charging control, fuses and switch
L line equipment
P protection and sectioning device
S selector set
T telephone instrument

joint traffic with other telephone plants. An installation on this system comprises only one selector circuit.

In the system ATA 60 the extensions are called by means of a key-set in the train dispatcher's instrument. The system is in the main built up in the same manner as system ATA 50, but the train dispatching equipment and the relay set are of different construction. Joint traffic may be arranged with an automatic telephone exchange, to which the train dispatcher's instrument is connected over an ordinary subscriber's line. To make a call in the automatic telephone exchange the train dispatcher's instrument is also provided with an ordinary dial. An installation on this system may comprise up to three selector circuits and one connecting circuit to the automatic exchange.
The equipments for the extensions are precisely the same in both these train dispatching systems.

Fig. 5 X 3919
Train dispatcher's instrument DHH 1001
for train dispatching system ATA 50

System ATA 50

In system ATA 50 the *train dispatcher's equipment* comprises a telephone instrument DHH 1001 and an additional speaking set consisting of breastplate transmitter and head-gear telephone. Occasionally the equipment is supplemented by a loud speaker or a loudspeaking telephone, which may even serve as substitute for the breastplate transmitter and the head-gear telephone. The train dispatcher's instrument, Fig. 5, is a modern table instrument with bakelite case and provided with connecting jack for the additional speaking set, which last is fitted with the necessary plug so that it is simple to connect to the train dispatcher's instrument.

The train dispatcher's instrument receives its current feed from the line equipment battery. The transmitter is provided with a key that is kept pressed while speaking. The breastplate transmitter is of the standard type, receiving current when the microphone is raised. The head-gear telephone is always connected on the selector circuit while the handset is in place. When the handset is lifted the head-gear telephone is disconnected, but may be connected in parallel with the handset by pressing the key on the train dispatcher's instrument. The calling device in the instrument is a buzzer.

The train dispatcher's equipment may be employed in various ways according to the nature of the traffic. For small traffic, consisting of short communications between the train dispatcher and the extensions, the handling of the conversations may be done with the handset alone, the extra telephone set then being superfluous. If, however, the train dispatcher is to receive or give long reports, necessitating that his hands be free to write, refer to time tables etc., it is more convenient to employ the breastplate and the head-gear.

The *line equipment* BDL 5301 consists of a relay set mounted in a grey-enamel sheet metal case, Fig. 6. The purpose of the line equipment is to receive the calls from the extensions and transmit them to the train dispatcher's instrument and, for calls from the train dispatcher, to convert the dial impulses into operating impulses at comparatively high tension, which act on the connected selectors.

A line relay constitutes the call receiving device and this is connected to the selector line as long as the plant is not being used for calls. This relay may be made sensitive for calls over selector lines with high resistance. Immediately a call comes the supervision of the line is taken over by another relay, this having adjustable windings so that it may be adapted to the electrical properties of the selector line and thus ensure high sensitivity.

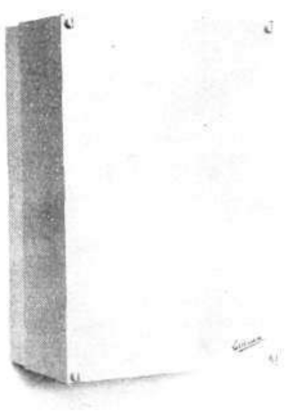


Fig. 6 X 3920
Line equipment BDL 5301
for train dispatching system ATA 50

The dial impulses from the train dispatcher's instrument are converted into operating impulses by an impulse relay which works in time to the dial impulses and for every pulse the relay connects impulse tension to the selector

Fig. 7 X 5546
Train dispatcher's instrument DHE 1001
for train dispatching system ATA 60

line over a filter which cuts off the high harmonics of the impulses. Consequently no sharp noises arise in a telephone connected in during impulsing, such as when the train dispatcher is connecting a call between two extensions. In addition the filter creates balance on the selector line during impulsing so that noises do not arise in telephone circuits running parallel.

System ATA 60

The *train dispatcher's instrument* for this system is the DHE 1001, fitted with connecting jack for an extra speaking set consisting of head-gear telephone and breastplate microphone. The train dispatcher's equipment may, as with system ATA 50, be supplemented by a loud-speaker or a loud-speaking telephone. The train dispatcher's instrument, Fig. 7, is an up-to-date table instrument with bakelite case, fitted with operating switch, a call lamp and a clearing signal lamp for each selector line. The operating switches each have three positions, *viz:* »off» position, position for answer and call and a position for connecting up two selector circuits or one selector circuit and a circuit from the train dispatcher's instrument to an automatic exchange.

To call the extensions the train dispatcher uses a set of ten white keys. A call is made by pressing in turn the two keys for the ten and the unit digit in the call number. As the keyset is common to all extensions, there is more flexibility for enlarging the installation than would be the case were there a separate key for each extension on the train dispatcher's instrument. There is a red cancelling key to break off the impulsing if the key for a wrong number has been pressed.

A red control lamp lights during impulsing. As soon as the light goes out a fresh call may be made. By pressing a black key the ringing of an extension may be prolonged indefinitely. A buzzer in the instrument acts as acoustic calling device for the selector lines.

The line to an automatic exchange is equipped with a white knob for marking answer and call, and there is a green knob for connecting the automatic line to a selector line. Call to the automatic exchange is made by means of the dial and this also serves as reserve for the keyset. The calling device for the automatic line is a polarised AC bell located on the wall alongside the connexion rose of the instrument.

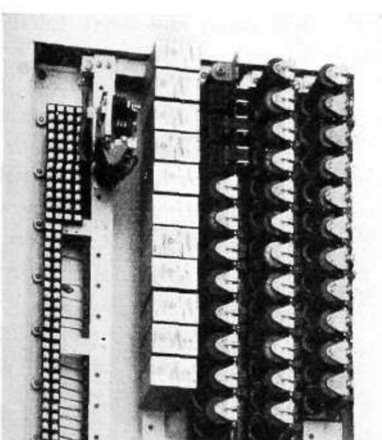


Fig. 8 X 3921
Line equipment BDL 7501
for train dispatching system ATA 60

The *line equipment* BDL 7501, Fig. 8, comprises considerably more relays than equipment BDL 5301. Not only are the line relays more numerous but

Fig. 9 X 5545

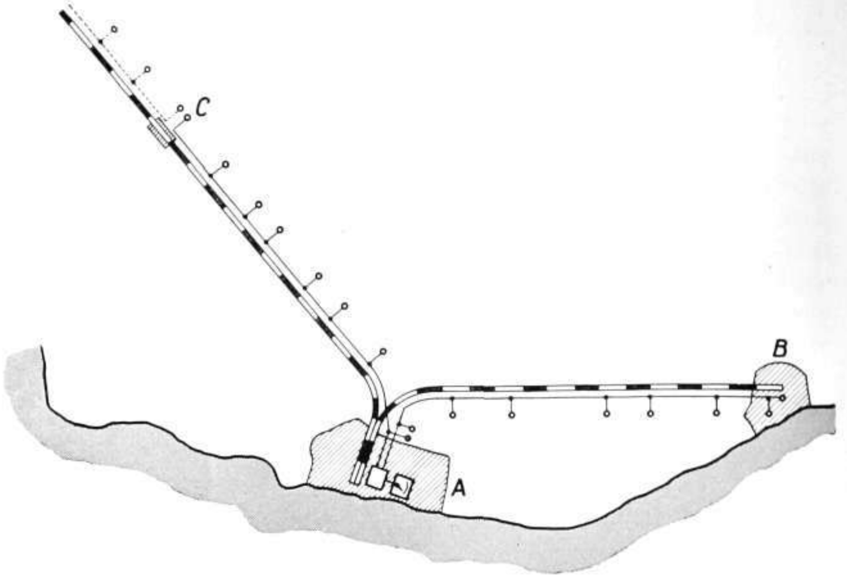
Common train dispatching for separate selector circuits

traffic on the two track sections AB and AC is supervised and directed by a single train dispatcher at station A

□ train dispatching equipment

[L] automatic telephone exchange

extension



there is a number of relays operated from the keyset in the train dispatcher's instrument. Along with a selector these check that the number of impulses transmitted to the line correspond to the figure pressed on the keyset.

It frequently happens that one train dispatcher has to attend to the supervision of two or more track sections, see Fig. 9, and in such case it is often advisable to provide the different sections with separate selector circuits, while the train dispatcher has a common operating equipment. This allows of longer selector circuits with a larger total number of extensions than would be the case if all the lines were combined in one.

If the railway is not well supplied with telephone circuits, it is possible for the train dispatcher plant to be utilised at times for a certain amount of traffic between the extensions. In such case more call facilities are available if the selector circuits are separate; the train dispatcher can be receiving or giving reports on one line while an internal call is proceeding on another. Calls may be exchanged between two selector circuits or between one selector circuit and the automatic exchange at the train dispatcher station.

Extensions

Each extension consists of a selector set OV 1102, a telephone instrument DHK 1001, a protection and sectioning device ND 10101 and a dry battery for feeding the selector set and the telephone instrument.

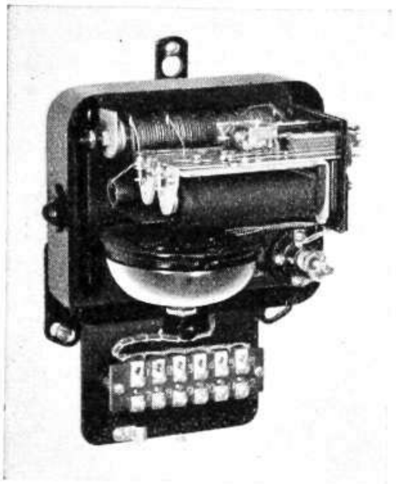


Fig. 10 X 3835

Selector set OV 1102

top, rectifier; middle, selector; below, bell, lamp and terminal block

The selector set OV 1102 is of the same construction as that in the Ericsson decentralised selector system, see Fig. 10. It contains the selector and the rectifiers together with a DC bell connected in parallel with a 4 V metal filament lamp, all mounted in a black enamel case with a red window in front of the lamp. This serves as visual calling device and prevents the bell from giving a signal during the brief instant that contact making occurs as an operated selector passes its own calling position. The bell is shortcircuited by the lamps as long as the lamp is cold and has low resistance. It is only when the lamp begins to glow, *i.e.*, when it has been under tension for appr. 0.5 s, that its resistance is high enough for the bell to ring.

The telephone instrument DHK 1001 is a table instrument in bakelite for local feed, Fig. 11. Its only difference from the DHK 1101 instrument used for the Ericsson decentralised system is that there is no dial. The transmission properties of the instrument are very good, despite the fact that the instrument impedance for an instrument in speaking position is comparatively high in order to keep down attenuation to allow for group calls. The impedance for an instrument in speaking position connected up with a selector set is

Fig. 11 X 3922
Telephone instrument DHK 1001
for extension

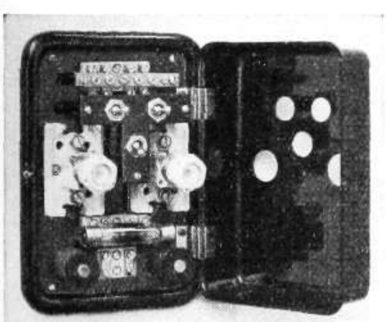


Fig. 12 X 3840
Line protection device ND 10101
top, terminal block with spark quench; middle, sectioning switch and fuses; below, rare gas valve and chokes

approximately 1 750 ohms, ÷ 23° at 800 c/s. The impedance for a telephone instrument and selector set at rest is about 0.75 megohm for voice frequency. The attenuation in an extension at rest, therefore, is very low and in no circumstances exceeds 0.01 neper.

Conversations between several extensions are often disturbed both because of the attenuation occurring when a number of instruments in speaking position are connected to the same circuit and also because disturbing noise at the places where the extensions are installed may be transmitted to the selector line by the microphones. Ericsson therefore also makes telephone instruments with key in the microphones for connecting the microphone current. These instruments are specially designed for selector plants where group calls occur frequently.

By having the telephone instrument and the selector set built as separate units, it is possible to employ the same telephone instrument for a number of selector circuits arriving at the same station. In such case each circuit has its selector set, while a single telephone instrument is employed for all the circuits. Switching is done by the switch RL 5001 for up to ten circuits, or switch RL 201 for two circuits.

Even when the selector circuits coming in to one station are of different kinds, i.e., circuits for system with decentralised selection and for train dispatching system, the same telephone instrument may be used for all the circuits together. Then, however, the instrument must be fitted with dial and DHK 1101 would be used. The telephone instruments DHK 1001 and DHK 1101 are both provided with fixed connexion roses, but similar instruments are available for connection with plug and jack, which is frequently a great advantage. There is, for the train dispatching system as for the decentralised selector system, a portable telephone instrument with selector set and battery built in.

The protection and sectioning device ND 10101, Fig. 12, contains pointed lightning protector, fuses, rare gas valve and chokes, together with three switches by which one or the other section of the circuit and the extension may be cut out. The protection afforded by this device is very good and it facilitates fault location on the line.

Current Feed

To provide current for the selector set and the telephone instrument a battery of 3—4.5 V is required for each extension. Best suited for the purpose are three bell batteries of 1.5 V, housed in a battery case BKY 1002.

The train dispatching exchange requires a power plant consisting of a distribution panel, a 24 V storage battery of 6—16 Ah and possibly a 150 to 200 V dry battery as emergency reserve. The distribution panel comprises for AC mains a rectifier and for DC mains a charging resistance — with automatic control device for charging the storage battery, a rectifier or a resistance with switching and protection relay to deliver impulsing current, together with switch, fuses and a terminal block. In the event the mains tension fails the emergency battery is automatically connected in by the switching relay. The protection relay comes into action if a shortcircuit occurs on a circuit while impulsing is proceeding. The relay then increases the resistance in the impulse circuit and closes an alarm circuit.

Impulse Repeating

It is generally the operating range of the impulses and not the speech attenuation that limits the length of the selector circuits. In order to allow of lines as long as possible, taking account of the attenuation, Ericson makes an impulse repeater BDL 3301. It consists of a relay set mounted in a grey enamel case. The impulse repeater requires a power plant similar to that at the train dispatching exchange.

Police Signalling System

G. BERGH, TELEFONAKTIEBOLAGET L. M. ERICSSON, STOCKHOLM

In recent years signalling plants and signalling systems have been adopted for a wide range of purposes. Even in police work they have proved an accessory of great utility when employed for ensuring greater efficiency and equalisation of labour. The ever increasing tasks laid on police authorities have led to increase in the need for men such as could only partially be satisfied, and in the circumstances it has been necessary to resort to all available technical appliances. For some years now a number of large towns in different countries have been making use of a police signalling system providing communication between police stations and the patrolling constables. Installations of this kind working independently have proved comparatively expensive, though they have been found to contribute very much to improvement in reporting and keeping contact.

Ericsson has produced a police signalling system enabling a police signalling plant to be installed at comparatively small expense as a complement to a fire alarm plant on the supervisory current system. Thanks to this, it is now possible for even small communities to install police signalling plants, since the cost is insignificant compared with that for a separate system.

A modern fire alarm plant on the supervisory current system consists of a central instrument to which one or more outgoing line circuit loops are connected. In these loop circuits fire alarm boxes are connected, located at various places in the area. The fire alarm boxes are fitted with signalling mechanism for the transmission of fire alarm to the fire station. To facilitate test and fault location the fire alarm boxes are as a rule provided with built-in telephone instruments, allowing of communication with the fire station. These telephone instruments are mounted in the box in such a manner that they can only be used by persons holding keys to the boxes. Moreover the telephone equipment in the older types of fire alarm boxes are hardly suited for use by the ordinary public, partly because a special handset is employed and partly because the telephonic communication is not of the best quality.

Fig. 1 X 5564

Police and fire alarm box

top, fire alarm box with usual equipment; below, police box with telephone instrument

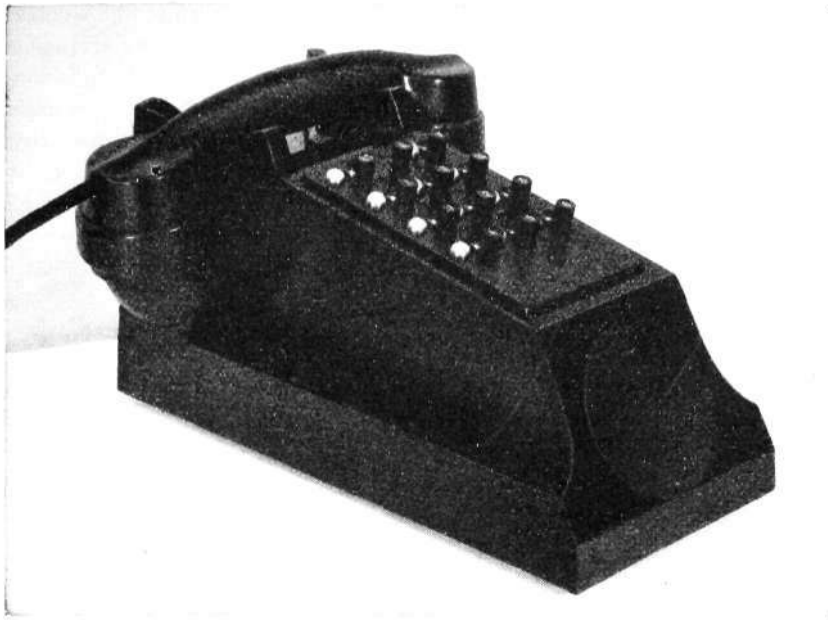


Fig. 2 X 5565
Telephone instrument for police station
with signal lamps and answering keys

The fire alarm box recently designed by Ericsson, the police and fire alarm box, is much superior in design to those hitherto on the market. The box consists of two sections mounted together. In the upper section, the fire alarm box, which is red enamel, there are fitted the signalling mechanism of Ericsson standard type, the connecting terminals for incoming lines and the rare gas protection, this last eliminating the danger of flash-over in the signal mechanism contact springs in the event of violent lightning discharges. The lower section of the box, the police box, is black enamel and contains the telephone appliance and rare gas lightning protector against atmospheric discharges and in addition has a space for a relay to give flash signals in the lamps mounted above the boxes. The telephone equipment includes Ericsson standard bakelite handset which in combination with a special telephone connection gives very good speech transmission, so that it may be used by the public for telephone communication with the police station or the fire station.

The door of the police box has a handle which is normally kept sealed. When the handle is turned anti-clockwise the seal is broken and the door may be opened, whereupon a telephone call is sent out automatically. It causes a resistance to be connected momentarily in to the circuit loop, thus weakening the supervisory current. A relay, connected in series with the supervisory current relay at the central exchange, is released by this and transmits a call signal over a special circuit to the police station exchange, causing a signal lamp to light up there indicating the district from which the call comes. The person on duty at the police station then presses the answering key belonging to the lighted lamp and comes into communication with the calling box. Such a telephone call to the police station does not operate any bell or lamp at the fire station, but passes through it without disturbing the staff there. Nor is it possible for a call between the police and fire alarm box and the police station to be overheard at the fire station.

The police box door may be opened with a special key for service calls by firemen or policemen. In such case the seal on the handle is not broken, nor does any call go out, as the key acts on a spring set which shunts the calling device. After the door has been opened it is possible to obtain telephone communication with the fire station by pressing a special key located behind a shutter. This earths the line and breaks the circuit for a moment and in this way a telephone signal is received at the fire station. If communication with the police station is required, then the key acted on by the door is pressed, causing call signal to go direct to the police station in the manner above described.

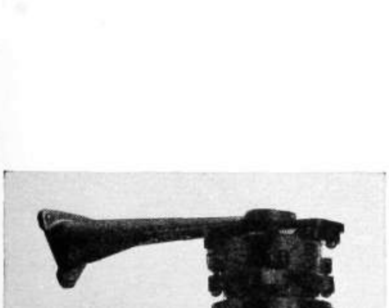


Fig. 3 X 3932
Signal lamp
with lens for emitting flash signals

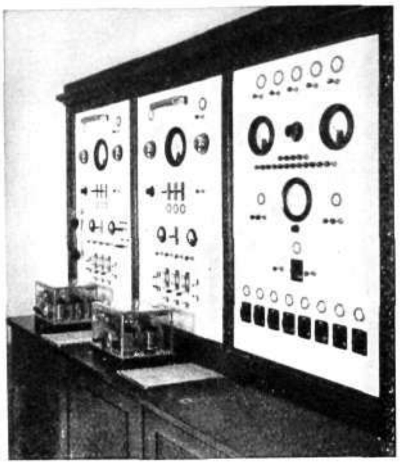


Fig. 4 X 3933
Central equipment at the fire station
left, two line panels; right, charging and instrument panel

To enable the plant to be employed for sending out call signals to patrolling constables, signal lamps are mounted above the boxes, these burning day and night and indicating the position of the boxes. When an answering key is pressed at the police station exchange a reinforced current impulse is transmitted on the corresponding circuit loop from the exchange. This impulse energises the call relays in the police boxes, which are then attracted and mechanically locked. When the relays attract, they close circuits in the boxes concerned to mercury relays which are connected to the signal lamps above the boxes in such a manner that the lamps make flash signals. When the key at the police station exchange is pulled out again there goes out on the loop a current impulse the same as before but in reverse direction. This operates another relay in the boxes, which releases the mechanically locked relays and these return to home position. The lamps then cease to flash and once more burn with steady light. To enable the call signals to be visible in daylight as well, the signal lamps above the boxes are equipped with a lens arrangement.

The equipment required at the police station consists of a telephone instrument with keys and signal lamps and the necessary relays. If the distance between the fire station and the police station is more than 500 m, a 24 V storage battery and a rectifier are also required.

At the fire station exchange there are required a relay set, a key and a lamp strip, as also a rectifier or a battery for the reinforced current impulses that actuate the call relays in the police and fire alarm boxes.

Mine Rescue Telephone

R. C. WOODS, ERICSSON TELEPHONES LTD, LONDON—BEESTON

The Coal Mines General Regulations 1911 require owners of mines to which the regulations apply, to make definite provision for rescue work in mines after an explosion, fire or other accident. Telephone communication between the rescue brigade and its base is obviously of considerable importance. Ericsson Telephones Ltd in collaboration with the Mines Department Testing Station have constructed a Mine Rescue Telephone which was officially tested and certificated on 18th June 1938, after which the production was immediately undertaken.

When a rescue corps is called to a mine and commences operations, a base is established as soon as possible in fresh air but as near the irrespirable zone as possible. Often the existing mine telephone system will provide for the communication between the base and the surface or the shaft bottom, or an instrument can be connected on to a line.

For communication between the rescue brigade and the base, however, greater difficulties exist. As the brigade or team, of five to eight men, will be wearing breathing apparatus, speech is impracticable and communication has to be established by other means. Uniform codes of signals are prescribed, one for use between members of a brigade, for which each man carries a bulb hooter, and one for electric signalling. Each code consists of five simple signals only. While the existing mine telephone system may provide for the telephone communication between the rescue corps and the base, it cannot be depended upon and it would but rarely prove convenient, speech not being practicable owing to the breathing apparatus.

The mine rescue telephone constructed by Ericsson Telephones Ltd, Fig. 1, consists of two units, a base station and an advance station, connected continuously by a light but tough cable. In the constructional features of the design, particular attention has been paid to strength with low weight and to making the equipment convenient to carry and handy to operate, so as to add as little as possible to the arduous task of the rescue party. Both the case of the base station and the frame of the advance station are cast in aluminium-silicon alloy to obtain a robust yet light housing for each unit.

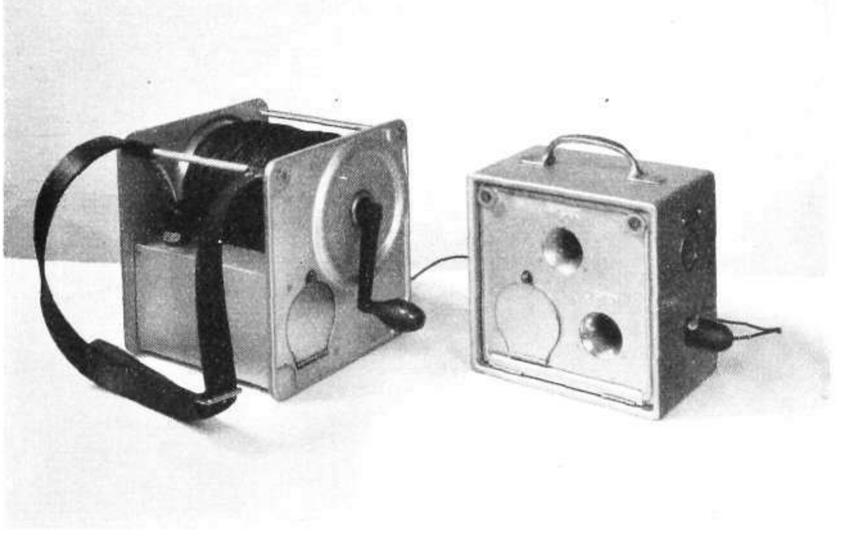


Fig. 1 X 5562

Mine rescue telephone

left, advance station unit with cable drum for the advance party, right, base station unit

Signals in both directions are effected by buzzer, using the code set out in the regulations. The note is distinct and penetrating, the comparatively high frequency avoiding any chance of confusion or obliteration by other noises. In addition the base party can speak to the advance party, both speech and signals being received on the loud speaker at the advance station unit. Key signalling only is provided from advance party to base. Many considerations were reviewed before deciding to limit to key signals only from the advance party. Among these may be mentioned technical considerations of efficiency, increased weight and cost, and the reduced mobility of the advance party if both-way speech were provided. When oxygen breathing apparatus is worn, clear and reliable speech is not practicable. Even if special transmitter and receiver were fitted, as smoke helmets would permit, the use would tend to be restricted to one man and would probably need the services of an extra man in the advance party.

The base station unit is about 24 cm square with a depth of 16 cm. The weight is 7 kg. On its front is fitted a sensitive transmitter, a small loud speaking receiver and a high-frequency buzzer. Provided in the buzzer mounting is a small key which when depressed connects the buzzer, via the induction coil, to the adjacent receiver, so that the former can be tested to confirm that signals are being sent out. A convenient handle provides for adjustment of the buzzer when the test indicates this to be desirable. A hinged metal flap protects test key and adjustment handle from dust and accidental damage. On the left of the unit is a »speak» key which must be operated to speak to the advance party. This connects the transmitter battery and at the same time disconnects the local receiver circuit, thus ensuring the highest efficiency of operation. To be seen on the right hand side is a similar key for calling the advance station. This operates the buzzer and a high-note call is transmitted via the induction coil. As this coil transmits both speech and signals no direct current is passed to line. The keys are sealed, against the entry of dust, by flexible leather diaphragms. When the keys are in their normal position the loudspeaking receiver is connected directly to the trailing cable and hence to the advance station unit. Any signal sent out by the advance party is thus immediately reproduced by this receiver.

The line cable is connected by plug and socket on the right of the case. This cable is of special design having a composite conductor of copper and steel with tough, impregnated insulation.

Fig. 2 X 5563
Advance party about to commence operations

The strong alloy frame of the advance station unit bears the cable drum and the totally enclosed case containing the communication apparatus. The size is about 180 cm^3, and the weight, with a full reel of 250 m of cable, about 12 kg. Particular attention has been directed to producing a form as convenient as possible to carry, easy to operate and immune from minor mechanical damage, so that the advance party enjoy the advantages of communication without having their activities impeded. During the advance, while the cable is being unreeled from the drum, the line is continuously connected to both sets and speech and signals can be transmitted. The communication apparatus is similar to that of the base station except that no transmitter is fitted. The same facilities for test and adjustment of the buzzer are also provided.

The batteries are of the ordinary cycle lamp type so that replacements of the correct type are readily obtainable. To cover the possibility of use abroad under tropical conditions, approval has been given to the alternative use of a standard type of inert cell. Battery voltages are 6 V and 3 V respectively for base and advance party units. The safe operation of the system in dangerous atmospheres is a feature of the electrical design. The high sensitivity obtainable with a good receiver is used to advantage and, by combining high note buzzer signals with speech, there is no direct current flowing in the line. The line currents themselves are of small dimensions, incapable of producing ignition in the most dangerous of atmospheres. As regards the local circuits at each unit, the buzzers are fitted with non-inductive shunts and with condensers: as an additional safeguard the induction coil primary of the base unit has a safety shunt provided.

If during rescue operations it is desired to extend beyond the first cable length, a further advance party instrument can be connected by a simple plug and the circuit transferred from the first to the second unit.

Ericsson Technics

Ericsson Technics No 2, 1939

Sigurd Kruse: Theory of Rectifier Modulators

The purpose of the present work is to study the performance of rectifier modulators in a more detailed and exact way than is possible with the commonly used »commutator theory». The actual rectifier curve $i = f(v)$ is taken as starting point. The voltage across the rectifier is composed of the carrier voltage on which are superimposed the modulating voltage and the voltages of the modulation products. The carrier voltage is assumed to be a periodic function of time but otherwise arbitrarily shaped. The function $f(v)$ is developed in a *Taylor*'s series with the superimposed voltages as increment. If the modulator is to work without non-linear distortion, the increment must be so small that the terms of the first power in the series dominate. The equations relating the input and output currents and voltages of the modulator are thus transformed into a system of linear equations in the modulating and modulated currents and voltages, the coefficients of which are functions of the carrier voltage. When the latter is known as a function of time, the coefficients may be developed in *Fourier*'s series. A simple rule for the calculation in vectorial form of the modulation products is derived and used to transform the original equation system into a system of linear vector equations having constant complex coefficients. Thus the modulator may be considered as being a linear multi-terminal network. The properties of the system of equations are examined and a theorem of conjugate reciprocity of the modulation products is established and proved to be valid under certain conditions. The general expression for the effective attenuation of the transmission from the source of the modulating current to an arbitrary modulation product is established. The dimensioning of the modulator with a view to obtaining minimum effective attenuation is determined in a few cases of practical interest and the multipole properties of the modulator are examined.

The theory developed for a ring bridge modulator is applied to other types of rectifier modulators, and a few examples are treated numerically and graphically. In the appendices, the matrix of the system of vector equations is studied and a few methods of harmonic analysis of the various functions are indicated.

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CONTENTS

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Electrical Measuring Instruments

R. LUNDQUIST, TELEFONAKTIEBOLAGET L. M. ERICSSON, STOCKHOLM

The manufacture of electrical measuring instruments, as now carried on by Telefonaktiebolaget L.M. Ericsson, comprises in the first place instruments with the more simple measuring systems for current and voltage measurement of DC and AC. Moving coil instruments and moving iron instruments are made as ammeters and voltmeters, for various ranges of employment, e. g., motor cubicle instruments, large panel instruments for wireless and signalling purposes, marine instruments and so on.

To provide for all ranges of employment two sizes have been made of the two measuring systems, the moving coil systems and the moving iron systems. The moving coil systems are intended only for DC measurements, though by the addition of rectifiers they may also be used for measuring AC. The moving iron systems are for both DC and AC measurements.

Moving Coil Systems

The *large system*, Fig. 1, has permanent magnet of tungsten steel and pole pieces of special malleable iron. The pole pieces enclose an aluminium frame holding the core and the moving coil. The pointer, springs and shaft ends fit in the moving coil. The moving coil has point bearing, with shaft ends of hardened steel working on synthetic sapphires.

The system is furnished with adjustable restoring device for correcting the pointer's zero position. Deflection of the pointer is about 80°. The requisite damping is obtained by means of the counter-EMF arising in the short-circuited aluminium frame as it moves in the magnetic field. The current is transmitted to the moving coil by two spiral springs of copper-bronze or phosphor-bronze.

The system may be made for current intensities from 30 μA to 10 mA with direct connection to the moving coil and from 10 mA to 5 000 A by the connection in parallel of shunts, Fig. 2. As a voltmeter the system may be connected to voltages from 20 mV up to 1 500 V over limiting coils.

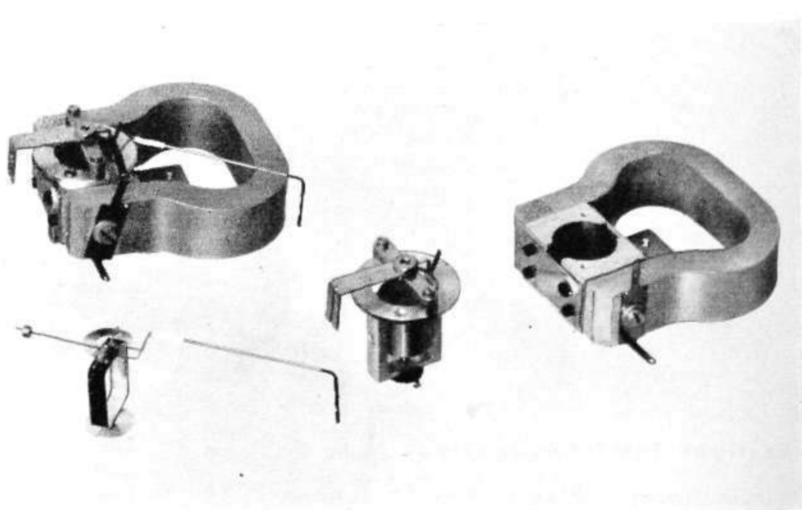


Fig. 1 X 5556

Measuring system for the large moving coil instrument

top left, complete; below, moving coil, frame and magnet

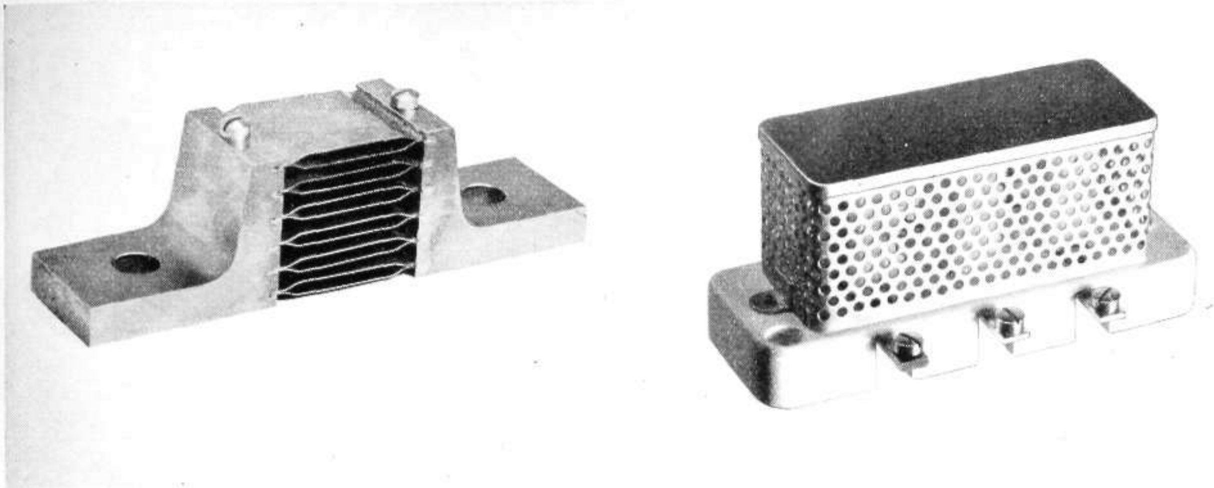


Fig. 2
Shunt and limiting coil

X 7199

The error is normally ± 1.5 % but may by special adjustment be improved to ± 0.2 % of full deflection. The moving coil ammeters for connection to separate shunts are calibrated for about 60 mV voltage drop. The voltmeters may be supplied with various internal resistances; the normal figure is 150 ohm/V, equivalent to 6.67 mA current consumption. They may, however, be supplied for smaller current consumption, *e. g.*, 1 mA, corresponding to an internal resistance of 1 000 ohm/V.

The *small moving coil system*, Fig. 3, is provided with permanent magnet of cobalt steel, one of two qualities being used according to the range for which the systems are to be employed. The actual difference between the large and the small moving coil systems is, as far as design is concerned, that the magnet in the small system has not loose pole pieces — for convenience in manufacture — the two ends of the magnet being shaped into pole shoes, between which the frame with core and moving coil is inserted. The journalling is the same as with the large system, that is with point bearings. The pointer deflection is about 80° and the system is provided with zero restoring device.

The small moving coil system may be made for current intensities from about 200 μA up to 10 mA with direct connection to the moving coil and from 10 mA up to 5 000 A by the connection in parallel of shunts. As a voltmeter the system may be employed for voltages from 60 mV up to about 600 V over limiting coil.

The error is normally ± 1.5 % of full deflection, but may be improved up to ± 0.50 % by special adjustment of the measuring system. The current con-

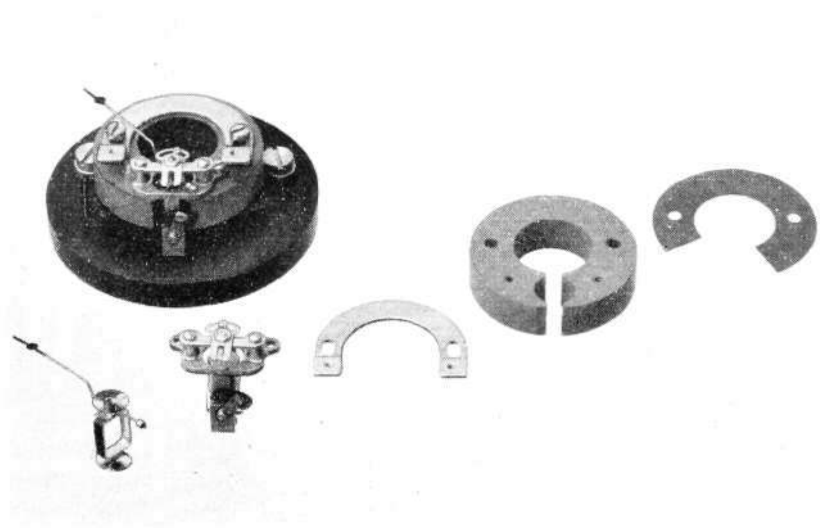


Fig. 3
Measuring system for the small moving coil instruments

X 5588

top left, complete; below, moving coil, frame, scale segment, magnet and insulation plate

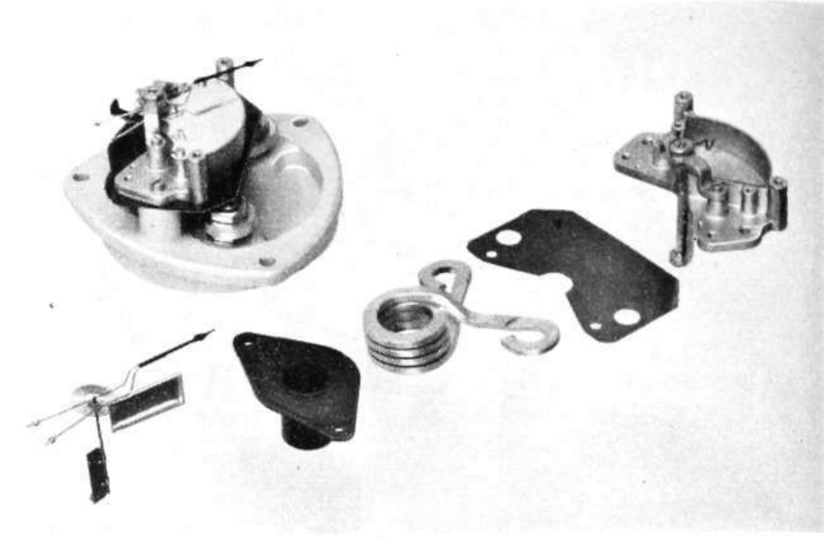


Fig. 4 X 5589
Measuring system for large moving iron instruments

top left, complete; below in row, moving system with pointer, damping vane, moving iron and spiral spring, field spring, field coil, winding, insulation plate and frame

sumption is 5 mA representing an internal resistance of 200 ohms for voltmeters and the voltage drop in ammeters with connection to shunt is 60 mV.

Moving Iron Systems

The moving iron systems are, like the moving coil systems, made in two sizes. The *large moving iron system*, Fig. 4, is intended for the measuring of AC and DC and consists of a frame of die-pressed aluminium alloy, the movement made up of a shaft, moving iron, spiral spring and pointer; and finally a field coil which encloses the moving iron and the fixed iron. The movement has a sapphire bearing. The pointer deflection, about 85°, is obtained by repulsion between the iron mounted on the shaft and the fixed irons which are fitted partly on the frame and partly in the field coil. By using different numbers of fixed irons different scale characteristics may be obtained, *e. g.*, whether the scale is to be as uniform as possible or is to be extended between certain points to provide facility within that special interval for more accurate reading. The system is provided with zero restoring device.

The oscillation of the pointer is checked by air damping obtained by a vane connected to the shaft oscillating in a closed damping chamber. The field coils, the frames of which are of pressed material, may be wound for the direct connection of currents with intensity from about 500 mA to 300 A, and in special cases up to 500 A, and for direct connection in series with limiting coils for voltages from 5 V up to 600 V, in special cases 1 500 V. For current intensities exceeding 300 A and voltages above 600 V the system should be connected over measuring transformers for 5 A or 110 V secondary respectively.

The error normally is ± 1.5 % of full deflection. The loss in the ammeters for 5 A is about 0.8 VA and for voltmeters about 4.5 VA with 110 V.

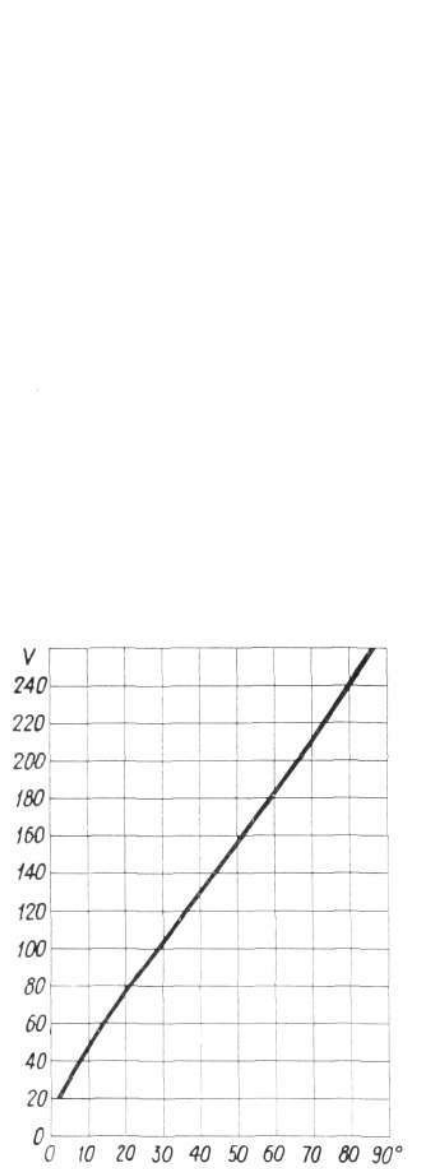


Fig. 5 X 3955
Pointer deflection as a function of the voltage

This moving iron system is characterised by good scale character, large adjustment facility, small dependence on frequency and high mechanical factor of efficiency. The scale divisions are almost uniform starting fom 10 % of nominal current or nominal voltage, as may be seen from Fig. 5. Specific adjustment facility, *i. e.*, the ratio between electro-magnetic torque and pointer deflection, constitutes a check on the instrument's sureness of adjustment; the higher the specific adjustment moment the more readily the pointer comes to rest at the correct point on the scale. As may be seen from the curve, Fig. 6, the large Ericsson moving iron system has very high and level specific adjustment moment at various voltages. From the curve, Fig. 7, giving error as function of the frequency, one can judge the low dependence on frequency of the measuring system, between 25 and 60 c/s.

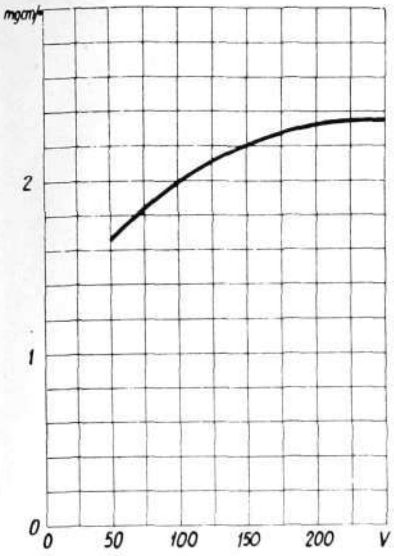


Fig. 6 X 3957
Specific adjusting moment for various voltages

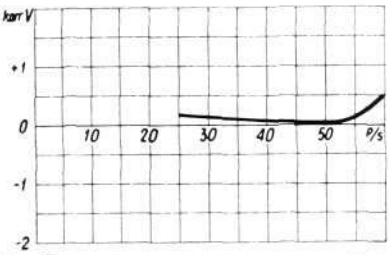


Fig. 7 X 3958
Error as a function of frequency

According to *Keinath*, the ratio between the torque necessary for 90° deflection and the weight of the movable system constitutes a measure of the instrument's mechanical efficiency. This »mechanical efficiency factor» has been calculated for Ericsson's large moving iron system at 1.11 %. This high figure means that the measuring system will stand vibrations and oscillation to a large extent. For purposes of comparison it may be mentioned that a factor of efficiency equal to 1.0 is regarded as good.

The *small moving iron system*, Fig. 8, is as regards construction a miniature of the large system, and like it has proved to possess very good mechanical and electrical properties. The field coils may be wound for connection of currents with intensity from 100 mA up to 50 A and for voltages from 5 V up to 600 V in series with limiting coils. For current intensities over 50 A and voltages above 600 V the system should be connected over measuring transformer for 5 A or 110 V secondary respectively.

The measuring accuracy is normally ± 1.5 % of full deflection. The system has low loss: in ammeters for 5 A it is about 0.45 VA and in voltmeters for 110 V about 3—3.5 VA. The small moving iron systems display to a large degree the same distinctive qualities as the large.

Construction

The moving coil and moving iron systems above described are fitted in large panel instruments, small panel instruments, panel instruments of curved type, marine instruments and motor cubicle instruments.

Panel Instruments

The *large panel instruments*, Fig. 9, have circular cases of pressed sheet-iron. They are made both for external fitting on the panel and for flush fitting. In the latter case they have a special flush fitting ring. Sizes of instruments, reckoned on the base-plate diameters, are 225, 185, 150 and 110 mm. In colour the cases are supplied in dull black. The cases are dust and splash proof enclosed.

All instruments have zero restoring screw at the front for adjustment of the home position of the pointer. The measuring accuracy of the moving coil instruments is ± 1.5 % — ± 0.5 % and for moving iron instruments ± 1.5 %. Test voltage is 2 500 V.

Ericsson's *curved front instruments*, Fig. 10, are intended for flush mounting only. The cases are cast of light metal alloy and are dust and splash proof

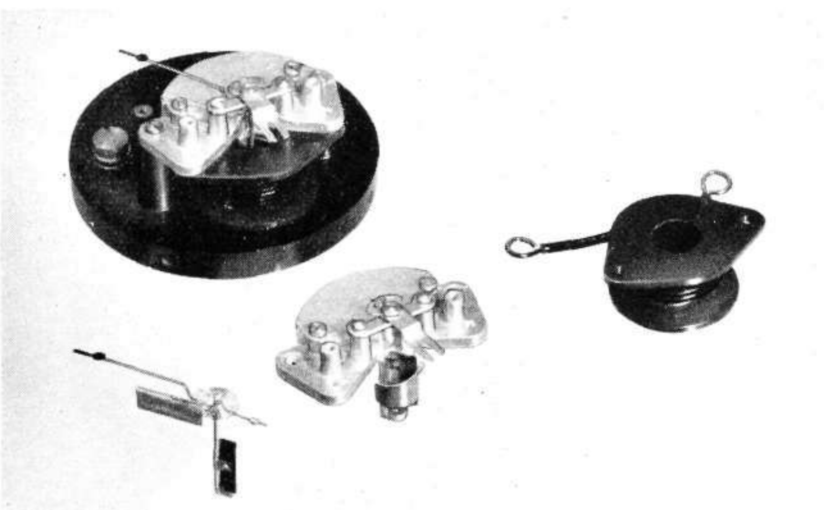


Fig. 8 X 5559
Measuring system for small moving iron instruments
top, complete; below in row, moving system, frame and field coil

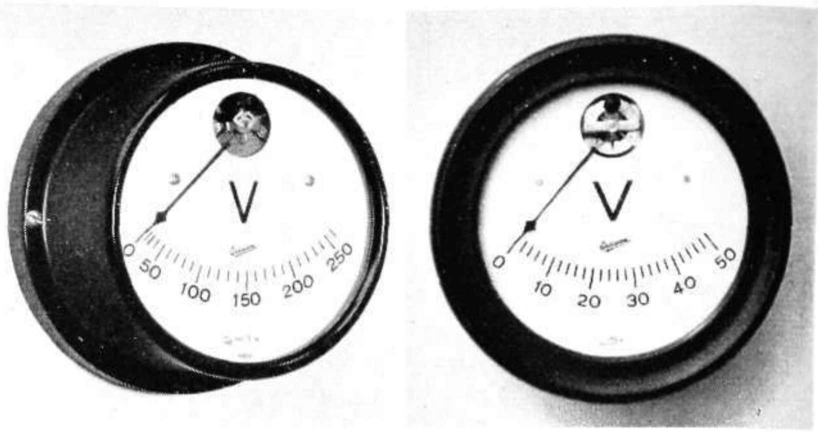


Fig. 9 X 5591
Panel instrument of large type
left, for external fitting; right, for flush fitting in panel

enclosed. The colour is dull black. The dimensions are 154 mm×70 mm over flanges. The curved front instruments may be mounted with the scale horizontal or upright.

The large panel instruments and the curved front instruments are fitted with measuring systems of the large type, with one exception, the panel instrument with 110 mm base-plate diameter for DC measurements only, this having the small moving coil system.

The measuring accuracy for both moving coil instruments and moving iron instruments is ± 1.5 %. Test voltage is 2 500 V.

Fig. 10 X 3959
Curved front instrument

Small Instruments

The small instruments, Fig. 11, are intended solely for flush mounting on panels, the sizes being 65 mm and 90 mm according to the diameter of flange. The cases are normally of black pressed compound. The small instruments are made only with measuring systems of small types.

These instruments also are provided with zero-restoring screw on the front. In addition they are provided with iron screen against disturbing action of outside fields.

The measuring accuracy for the moving coil instrument is from ± 1.5 % up to ± 0.5 % and for the moving iron instruments 1.5 %. Test voltage is 2 500 V.

Marine Instruments

The marine instruments, Fig. 12, have two kinds of case. One is designed for flush mounting with rear connections, the other for external mounting with front connection over a cable box. The instruments are watertight and made to meet the Swedish Admiralty stipulations; they stand an excess pressure of 1 at. As in preceding instruments the normal colour is dull black. The cases have a flange diameter of 195 mm.

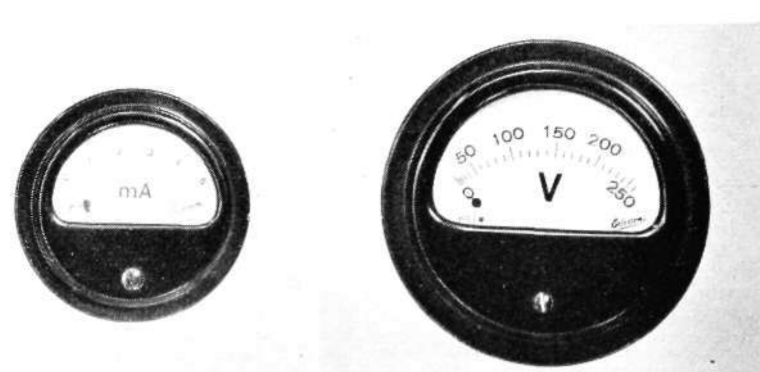


Fig. 11 X 5592
Small instruments

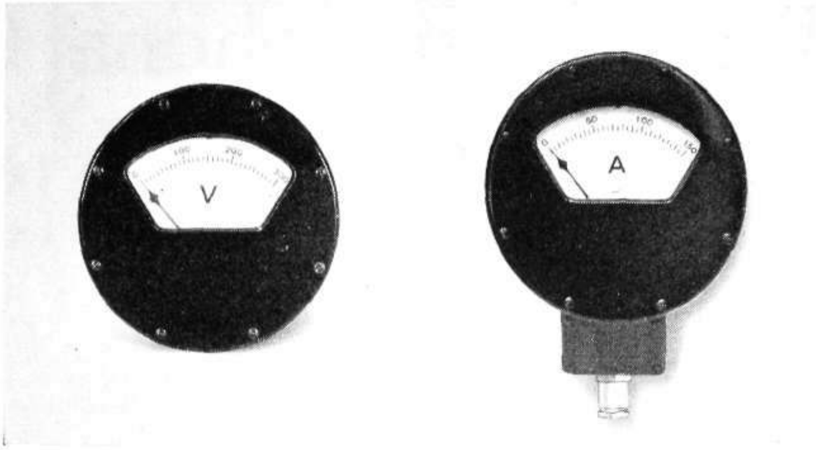


Fig. 12 X 5593
Marine instruments
left, for flush fitting, with rear terminals; right, for external fitting, with terminal connection in front over cable box

The marine instruments have the same systems and the same connection facilities as the large panel instruments.

The measuring accuracy for the moving coil instruments is ± 1.5 % and for the moving iron instruments ± 1.5 %. Test voltage is 3 000 V.

Motor Cubicle Instruments

Fig. 13 X 3960
Motor cubicle instrument

The motor cubicle instrument, Fig. 13, has a strong case of cast-iron and is made in six types; four with single system and two with double system. Usually the cases are enamelled in dull machine grey.

The scales for the ammeters have a contracted upper surge area. This surge area is provided to allow of momentary loads up to 300 %. The scale divisions begin at 10 % of the highest figure of the nominal range.

All the types of motor cubicle instruments are equipped with the large moving iron system for connection to DC and AC.

The measuring accuracy is ± 1.5 % and the test voltage 3 100 V.

Leading Telephone Cities of the World 1929—1937

A. LIGNELL, LATE DIRECTOR OF TELEPHONES, STOCKHOLM

It is of course natural that the leading telephone cities of the world should be found in America, since the United States of America occupy a predominant position in respect of telephones. The American Telephone and Telegraph Company and affiliated undertakings had on January 1st, 1939 — despite the temporary setback occasioned by the economic crisis of 1931—1933 — 49 % of the telephones of the world, though the number of inhabitants only amounted to 6 % of the total population of the globe.

The European countries had at the same date 37 % of the world's telephones with a population figure which represented 26 % of the earth's population. In the diagram, Fig. 1, the cities of the world with the highest telephone densities are shown in order and for some of them the variations in telephone density for the years 1929—1937 are also given. America lies at the top. Stockholm's position is foremost among European cities, being third in order in world statistics. Then come eight American cities and twelfth in order is Berne. Basle and Zurich have approximately the same telephone density as Oslo and Copenhagen. London displays 17.2 telephones per 100 inhabitants and has shown a sharp rise in recent years; unfortunately comparative figures for the years prior to 1936 are not available.

The average figure of 16.7 for all the Swedish towns together with the exception of Stockholm — 116 towns of widely varying sizes — is remarkably high. At the same time 54 American cities of more than 200 000 inhabitants had 21.97 telephones per 100 inhabitants.

The changes in the numbers of telephones per 100 inhabitants in the period 1929—1937 are given for five American cities and some European ones. The expansion in the case of the American cities has been affected to a great extent by the 1931—1933 economic crisis, while the curves for the European cities largely display progressive rise. Stockholm for the period 1929—1937 has a rise of 6 % and, if 1938 is included, 8.5 %. Basle shows up to and including 1937 the greatest rise in telephone density with 10.9 %, Berne and Zurich having 10.6 and 8.1 % respectively.

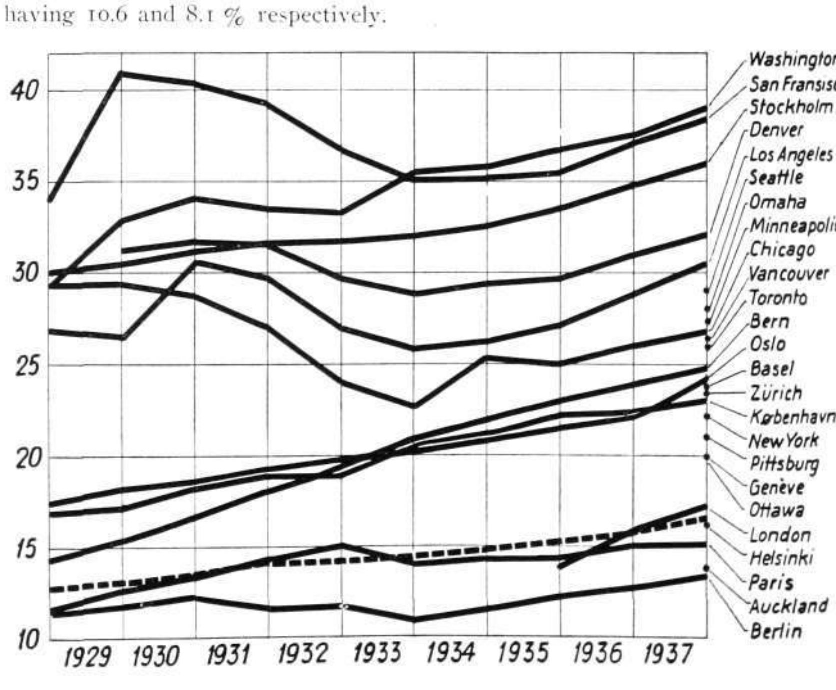


Fig. 1 X 5571
Diagram of the world cities with greatest telephone density 1929—1937
---- all the 116 Swedish towns besides Stockholm

New Interlocking Plant at Sundbyberg

H. DETSNER, TELEGRAPH & SIGNAL ENGINEER, STOCKHOLM–VÄSTERÅS–BERGSLAGENS RAILWAYS, VÄSTERÅS

Interlocking plants have long been in use on railways. Formerly mechanical interlocking plants predominated and these are still by far the most frequent, though in the last 10 to 15 years electrical interlocking has come more and more into use. With the electrical interlocking, a very much larger area may be controlled from one central point than with the mechanical plants; moreover, it is generally possible to handle current traffic requirements in a more flexible manner with electrical interlocking. It may therefore be said that the electrical interlocking plant usually finds its place at stations with a large and varying traffic distributed over the greater part of the 24 hours. Each individual case, however, provides its own problems which without exception require to be considered and solved in their own special manner. What follows seeks to present a rather general account of the special conditions at Sundbyberg and how the plant has been made to meet them, as well as what it was hoped to gain thereby.

The track arrangements at Sundbyberg are exceedingly restricted in relation to the comparatively large traffic that has to be dealt with. Parking space for rolling stock is rather limited and the location of the tracks is such that shunting must invariably be done on the train tracks. The station normally deals with a trains numbering some 90 per day, comprising about 60 suburban trains, 20 express and passenger trains and 8 goods trains. There are moreover at the station locomotive sheds and because of their location here, while the departure and terminal station for the long-distance express and passenger trains is Stockholm C (for goods trains Tomteboda Nedre), a number of single engines must be passed between Sundbyberg and these stations. At holiday times the movements at the station are augmented considerably, both because of doubling of trains and because the reversing of the passenger trains, ususally done at Stockholm C, must then be carried out at Sundbyberg. Shunting with shunting engines is proceeding throughout the day and moreover shunting is done with goods trains.

The station is situated on the 11.4 km long double track between Stockholm and Spånga. The interlocking area comprises in addition to Sundbyberg proper, three further traffic spots, namely Huvudsta, Huvudsta C and Sundbyberg N, an area covering 3.5 km in length. The boundary with the Stockholm C interlocking area is at Huvudsta.

Sundbyberg proper consists of two main sections, the passenger station with three train tracks and the goods station to the east of it. At Huvudsta, in addition to the double track to Tomteboda Övre there is junction over a single track for goods traffic with Tomteboda Nedre. At Sundbyberg N tracks branch off to factories in the neighbourhood, including the Ulvsunda industrial district. The double track is traversed in the interlocking area by four public roads, two of them constituting busy streets in the central parts of Sundbyberg. The level crossings are provided with crossing gates which in conjunction with the installation of the interlocking plant have been equipped with electrical operation, controlled from the central interlocking machine.

At Sundbyberg proper there were previously two lever mechanical interlocking machines about 30 years old. Line blocking with block-fields were arranged to adjoining control places and in addition there was station interlocking to the train dispatcher's office. Besides these two plants there were similar ones at Huvudsta and Sundbyberg N. The level crossing gates at Huvudsta C were controlled locally on the spot, the other gates from the nearest interlocking machine.

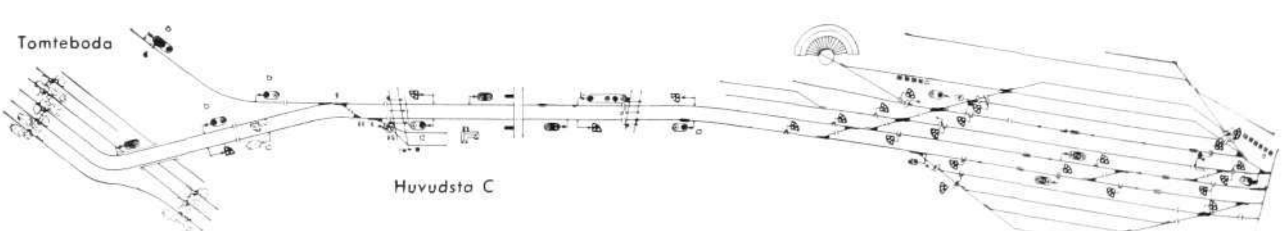
On account of the heavy employment during 30 years the mechanical plants had become completely worn out. Moreover the plants had from the beginning been of a rather primitive construction. An investigation made showed that fairly comprehensive and costly repair, replacement and extension work would be required to bring the mechanical plants up to a satisfactory state. On the other hand this work if carried out would mean keeping to the rigid mechanical system with its demand for more staff for a considerable time to come. In view of this it was questioned whether once for all a new electrical interlocking system should not be built, and after the necessary investigation this was decided upon. In view of the almost unlimited range of the electrical interlocking plant a number of attended places could be combined in one, thus saving expense and moreover advantages in regard to handling of traffic might be counted on.

Traffic

The first stage in the construction of the interlocking plant comprised Sundbyberg proper and Sundbyberg N. The plant was then extended to take in Huvudsta and Huvudsta C. As stated, factory tracks branch out to Ulvsunda and other places in the neighbourhood, on which there is shunting every day. The shunting is handled by shunting engines from Sundbyberg. Before the installing of the electrical interlocking plant, when Sundbyberg and Sundbyberg N were separate operating stations the movements between these two places were carried out as trains which invariably, when they were not included in the time-table, had to be ordered by the train dispatching office. In the event of unexpected requirements the system was inelastic and cumbersome. Moreover, the mechanical interlocking devices at both places were constructed for left-hand track traffic and the shunting trains in the direction of Sundbyberg N—Sundbyberg had to go over to left-hand track and cut across track II at both places, since as a rule they had to take one of the tracks VII—XII of the goods station at Sundbyberg. On account of this and of the short station distance these shunting trains took up the whole double track on their return to Sundbyberg. By extending the electrical interlocking plant at Sundbyberg to take in Sundbyberg N as well, these movements could be carried out as shunting movements which the station could undertake as required and then when the position of trains and other work at the station

Fig. 1
Track diagram at Sundbyberg

X 7208
X 7204

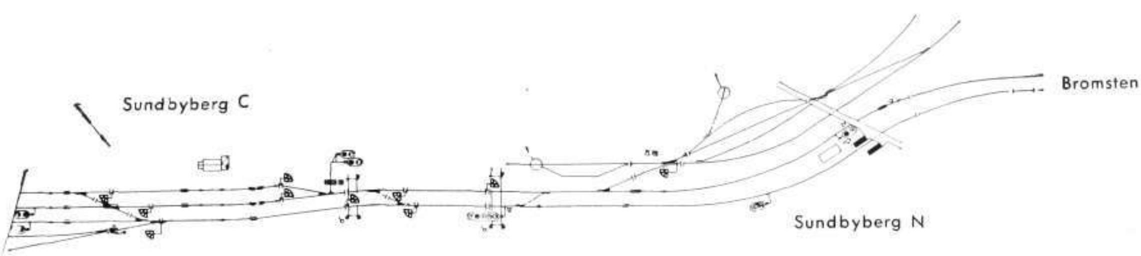


was most convenient. Further, since the interlocking plant controlled the whole track area to Sundbyberg N, there was no necessity to occupy track III with these shunting trains, which may consequently now use the right-hand track for the return to Sundbyberg. The previously existing junction track in the double track at Sundbyberg N was taken away as no longer necessary. By this arrangement a difficulty was solved, which had been present for many years and which had even been the cause of plans for a third track between Sundbyberg and Sundbyberg N.

As concerns shunting at Huvudsta and the movement of goods trains to Tomteboda nedre a similar arrangement was made as at Sundbyberg N. As Huvudsta was a separate station all shunting was carried out there of the goods trains during the time they were at the station. On account of the situation of the tracks, shunting could only take place with the trains in the direction of Tomteboda and trucks whose destination was north had first to be hauled to Tomteboda Nedre and then back to Sundbyberg for dispatch from there. Moreover the down track was occupied during the whole of the shunting, which was frequently inconvenient, especially when there was dislocation of the train services. Since Huvudsta has also been controlled from Sundbyberg the shunting now takes place with locomotives dispatched to Huvudsta as required from Sundbyberg when it is most convenient, taking into account the position of trains and other circumstances. The shunting trains usually take the down track in both directions. Goods trains no longer stop at Huvudsta.

The extension of the electrical interlocking plant to Huvudsta made possible still another simplification as regards the progress of goods trains to Tomteboda Nedre. These start as a rule from track VII at Sundbyberg and previously had to go over left-hand track to Huvudsta thus having to cross over the up-line at both places. On account of this and the short station distance both tracks of the double track were occupied by these trains. Goods trains to Tomteboda Nedre are now dispatched on the right-hand track and the down track is now free of these trains. The shunting junction at Huvudsta in the double track could now be dispensed with like the corresponding track at Sundbyberg N, but is retained for the time being as a reserve connection.

It has already been stated that a number of single engines proceed daily between the locomotive shed at Sundbyberg and Stockholm C or Tomteboda Nedre. These locomotives which proceed as trains always, before the arrival of the electrical interlocking plant, must be taken in on the passenger train tracks I or II and depart from track I or III. Between the locomotive shed and the passenger station the locomotives were piloted by the shunting staff. It was very necessary to avoid having these locomotives on the passenger tracks and at the western part of the goods station where shunting was continually proceeding. In view of this the electric interlocking plant was designed and made so that these locomotives may now go direct to and from the locomotive shed without troubling the shunting staff and without either occupying the passenger tracks I, II or III or passing over the very busy western part of the goods station. For an outgoing locomotive the procedure is as follows: as the time of leaving approaches the locomotive should be standing ready on the track at the locomotive shed. The interlocking plant is set for that and puts the dwarf signal on the shed track to »clear» which in this case also means »go». The locomotive moves forward and stops on track VII just



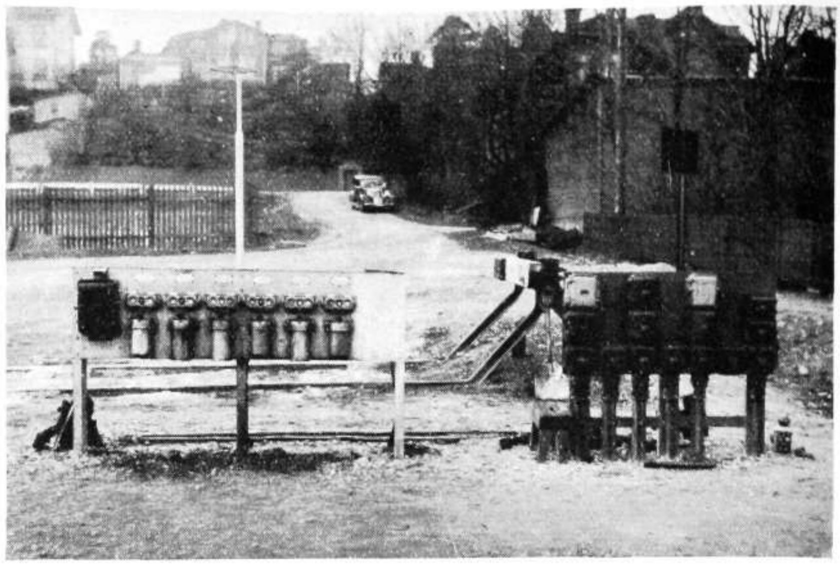


Fig. 2 X 5596
Contact devices for local operating of points

before the nearest dwarf signal. The departure from track VII is cleared from the interlocking plant, clear signal is shown on the main signal (for locomotives proceeding to Tomteboda Nedre, which use the right-hand track, the clear signal is given only on the dwarf signal) and the departure signal is given by the train dispatcher who presses a button at the interlocking plant. The button causes an illuminated *A* to appear in an electrically illuminated device in front of the locomotive, which thereupon goes. Incoming locomotives are directed in similar manner direct to the locomotive shed. All movements and the signals given may be observed by the train dispatcher on an illuminated track diagram set up in his office.

At a station with dense traffic and restricted track conditions the great adaptability of the electric interlocking plant to varying conditions is especially valuable. Thus alternative train roads on the same signal picture may be arranged if required and by means of dwarf signals it is possible for a train, though at reduced speed, to be directed in a multitude of ways, depending on the degree of complication of the track system. At Sundbyberg the facility of arranging alternative train roads on the same main signal picture has been utilised in one case only, *viz:* for trains from Bromsten to track VII: the entrance road may as required be directed over passenger tracks I, II or III.

Interlocking Machine

An important question when planning the installation was the choice of location for the interlocking machine. Two alternatives were to be considered, one in a separate interlocking plant building at the station, the other to locate it in the train dispatcher's office. The latter alternative was chosen for a number of reasons, one being that the train dispatcher should not be entirely divorced from the safety service but should himself be able to supervise the interlocking machine. It was reckoned also that at quiet times of the day the train dispatcher might be able to deal with the whole of train operation without the assistance of a man for the interlocking machine. This last expectation, however, has never been realised. It was found that the station required a man permanently in attendance on the central interlocking plant.

Another question which was settled in conjunction with the fixing of the location of the interlocking machine was the manner of dealing with shunting. With a separate interlocking plant the shunting would be done by dwarf signals with all moving of points attended to from the interlocking plant. With the arrangement decided upon the shunting may also be done in that manner, but as a rule only the clearing of the train roads is done from the interlocking machine, the changing of points being carried out by the shunting staff by means of special point levers on the track, Fig. 2. When a track is made free for shunting the dwarf signals concerned are set at »out of use». In order that the shunting staff may know that local changing of points may be carried out, this is indicated by a pilot lamp lighting at the point lever. There are two other lamps at the lever which show in what position the points are set.

The points and scotch blocks in the train roads are provided with electric motor drive in the ordinary way. Joint working points or points and scotch blocks are as a rule connected in pairs to the same lever. Points and track dogs for parking tracks connected to train tracks are locked electrically but cannot be operated from a distance; the shunting staff therefore must throw these over to make them lock. The farthest point operated from the interlocking plant is 2 km distant from it.

The interlocking machine itself, supplied by Signalbolaget, is of the type now in general use on the State Railways. It has no mechanical locking between the levers but all locking and dependent movements are produced electrically. Each lever therefore constitutes a mechanical unit in itself having no other connection with other levers than electric circuits. The feature of the system is that the levers are furnished with blocking magnets which block or release the lever, the circuits for these magnets being drawn over contacts at other levers or relays for producing the requisite interdependence. The system provides great adaptability, particularly at large stations with complicated track systems and varied traffic. Thus, as stated, the train roads may be arranged for alternative roads.

With an electrical interlocking plant covering an extensive track area it is not possible directly to watch over the area. In order that the interlocking plant attendant may be able at all times to follow what is taking place at the station this has been reproduced on an illuminated track diagram, arranged above the interlocking machine, see Fig. 3. Lamps on the track diagram indicate the signal pictures made by the main signals and the dwarf signals, also whether tracks are occupied by rolling stock or not. Free tracks are marked by lighted lamp and occupied tracks by unlighted lamps. The four signal pictures of the dwarf signals are marked by lamps of different colours. The main signals are indicated by red and green lamps which are directly connected in series with the signal lamps themselves.

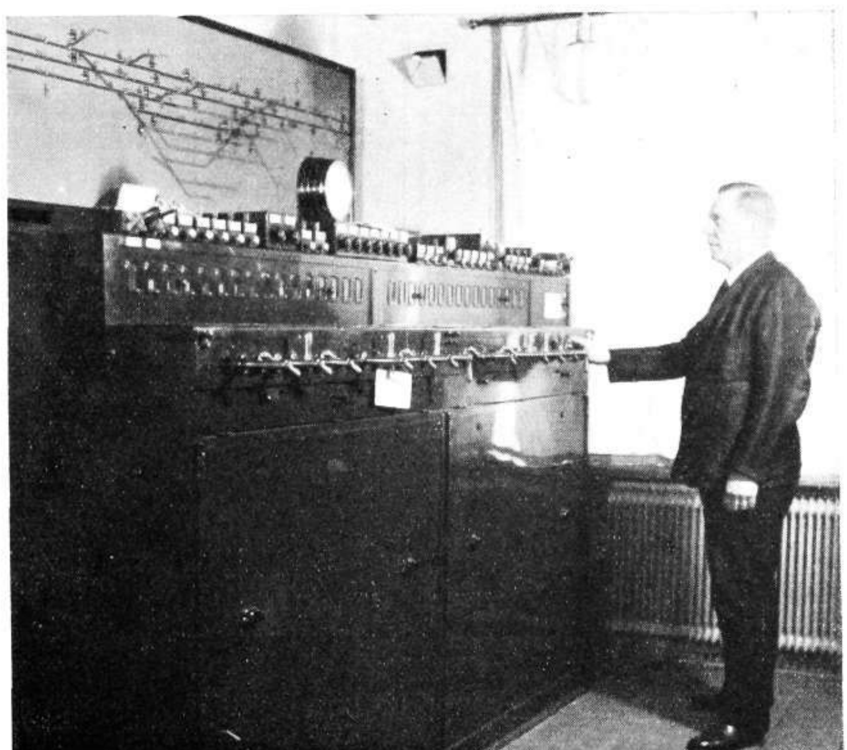


Fig. 3 X 5558
Interlocking machine with illuminated track diagram

For signalling there are used in the plant dwarf signals, main light signals and distant signals of current type. The track area is divided into block sections at the limits of which dwarf signals are set up as entrance signals. Block sections may consist of one or more track circuits. The dwarf signals often apply to entrance for different block sections according to the way the points are set; thus the dwarf signals as a rule do not show which track is clear but only that there is a track clear.

At Sundbyberg the dwarf signals can as a rule display four signal pictures, »stop», »caution», »go» and »out of use». Caution signal on a dwarf signal requires, in addition to its lever at the interlocking plant being thrown, that enemy signals display »stop» and that the points on the block section concerned shall be in running position, but it does not require that the track shall be free. The main significance of the signal picture is for shunting, when it is necessary to approach trucks on the track. Points, safety-points and scotch blocks on the block section are locked by the dwarf signal being set at caution. In general the locking is released immediately the signal is set at stop, and as a result it might happen that a signal be set at »stop» and the point or scotch block changed immediately in front of a vehicle which had not observed or could not stop for the stop signal. In view of this possibility there have been arranged for certain of the centrally placed scotch blocks time contacts which lock the block a little while after the signal has changed to »stop».

In order to make a dwarf signal display »clear» there is required in addition to the fulfilment of the conditions for »caution», that the track is free and any level crossing gates are down and as a rule that the lever for the succeeding signal is thrown. On the line Huvudsta—Sundbyberg where no shunting occurs, the devices are such that the signals show »stop» not »caution» when the track is occupied.

Obviously there is nothing to prevent signalling being carried out with dwarf signals for trains as well, and this is done for traffic on the right-hand track and in other cases. In the ordinary way, however, this would cause loss of time, since trains making continuous progress over a number of dwarf signal sections could only proceed at far too low a speed. Therefore, for the more fixed train roads for entrance and departure main signals are arranged, these showing clear signal by one or more green lights. The most distant signal is 2.5 km from the signal cabin.

Clear signal on a main signal presupposes that all the dwarf signals in the train road are set at »clear»; the train road therefore is locked by the dwarf signals and the dwarf signal levers in turn are locked by the main signal. The locking is also executed for the gates at the level crossings.

In all train tracks, electric track circuits are arranged these being also drawn to side tracks as far in as is necessary to provide freedom from obstacle and for blocking the safety-points. Sidings and ranger tracks are not provided with track circuits.

Track circuits are as is known obtained in such a way that the track area is divided up into sections by insulations in certain rail joints. In each section electric current is fed in at one end, this being taken out at the other end of the section to a track relay the armature of which takes up different positions according to whether the track is occupied by vehicles or not. The movements of the armature are utilised for various marking and safety purposes. At Sundbyberg the track circuits are employed for marking on the track diagram where vehicles are, for blocking of points so that they may not be changed from the interlocking plant when such is not allowable because of movements of vehicles in the vicinity, for locking of train roads after main signals have been set at »clear» and the train has entered the road, and to prevent clear signal being shown when the track is occupied by vehicles.

Fig. 4 X 3962
Starting signals west

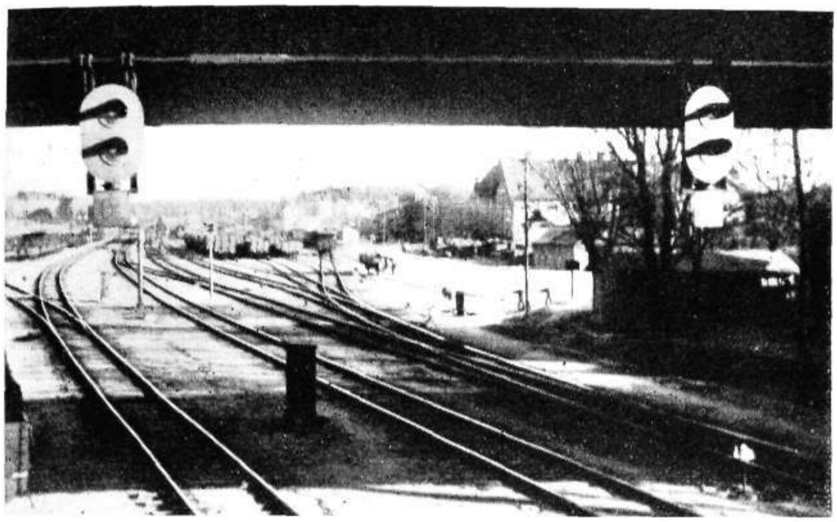


Fig. 5 X 5595
Starting signals east

The point blocking is arranged in such a manner that the point lever blocking magnet is without current when the track relay falls, *i.e.* when there are vehicles on the track, and the point lever then cannot be thrown.

When a main signal is set at »clear» the points in the train road, as stated, are locked. As the front of the train passes the signal this changes to »stop» but the points in the train road are kept blocked by the action of the train on the track circuits and are only released progressively as the train proceeds and such release is permissible.

As has been said, the interlocking plant area is traversed by four public roads. The level crossings are all provided with electrically operated crossing gates, controlled from the central signal cabin. The gates lie as far as 1.8 km distant from the signal cabin so that direct supervision of the level crossings is not possible. On the track diagram therefore indicating lamps are provided for each pair of gates which show whether the booms are raised or lowered and whether the gate warning lamps are lit. The gates moreover are interlocked with the main signals so that on the one hand clear signal cannot be given without the gates being down, and on the other hand the gates cannot be raised once clear signal is shown until the train has passed the crossing. To facilitate the work of interlocking and to avoid holding up traffic on the roads more than necessary, the gates are raised automatically when the last wheel-pair of the train pass the crossing. Formerly, when the gates were controlled each by a special attendant in the nearest mechanical signal box, there were frequent complaints by the public that the gates were kept down too long, but since the arrangement with automatic raising has been put in no further complaints have been heard, despite the fact that the gates, following the introduction of locking connection with the signals, have to be lowered earlier in relation to the train than previously. The cessation of complaints would appear to be due to the wellknown circumstance that the public accept with a certain patience that the gates are lowered in good time before trains, but regard themselves as inconsiderately treated if the gates remain lowered after the train has passed by.

In order that traffic may be handled in the best manner possible with an extensive electrical interlocking plant there is required the maintenance of close collaboration between the signal cabin and the shunting staff. This collaboration requires good means of communication and for this reason a number of telephones have been put up in the track area, by means of which the shunting staff can communicate with the signal cabin. Electric sirens out in the station enable the signal cabin to attract the attention of the outdoor staff. In addition telephones communicating with the signal cabin are provided at the main signals, for use in letting trains proceed when the signal cannot be set at clear. With an electrical interlocking plant of large extent, having numerous signals and dense traffic supervised from a central spot, the difficulties in the case of fault in the plant in moving the trains forward are obviously greater than when the area is distributed among a number of small interlocking plants with staff available at each plant. The ordinary rules for train road examination and for taking a train past stop signal can usually not then be employed. If clear signal cannot be given, *e. g.*, because of defective track circuit, the train dispatcher certainly can see it on the track diagram, but he cannot know what kind of fault there is on the track and as a rule has no means of inspecting outlying tracks. Generally there is no time to send out men to signals located a distance away for signalling. Special regulations have been drawn up therefore prescribing how engine drivers and train dispatcher shall proceed when a main signal cannot be set at »clear». When a train has stopped at a stop signal, the reason for which the driver does not know, he must after waiting two minutes call the signal cabin from the telephone at the signal. The train dispatcher has the right then, if he does not know of any obstacle to the train, of giving the driver permission to take the train past the stop signal without any kind of signalling taking place there. In such event the driver must take the train forward with special caution, carefully observing signals, points and track and at such low speed that the train can be quickly brought to a standstill if any hindrance is discovered by the driver, such as stop signal, wrongly set points, vehicle on the track or other obstacle. Examination of the train road therefore is to a certain extent entrusted to the driver.

Relays, converters etc. required for the plant are housed in a cellar of the station building. The power is taken from the Sundbyberg Electricity Works. To provide against local interruption of current the plant has been connected to two of the Electricity Works transformer areas. In the event of interruption of current affecting the whole supply works, the plant has no reserve of its own; it is considered that the town will get its emergency plant to work quicker than the unaccustomed station staff could start a reserve unit of their own for the plant.

The total installation cost amounted to 260 000 kronor, in which are included the building of central platforms and waiting room at Sundbyberg N and track changes in conjunction with it. In judging the financial result there should be deducted from the installation costs the amount which, in the event the electrical plant had not been executed, would have had to be expended on the mechanical devices to put them in proper condition, which amounts would not have led to any savings. These amounts are estimated at 60 000 kronor, so that the extra cost for the electrical plant will be some 200 000 kronor. By entirely releasing Huvudsta, Huvudsta C and Sundbyberg N from safety service, it has been possible to reduce the service of staff at these places to a considerably degree or, at Sundbyberg N, dispense with it altogether. Ticket selling at this place is handled by a private undertaking and at Huvudsta C the service is handled by a woman attendant. The savings made possible by the electrical interlocking plant amount to about 35 000 kronor per year. Apart therefore from the advantages as regards handling of traffic that have been gained through the plant, it is therefore fully justified also from the economic point of view.

Interlocking Plant at Upsala C

HERMAN HOLMQUIST, SIGNAL ENGINEER, STATE RAILWAYS, STOCKHOLM

As far back as 1913 there was installed at Upsala an electric interlocking plant, up-to-date at the time, which has worked satisfactorily throughout the years. Naturally, however, it called for a numerous staff while in addition there were men for operating crossing gates at a large number of level crossings. Then when the line was electrified this caused the mechanical semaphores, of which there were a large number in the plant, and the scotch block signals on masts to be difficult to observe on account of the overhead line bridges and the overhead lines. For several reasons also it was considered advisable to exchange the old plant for a modern interlocking plant with light signals and track circuits, which moreover was a necessity to enable Upsala station to be connected to the automatic interlocking Stockholm—northwards.

The new interlocking plant with illuminated track diagram, relays, point machines, locking devices and dwarf signals was ordered from Signalbolaget, while the greater part of the cables was supplied by Sieverts Kabelverk. The work of installing was begun in the autumn of 1936 and was largely completed by the autumn of 1937. For various reasons, however, the plant was only put into operation in February 1938.

In the older installation the signal cabins numbered three and all the points requiring to be set for fixing a train road were centrally controlled from the signal cabins. The electrical station blocking and the track locking were dealt with by the train dispatcher. Single track section blocking with blocking apparatus was arranged to Upsala Norra and there was double-track section blocking southwards. In the new safety installation the three interlocking machines are united in one central interlocking machine housed in the same building that formerly occupied by interlocking machine II at the south end of the station area. The plant works as order interlocking machine, since signal to an incoming train is given without reference to the train dispatcher. With departing trains the train dispatcher gives bell signal to the cabin when the train is ready to leave, this to avoid the train roads being locked too soon in the event of lateness.

Fig. 1 X 5575
Dwarf signals in the station track area

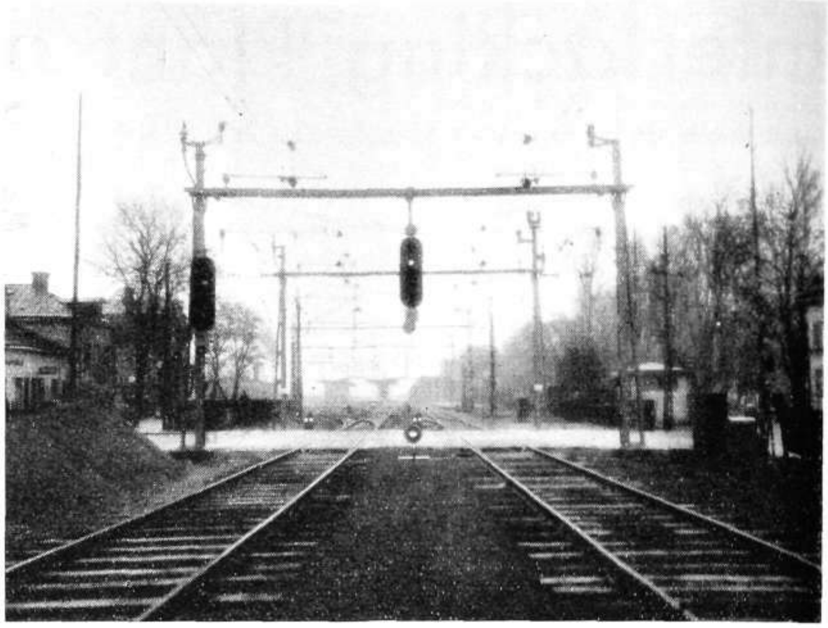


Fig. 2 X 5574
Entrance from north to Upsala C
with home signals, dwarf signals, caution signal and electrically operated gates for the level crossing

All shunting movements in the station area are directed from the signal cabin by means of dwarf signals, Fig. 1, while shunting on the ranger track is done by local switching devices for all the central switchable points. When the signal cabin gives permission for local switching, the dwarf signals concerned are set at »out of use». On the entrance or departure of a train on the ranger track the permission for local switching is withdrawn and the signal for the train is given by the interlocking plant.

All the train tracks are insulated, *i.e.*, formed into track circuits on which traffic is directed by dwarf signals. By means of the track circuits the giving of clear signal is prevented for tracks which are occupied by vehicles. The track circuits are also employed to prevent centrally switched points being switched from the interlocking machine when vehicles are in the track circuit. The dwarf signals which constitute home signals cannot be observed with sufficient clearness by rapidly approaching trains, but must be repeated by light signals set up on power line poles or in bridges, Fig. 2. For departure roads, indication that the train road is cleared is given by green light below the ordinary white in the innermost dwarf signal.

A modern electrical interlocking plant of the type used at Upsala is distinguished from older types of plant by the fact that in the latter only two train roads may be set by each signal lever. The interdependence with the

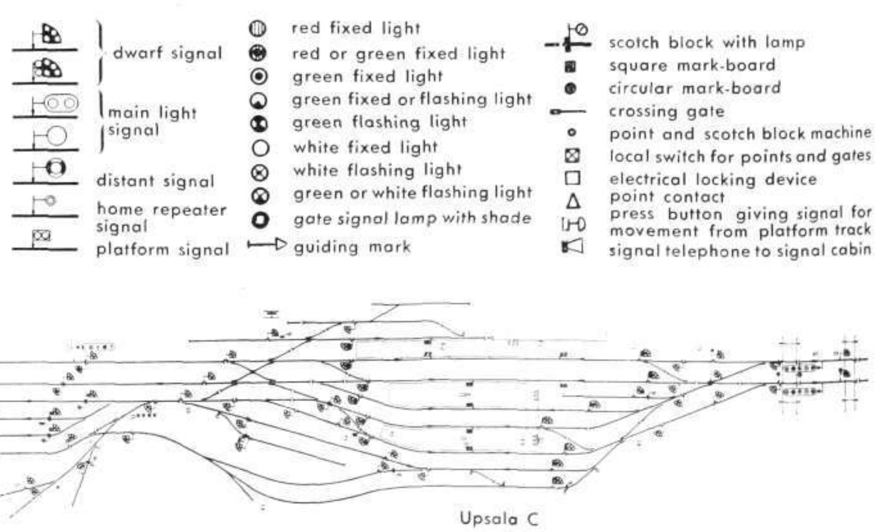
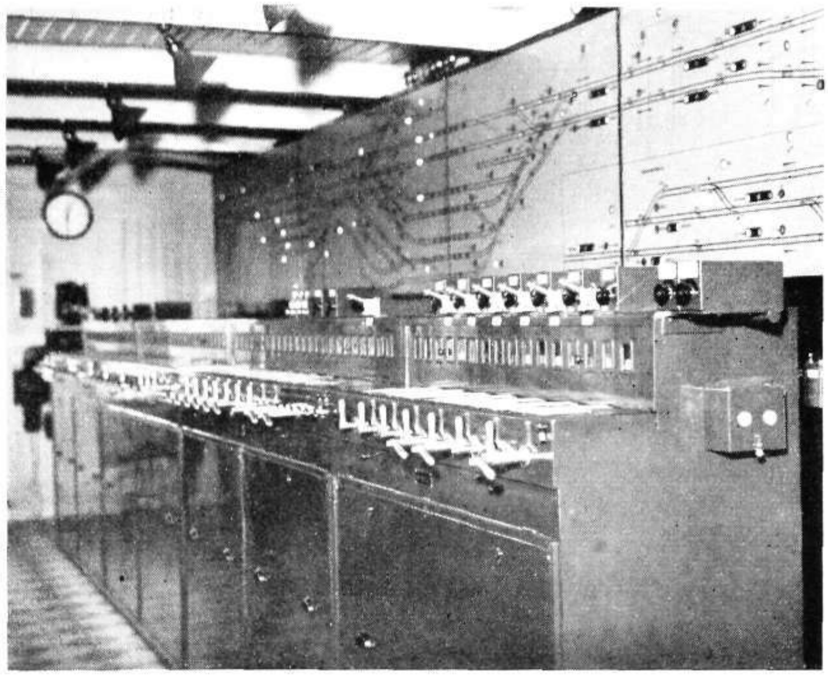


Fig. 3 X 7198
Track diagram at Upsala C

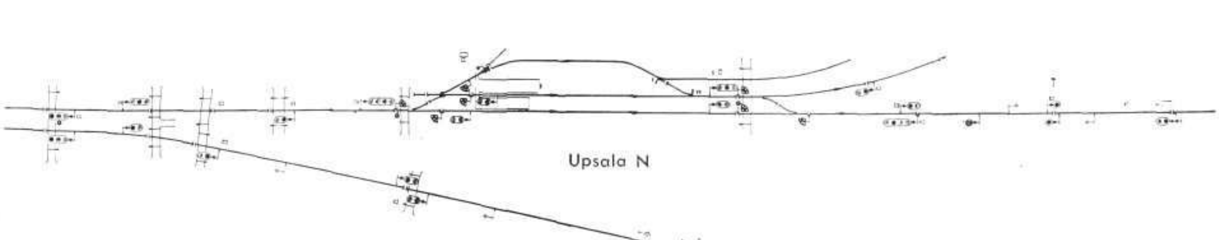
Fig. 4
Interlocking plant
with illuminated track diagram

X 5576



point levers is then obtained by means of mechanical guides which on throwing the signal lever are pushed to one side and by means of locking elements lock the point levers in plus or minus position. This mechanical interdependence is absent in a modern interlocking plant, being replaced by electrical locking. This means that it is possible with a single signal lever to give signal to all the train tracks on the station area where the track system allows of the train entering. When the signal lever is thrown, *e. g.*, to the right, there is obtained clear signal for the track for which the points are set, but only on condition that the train road is free of vehicles. The throwing of the lever to left gives clear signal for departure from the track from which the points at the moment are set. The signal cabin attendant therefore must take care that the points are set just to or from the track concerned. This is ensured by the train roads being mostly made up of several dwarf signal train roads, which must be set first. When finally the main lever is thrown, a special pilot lamp marks the tracks for which signal has been given.

The advantage with the modern interlocking plant is thus that a large number of train roads may be obtained without the interlocking plant being unreasonably cumbersome. Thus it is possible to have train roads out and in on all tracks in the station area to and from all lines, even for right-hand track traffic with double track lines, Fig. 3. This allows of a freedom of movement hitherto unimagined as regards employment of the station area for the entrance and departure of trains. A great advantage also is the direction of shunting work from the signal cabin by means of dwarf signals. In this way the points are locked at each shunting movement which appreciably increases the speed in shunting. If only one track circuit is free from vehicles the dwarf signal shows »caution», but if two track circuits are free the caution signal automatically changes to »clear», whereby the speed may be increased while safety is retained. The shunting movements at a passenger station are practically the same day



after day, so that the signal cabin staff has no difficulty in directing them. In the event of lateness or other interruptions, communication with the signal cabin is obtained by means of telephones in the track area.

Behind the interlocking machines there is an illuminated track diagram on which the track system is shown and each track circuit is marked by a lamp. All the signals also are repeated on the track diagram, so that it is possible to observe their positions at any moment, Fig. 4. The signal cabin staff can observe all movements over the station tracks on the plan and have therefore actually no need to follow the movements through the windows. The track diagram includes the Upsala ranger and station tracks, also the track system at Upsala Norra and intermediate line, as well as the line to Old Upsala. Points and signals at Upsala Norra are also operated from the central interlocking machine. Automatic block sectioning is arranged southwards to Bergsbrunna and northwards by single track via Upsala Norra up to Brunna station. On the single track the direction to be taken by trains is directed by the interlocking plant at Upsala C. This interlocking plant can also carry out train meetings at Upsala Norra where there is no train dispatcher.

A special feature of this interlocking plant is the large number of crossing gates across streets and roads in and outside Upsala, which are operated electrically from the signal cabin. The number of level crossings is no fewer than 13. All the gates are protected by light signals, which display »clear» only when the gates have been lowered. Immediately the last vehicle of a train has passed a level crossing the gates are raised automatically. On the track diagram at the interlocking plant there are pilot lamps for each level crossing, these indicating whether the gates are up or down and that the red lamps facing the road are burning when the gates are down. It has ben found that no trouble is experienced in operating all these gates centrally, and no accident has occurred up to now, despite the fact that there is no attendant at the street and road crossings.

It is obvious that a plant as described must involve a large capital outlay, in this case a total of about 550 000 kronor. This amount, however, will yield interest through the reduction in staff that could be done after the plant was completed, by the concentration of three interlocking plants into one, by the taking away of the train dispatcher from Upsala Norra, by dispensing with the attendants previously required for operating the various level crossing gates. The saving in cost of staff amounts to 36 000 kronor per year, while in addition there are the advantages described with the handling of the trains and the utilisation of the station tracks for the ever growing traffic.

Mains Connected Automatic Switchboard for 10 Lines

H. FREDBORG & V. E. SJÖDIN, TELEFONAKTIEBOLAGET L.M. ERICSSON, STOCKHOLM

Telefonaktiebolaget L.M. Ericsson has quite recently put on the market a new automatic telephone switchboard OL 15 for 10 extensions, and which may be connected to the AC mains. This switchboard is a development from the automatic switchboards OL 10 and OL 12, designed some years ago, and like them it is equipped with a single conversation facility. In contrast to the previous switchboards, however, switchboard OL 15 provides facilities for both secret and non-secret conversations and, in addition, for general calls, i. e., calls to all extensions simultaneously. Another advantage is that ordinary telephones with AC ringing may be used.

Ever since the two automatic switchboards OL 10 and OL 12 were put on the market, they have been in exceedingly great demand. It was therefore evident that the switchboards met a decided need. An automatic switchboard of the ordinary type, as we are aware, is provided with facilities for several simultaneous conversations which makes it far too expensive for the very smallest installations. A switchboard with only one conversation facility, on the other hand, may have a very much simpler and consequently cheaper construction than a switchboard with facilities for several simultaneous conversations. Examples of cases where a switchboard with one conversation facility may suitably be employed, are small offices and businesses, shops, private residences etc.

In switchboards OL 10 and OL 12 the source of current employed consists of dry batteries which gradually become exhausted and must be replaced. Recently, therefore, the dry battery has frequently been replaced by a storage battery which is kept charged by a constantly connected rectifier. In this way, of course, replacement of dry batteries is avoided but, on the other hand, the storage battery requires inspection and the charging requires checking at regular intervals. The most efficient solution of the problem is obviously to have the switchboard connected direct to the AC mains.

In switchboards OL 10 and OL 12, it will be recalled, instruments with DC bells are used. The power of the galvanic ringing is limited by the voltage of the battery used, about 12 V. By mains connection there is obtained the advantage that ordinary telephone instruments with AC ringing, *e. g.*, DBK 1101, may be used. The AC ringing may be made considerably more effective since the ringing voltage, obtained by transforming the mains voltage down, may be chosen at will. In Ericsson's new automatic switchboard OL 15 for mains connection the ringing voltage is approximately 85 V. Extra bells may be connected without trouble to an extension instrument that is equipped with AC bell.

The standard type of switchboard is usually made for connection to AC mains with tensions of 110, 127 and 220 V. By means of a simple changing of connections one switchboard may be used for any of these voltages. The frequency of the AC mains may in the normal execution of the switchbord vary between 40 and 60 c/s. If required the switchboards may be supplied for other voltages and frequencies.

The switchboard is intended also for connection to DC mains, but then it must be supplemented by a vibrator converter. Where electric current is not available or where interruption of current supply occasionally occurs and the use of the switchboard cannot be dispensed with during such interruptions, it is necessary to install a switchboard for battery operation instead of one for mains operation. Ericsson therefore will still manufacture switchboard OL 12 as well as OL 15.

In designing this switchboard the aim has been to make it as far as possible independent of variations in the mains voltage. If the normal mains voltage is 220 V the switchboard will work satisfactorily even though the voltage falls to 190 V or rises to 250 V.

To ensure economy in operation the power consumption of the switchboard must be low. With 220 V mains voltage the power consumption when idle is less than 3 W and during conversation about 3.5 W. The maximum power consumption which takes place during dialling and while ringing signal is transmitted is 7 to 8 W.

Normal telephone instruments BDH, DBK and DBN for automatic systems are used with this switchboard. The resistance of the subscriber's line may amount to 400 ohms, which if normal circuit cable, *e. g.*, EEB 0.5 mm, is used, is equivalent to a distance between switchboard and instrument of more than 2 km. The instrument numbers are *1, 2, 3, 4, 5, 6, 7, 8, 9, 0*.

Construction

The switchboard OL 15, Fig. 1, is enclosed in a case of aluminium bronzed sheet-iron with the following dimensions, inclusive of protective cover: height 375 mm, width 250 mm, depth 160 mm. The net weight is about 9.7 kg.

When the protective cover is removed all the parts which are not dangerous to touch are accessible. Adjustment, testing and alteration of connections can thus be carried out while the switchboard is under current. Those parts which are directly connected to the mains and are under dangerous tension are guarded against being touched and cannot be reached until the switchboard has been made currentless. This is done by drawing out the contact plug visible on top of the switchboard. It is only then that the protective plate covering the parts under dangerous tension may be unscrewed and removed. A further protection is obtained if the switchboard earth terminal, to which all the metal parts of the switchboard are connected, is connected to a waterpipe or some other well-earthed object. Certain power companies stipulate that such a connection be made.

Connection to the AC mains is done by means of a cord fitted with a plug contact at the free end. It can be inserted in an ordinary wall outlet, so that no wiring is needed to connect the switchboard to the mains.

The battery eliminator contains a rectifier together with a transformer and a filter comprising two electrolytic capacitors and a choke to smooth the rectified

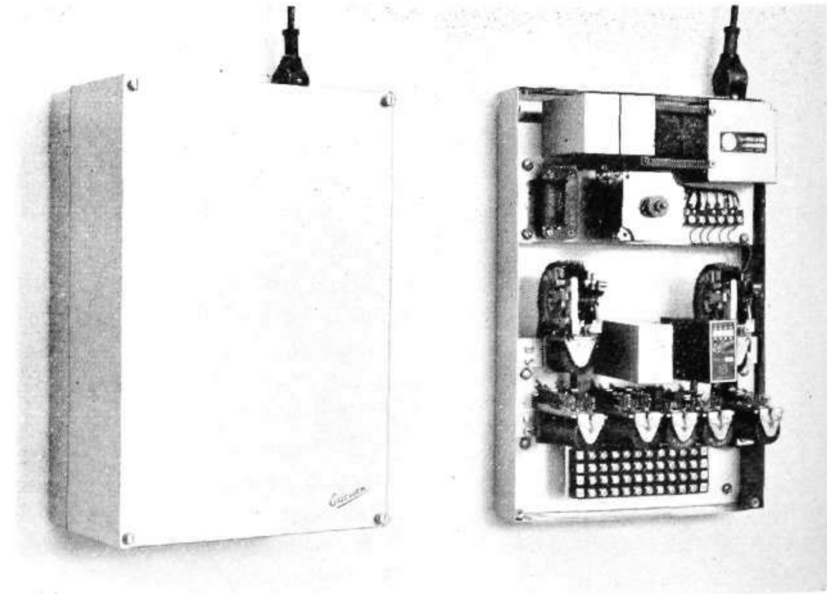


Fig. 1 X 5582
Automatic switchboard OL 15
left with cover, right with cover removed; at top, battery eliminator with rectifier, transformer and filter; in middle, capacitors and relays; at bottom, terminal block

current. The central part of the switchboard contains two selectors for the hunting of the calling subscriber and for the connecting in of the called subscriber, and in addition a number of relays and capacitors. The ten two-wire lines to the extension instruments are connected to the terminals at the bottom. The necessary alterations for secret or non-secret conversations, for cutting in facility on conversations going on and for general call are carried out on these terminals by means of bare wire stirrups.

Traffic Properties

Generally it is required that a conversation shall not be disturbed by a call from another extension. The switchboard is therefore as a rule connected for secret conversations. A switchboard of this simple type being provided with only one conversation facility, the switchboard will be blocked for all others, when conversation is going on between two subscribers. In some cases this may be a disadvantage and the switchboard has therefore been made so that it may be altered in a simple manner to enable conversations to be non-secret. This gives the advantage that, when the switchboard is occupied, any of the extensions may request the speakers to hasten the conversation so that a new call may be made. On the other hand, there is the disadvantage when all conversations are non-secret that they may be overheard at any of the extensions.

Consequently the new switchboard has been provided with one additional facility. The switchboard may be altered in such a way that some of the extensions — one, two or three — have the advantage of secret conversations, while those of the other extensions may be overheard. All calls, both incoming and outgoing, on the privileged instruments are secret. If the switchboard is occupied when a third party lifts his handset he does not come in if a conversation is going on between two privileged instruments or between one privileged and one non-privileged instrument. On the other hand he does come in if the conversation is going on between two instruments not entitled to secret connections and the person who has cut in can now require that the conversation be terminated.

One of these privileged extensions, namely the one having *1* as call number may, if desired, be equipped with absolute preference, which means that from this extension cutting in can take place on all connections, both those ordinarily secret and those not secret, and that all connections over this instrument are absolutely secret. Cutting in can therefore not take place from any other extension when the switchboard is occupied by the person who has absolute preference. This special advantage is suitably reserved for the head of the undertaking.

Still another advantage compared with earlier types of switchboards is offered with the new switchboard OL 15. The extension which may be given absolute preference, *i. e.*, usually that of the head of the undertaking, may have the facility of general call, that is the facility of calling all the extensions at the same time. This is done by dialling the digit *1*. This facility may come into use for the giving of general communications, instructions and the like applying to all extensions. It is also possible to arrange conferences in this manner, provided that normal telephone calls can be dispensed with during the conference.

Operation

When the switchboard is idle, see diagram Fig. 2, all instruments are connected to the impulse receiving relay *R2*, which is attracted and starts the switching process immediately the handset of one of the extension instruments is removed. The line finder *AS* is moved forward one step and relay *R1* attracts, thereby disconnecting all extensions from relay *R2*. During dialling, of course, only the calling instrument should be connected to the switchboard, since disturbance of the switching process might occur if another instrument called the switchboard during the dialling. The calling subscriber, therefore, is hunted by the line finder *AS* and is then connected alone to relay *R2*.

Relays *R2* and *R3* attract and dialling tone is emitted to the calling subscriber as a sign that the desired subscriber's number may be dialled. During dialling relay *R2* is attracted and released in time with the impulses of the dial. At each impulse the connector *LV* moves forward one step until it reaches the position corresponding to the desired subscriber's number. The relays *R3* and *R4* remain attracted during dialling.

At the close of the impulse train, relay *R3* is released while relay *R4* remains energized a few seconds by delayed action. During this period ringing current is transmitted to the subscriber connected by the connector. The ringing current passes through an extra winding on relay *R2*, so that the calling subscriber also hears that ringing signal is emitted. When finally relay *R4* is released, the ringing signal ceases and the speaking wires between the line finder and the connector are connected together. Speaking connection is established immediately on the removal of the handset by the called subscriber. If no answer is obtained, the calling subscriber may send out a new ringing signal if — without replacing the handset — he dials *1*, awaits new dialling tone, and then dials the desired number. During this time the switchboard is busy so that no other instrument can make a call.

When the subscribers replace their handsets at the close of a conversation, relay *R2* is released. Selectors *IV* and *AS* are stepped forward to home position and finally relay *R1* is released. The switchboard is then ready for a new call.

The alteration for secret or non-secret calls is made by means of the connection *B*. If this connection is made, relay *R1* will remain attracted during the conversation, thereby disconnecting all instruments not concerned. Consequently, when the handset is removed on any instrument, the conversation cannot be overheard. If the connection *B* is non-existent, however, relay *R1* is released immediately following the ringing signal. All the instruments will then be connected to the switchboard and a conversation may be overheard by anybody. Absolute preference for an extension is obtained by making connection *A*, Fig. 2. By this means the instrument in question will always — except during dialling and ringing signal — remain directly connected to the speaking wires of the switchboard, over which all speaking connections are established. Immediately the handset of this instrument is removed, therefore, a conversation going on may be overheard.

The general call facility is arranged by removing the connection *C*. If the subscriber dials his own number, relay *R1* is released immediately after dialling. This causes all subscribers' lines to be interconnected and ringing current is sent out to all extensions.

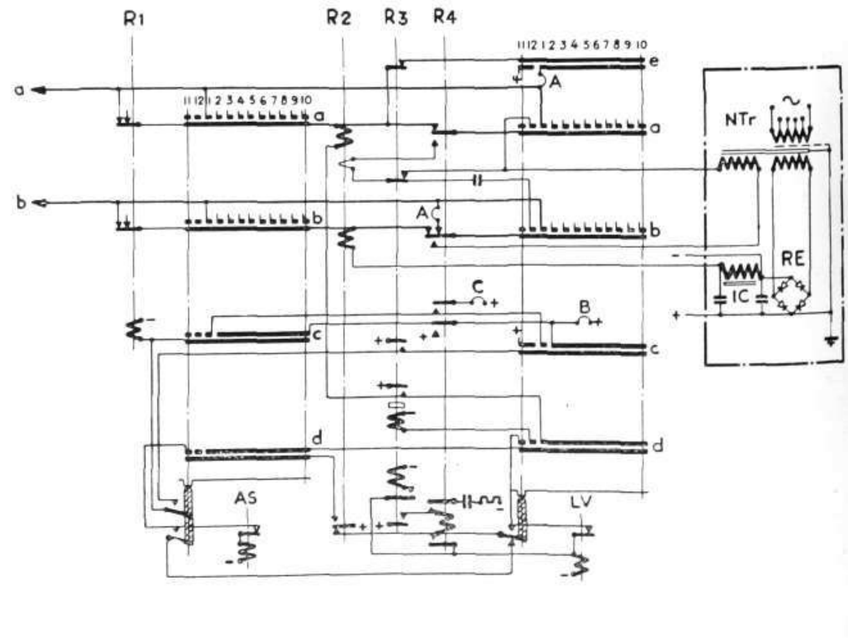


Fig. 2 X 5581

Circuit diagram for OL 15

a, b,	connections to instruments
A, B, C	connecting stirrups for different traffic facilities
AS	line finder
IC	feed current filter
LV	connector
NTr	mains transformer
R1	selective relay for secret conversations
R2	starting and impulse receiving relay
R3	impulse control relay
R4	ringing relay
RE	rectifier bridge

Ericsson Cable-Finder in India

FRANK HYLAND, BENGAL TELEPHONE CORPORATION, CALCUTTA

Fig. 1 X 3934
Locating a cable bend

In Ericsson Review No 1, 1939, was given a description of a cable-finder constructed by Ericsson. With this apparatus determining of the exact position of underground lines and piping may be conveniently done, which is of great value when repairing and blasting. The Ericsson cable-finders have been in use some time in Calcutta, British India, and in the following some measurements which have been made there will be described.

Measurement with the cable-finder constructed by Ericsson is based on the principal that an electro-magnetic field produced by an alternating current can be heard in a telephone receiver. From the intensity of the sound the position is determined of the electro-magnetic field and from it the position of the cable, underground line or piping sought. A cable-finder of this construction has been in use some time at the Bengal Telephone Corporation in Calcutta with the following results.

Fig. 2 X 3935
Locating a cable to avoid injury during street excavation

The buzzer transmitter was once connected to one pair of a 50 pair armoured telephone cable at the end of the cable 6 km from the central office where the pair was connected to the cable sheath and to earth. The output of the buzzer transmitter was lowered to 45 mA. The cable was then traced for a distance of about 800 m. In this distance the pair made several right angle bends round road corners and passed into cables of several sizes. On the approach of a canal bridge the cable carrying the pair was 2.5 m below the street surface. The position of the cables carrying this pair could all the time be accurately determined. The tone was clearly audible above the noises of busy roads and induction from adjacent power cables.

A 26 pair armoured telephone cable 2.5 km long was measured in the same way but only one wire of the pair was used. The cable ran partly parallel to a tramway track, the traction feeder of which ran along the cable within some decimeters of it on one side of the road. In spite of this the two cables could easily be located by the null method. The traction cable could also be located by using its own induction as the transmitter tone.

Fig. 3 X 3936
Determining by the null method the exact position of a cable

By applying the loose finder coil the selection of one of twelve 800 pair armoured telephone cables laid up in a cable rack was easily made by connecting the buzzer transmitter to a certain pair in the cable sought. This pair was earthed in the other end of the cable. The correct cable was readily identified by applying the loose finder coil to each cable in turn. In order not to disturb the telephone traffic going on at the same time on the other cables the output of the transmitter was adjusted to the lowest possible value, about 4 mA. In order to ascertain whether a particular cable could be identified when local conditions would not permit of the coil being applied against a cable, the output of the transmitter was increased to 20 mA. The finder coil was held away from the cable rack and it was possible to identify the cable by sighting the direction in which the finder coil was pointing when the maximum tone was heard.

The measurements described were carried out under normal field conditions in Calcutta. The testing officers were usually the centre of a crowd of noisy interested spectators or were working in heavy street traffic but in spite of this the measurements gave very good results.

New Sound Projector for Sub-Standard Film

R. BEAUJOIN, SOCIÉTÉ DES TÉLÉPHONES ERICSSON, COLOMBES

In France as in most other countries sub-standard film is used to an ever increasing extent for educational purposes. Since the State also has recognised the value of the improved instruction made possible by the sub-standard film with sound and, by making grants to schools, local authorities, agricultural institutes and other organisations has facilitated the acquisition of sub-standard film projectors for educational purposes, there has obviously been created a large market for such projectors in France and, since the 16 mm size has been internationally adopted for sub-standard film, in other countries as well. For this reason Ericsson, Colombes, has put sub-standard film projectors on its programme of manufactures.

In designing a sub-standard film projector, chiefly intended for school use, great demands must be imposed on the apparatus since it will usually be handled by persons who in most cases have no knowledge or experience whatever of film projection. The projector, therefore, must be simple to operate and of no delicacy of construction, it should be easily portable but steady, and moreover present the greatest safety in displaying the films.

In 1936 the authorities approved the sound film projector designed by Ericsson, Colombes, and at the same time the State undertook to make a grant to those institutions that purchased a projector of this type.

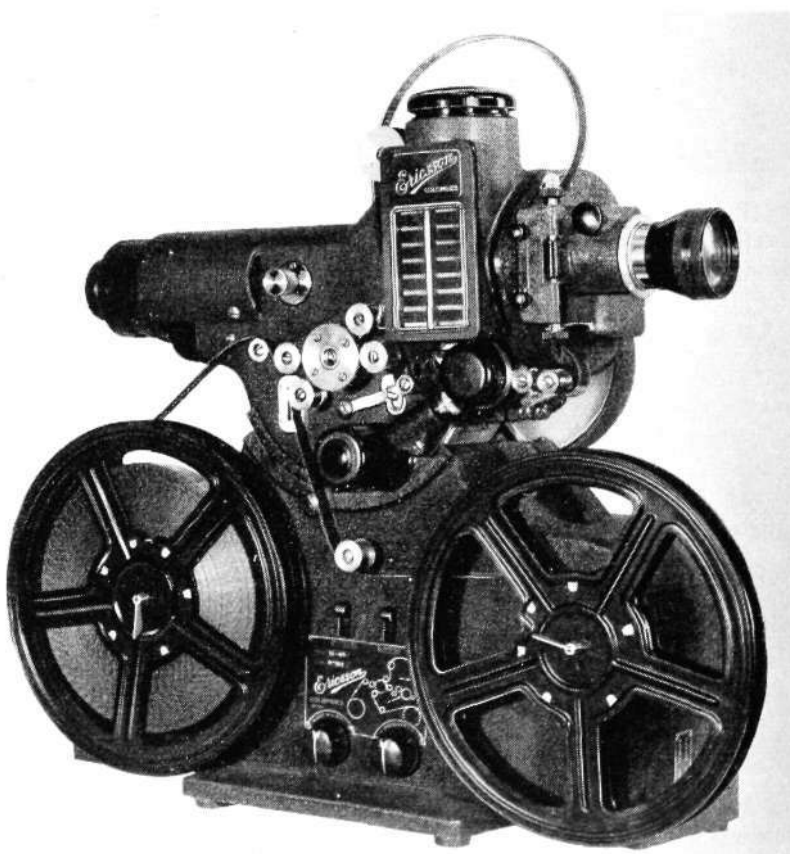
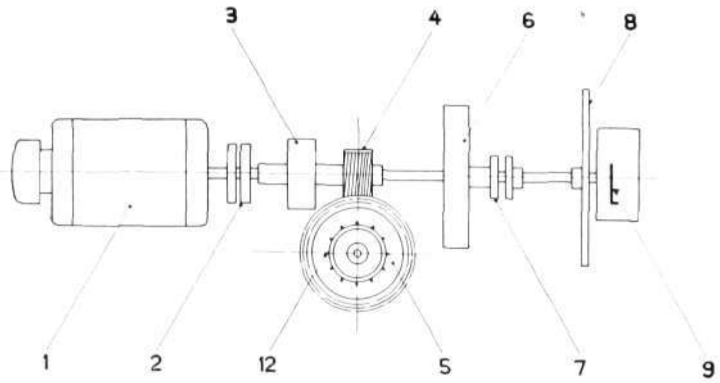


Fig. 1 X 5584
Sound film projector with filament lamp
for 16 mm film, with 300 m film reel



X 5587

Fig. 2
Diagram of driving mechanism

1 motor	6 fan
2 flexible coupling	7 flexible coupling
3 change-speed box	8 shutter
4,5 gearing for feed wheel	9 claws
	10 feed wheel

The Ericsson sound projector for 16 mm film, Fig. 1, is made up of two parts, one of which constitutes the stand and contains the microphone and power amplifiers; the other part holds the mechanical parts for feeding the film forward together with the projection lamp and optical equipment for image and sound. This latter part is movable on the stand, making it easy to adjust the image on the screen.

The apparatus is designed for 110 V AC current, 50 c/s and the current consumption is 800 W.

Motor Part

The general mechanism is reduced to the strict minimum, with all the parts mounted in line upon a single shaft, see Fig. 2. Upon this line of shaft are located: the motor, a flexible coupling, the change-speed box, the worm for operating the worm-wheel, the fan, a second flexible coupling, the shutter and the device for controlling the movement of the claws.

The *motor* employed is of the asynchronous type and it is started by an auxiliary phase with capacity; it operates with 110 V AC current, 50 c/s and its consumption is 105 W. The speed of the motor on full load is 2 880 r/m and its regularity of running is sufficient to permit of direct coupling to the shaft.

On the body of the motor is mounted a three-plug terminal, which is connected with the wires of the field winding and allows the motor to be taken out of the frame without disturbing the connections.

One *flexible coupling* serves chiefly to absorb the starting shocks and facilitates the removal and the exchanging of the motor.

The *gear box* is of the planet pinion type. It provides for the two speeds which are necessary for the travel of the silent and the sound films, 16 and 24 frames/s respectively. In the case of acoustic films a fork guide connects the driving pinions with the gear box body, the planet wheels being thereby locked and the whole unit driven at the motor speed, or 2 880 r/m. In the case of silent films the fork guide is disengaged by pushing in the stud which is held in position by a bayonet stop. The stud holds the body of the box and at the same time releases the driving pinion which then via the planet pinions drives the shaft at the reduced speed of 2 160 r/m, equivalent to 18 frames/s. The entire box is carefully balanced to prevent all vibration.

The *feeding drum* is driven by a worm with double thread and a worm-wheel of large diameter, giving a ratio of 1 : 40. This device, as also the gear box, rotates in an oil-bath.

The *fan*, located in the rear of the lantern, provides a sufficiently strong current of air to enable 750 W lamps to be used without excessive heating. It draws in cold air through the film guide channel and through suitably spaced orifices. Immediately after passing over the lamp, the air is discharged outside the projector.

One *flexible coupling* serves to facilitate rapid dismounting of the head of the apparatus comprising the optical system for projection and in addition controls the claws for the film travel, besides counteracting any possible effects of jerk in the claws upon the driving shaft and hence upon the feeding drum's even motion.

The *two-wing shutter* rotates two revolutions for each change of picture, thus giving four eclipses for each picture.

The *claws* operate without any springs, so that there is nothing to get out of order.

The claw device moves the film forward at the rate of 24 frames/s with a motor speed of 2 880 r/m.

Continous lubrication of all rapidly moving parts is ensured by oil-soaked felt packings at suitable points, these also serving to absorb the vibrations in the metal due to the jerky movements.

Projector Part

The projector for the pictures comprises: a concave reflector, a grid filament, a lamp condenser and a set of lenses with 35, 40, 60, 65, 70, 80 and 120 mm focuses, which can be readily interchanged according to the distance of the projection and the size of the screen to be covered.

The reflector and the condenser are fitted definitely at the factory, and require no subsequent adjustment.

The lamp, of 500 or 700 W, is held in the lamp-holder by a bayonet-fitting with unequal wings, which prevents all error in insertion. The movable lamp-holder, of moulded bakelite, is connected with the stationary terminals for current feed by plugs ensuring perfect contact, a definite and unmistakable placing and great facility in the removal and insertion of the lamp. Bakelite being a bad conductor of heat, this lamp-holder may be handled while the apparatus is in operation or immediately after stopping without any risk of burning.

The system for sound reproduction is based upon the projection of a mechanical slit which is reduced by optical means. The system is composed of the following parts: an 8 V, 32 W exciting valve, a condenser, a mechanical slit of 0.03 mm width, a lens and a photo-electric cell.

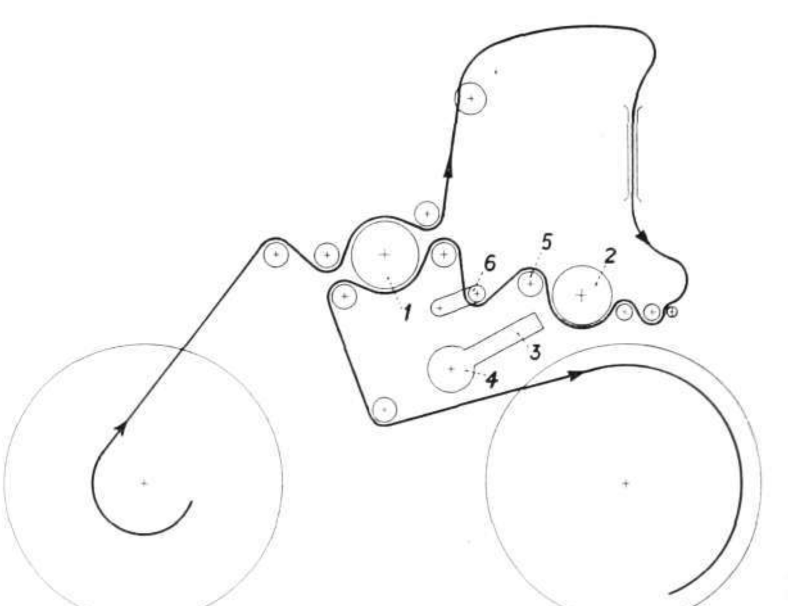


Fig. 3 X 5594

Diagram of the film's progress through the projector

1 feed wheel
2 photo-electric cell
3 lens for sound reproduction
4 lamp for sound reproduction
5 wheel to take up jerks
6 damping spring

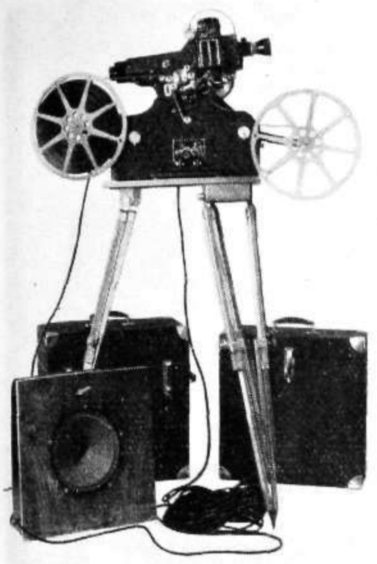


Fig. 4 X 3951
Projector with 600 m film reel
with loud-speaker and transport cases

In the same way as for the sound projection, the optical system provides for the interchanging of the exciting valves without making any adjustment. The caesium cell employed has a great sensitiveness at all feeding voltages varying from 100 to 130 V thus allowing a wide margin in the regulating of the power. The cell-holder is suspended in an entirely flexible manner, and has no mechanical connection whatever with the body.

After leaving the projection guideway the film's motion is jerky from the pull of the claws. For the reproduction of the sound, however, a perfectly even travel is absolutely necessary. To ensure this evenness, the film, after leaving the aperture, makes a loop before entering the guideway for the reproduction. This guideway is circular and consists of a stationary ring located on the same side as the margin record and of a drum rotated by the film. The film then passes over a rubber roller provided with a free flywheel and mounted in ball bearings. The inertia of the flywheel serves to steady the speed of travel of the film. Finally, a compensating roller actuated by a damped spring, stretches the film between the flywheel roller and the feeding drum. This compensating device takes up any differences which may exist in the perforations, the splices or other defects of the film.

Base

On this base are assembled all the controls; the plug box, motor switch, valve switch, knob for regulating the friction of the unwinding reel, switch for lighting the amplifier and switch for regulating the power.

The base also holds the two reel supports. Each reel support is provided with a friction device. The friction device for the winding reel serves to take up the differences of speed between the belt drive which is constant and the reel which varies according to the amount of unwound film. The normal apparatus is adapted to receive reels having 350 m of film. However, it can easily be supplied with longer reel supports which will receive reels for 600 m of film.

The amplifier, of 65 W, is located in the base. It is mounted on a rubber bed in order to prevent vibration which might cause disturbing noise. By means of a potentiometer the sound can be regulated according to the acoustics of the premises and the sound quality of the film. The volume of sound can be regulated according to the size of the premises.

An electro-dynamic loud-speaker, Fig. 4, 28 cm diameter, mounted on a 70×70 cm baffle (for permanent installation) or 50×50 cm baffle (for portable apparatus), owing to its size, permits of the diffusing without saturation of the power transmitted by the two valves of the push-pull stage.

A special plug-terminal is used for the connection of a pick-up or a microphone. The acoustic degree is also regulated by the potentiometer used for the sound volume. An extra loud-speaker may also be connected to the projector to permit a better distribution of sound in big localities.

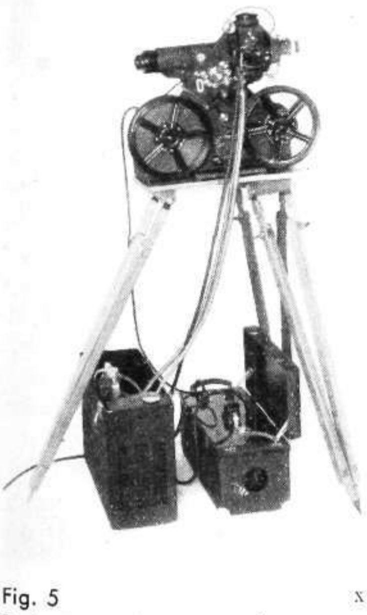


Fig. 5 X 3953
Projector with mercury lamp
with cooling unit and distribution box

Projector with Mercury Lamp

The Ericsson 16 mm projector has been designed for employment in schools and consequently is intended for display in comparatively small premises. However, in view of its rigid construction and good sound reproduction it has also been utilised in larger places. The filament lamp with which the projector is normally equipped certainly gives a well lighted image 4 m wide at 25 m distance, but does not provide sufficient light for larger premises. It has therefore been found necessary in the event of such employment to provide the projector with a stronger source of light.

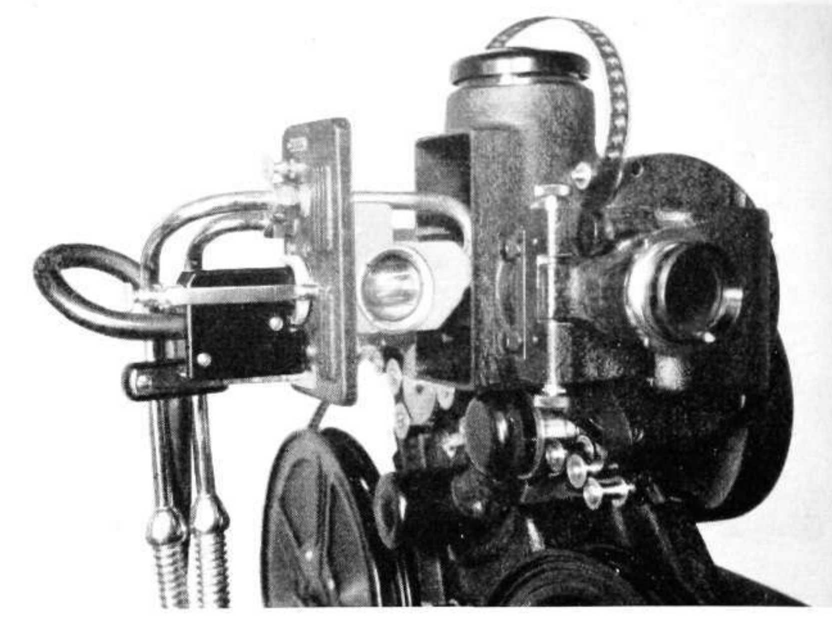


Fig. 6 X 5585
Mercury lamp and holder
with connections to cooling unit and distribution box

The arc lamp, on account of the heat it develops, which very soon injures the film, as also because of the risk of fire, is not so suitable for this purpose and Ericsson therefore uses for the large projectors a water-cooled high-pressure mercury vapour lamp as source of light. With such a lamp it is possible to have a well illuminated image 6 m wide at a distance of 40 m.

An apparatus of this type was exhibited in March 1938 at the Paris Film Exhibition and in November the same year was tested at the Central Testing Institute at Paris, being approved for employment even without projector cabin, which constitutes good evidence of its good safety qualities.

This projector, Fig. 5, the total current consumption of which is 9 A, is very similar to the projector with filament lamp, with some small modification in the optical equipment. The equipment necessary for the mercury light is placed on the floor beneath the projector and consists of a distribution box, a cooling unit and a mercury lamp.

The *distribution box* consists of a special transformer for feeding the lamp and an autotransformer for 90—250 V AC, 50 c/s. There are knobs on the distribution box for regulating the pump and the lamp and also a pilot lamp for distance control of the water circulation.

The *cooling unit* comprises a motor, a fan, a radiator and an automatic switch which cuts off the current to the lamp if the water circulation should be interrupted for any reason: this eliminates the main cause of fault in the lamp. The cooling water circulates in a closed system.

The *mercury lamp* is fitted in a lamp-holder which is inserted in the lamp house from the side, see Fig. 6. It is connected with the cooling unit by means of a flexible armoured hose for water circulation and with the distribution box by a rubber-insulated cable for current feed to the lamp. The mercury lamp has a current consumption of 550 W and a light density of 33 000 Hefner units/cm^2.

The two types of the Ericsson projector: with filament lamp and with mercury lamp, make it possible to utilise the projector in either the smallest or the largest localities. Moreover, packed in its two cases it is convenient of transport and it combines low current consumption with great safety of operation — the 16 mm film is non-inflammable — and is thus exceedingly well adapted for ambulating exhibitions, *e.g.*, for publicity films.

New General Catalogue

A new general catalogue nr 612 to replace catalogue 188 issued earlier will be published shortly. In the main it covers the same material as was included in the earlier catalogues, but it has been enlarged and made more complete. In the case of material which has received the new three-letter designations these have been inserted and a complete index of old and new designations has been added.

The new catalogue is distinguished from the former ones by the arrangement of the text in a single column with a wide margin at the left for illustrations, this greatly facilitating reference. The catalogue is divided into four main sections: telephony, telesignalling, line material and electricity meters.

A modification has been carried out in the telephony section. The three main groups, headed galvanic telephone installations, local battery plants and central battery plants, have been distributed in two main divisions. The first comprises telephone switchboards and instruments for public networks while the other deals with material for private systems. PB exchanges take up an intermediate position, these being designed to link traffic between an intercom telephone plant and the public telephone system.

The first division gives information regarding manual and automatic telephone exchanges, party systems and selective-calling systems, material for long distance telephony and telephone instruments on the LB and CB systems, the latter instruments including those with dials. The other division contains instruments for domestic telephones, self-selective, manual and automatic intercom telephone plants, manger's telephones and ship's telephones.

The telesignalling section is divided into the following sub-divisions: alarm installations, signalling plants, signalling devices, works control and special equipments. A newcomer among alarm installations is the material for air-raid warning. The works control sub-division comprises apparatus for control of staff and control of machinery, as also period control instruments.

The section for net material has been supplemented by some new items. Finally the electricity meters section has been enlarged by the addition of some new types and connecting diagrams for the meters have been added.

Ericsson Technics

Ericsson Technics No 3, 1939

T. Laurent: New Principles for Practical Computation of Filter Attenuations by Means of Frequency Transformations

In Ericsson Technics No 4, 1937, there has been demonstrated the possibility of systematically shaping by means of frequency transformations the image attenuation curve in a filter without dissipation to agree with certain arbitrary requirements. While the effective attenuation in a realizable filter is mainly made up of the non-dissipation attenuation, yet at the same time account must be taken of the additional attenuation due to dissipation in coils and condensers, of the winding and earth capacitances and of the reflections at the input and output terminals. The present paper will demonstrate how this may be conveniently carried out in conjunction with the shaping of the image attenuation curve on the above method. Determination of the attenuation due to dissipation is then done with a special graphic complex frequency transformation, allowance for winding and earth capacitances being made by the introduction of an extra frequency transformation with indirect *bn* function. With normal matching, the reflection attenuation in the pass band may be neglected and by a fortunate circumstance it is possible in simple manner to allow for the reflection attenuation in the stop band when the attenuation is transformed in the negative imaginary frequency range.

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CONTENTS

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Ericsson's Ball Selector and Selector Relay

H. BLOMBERG & E. WIBERG, TELEFONAKTIEBOLAGET L.M. ERICSSON, STOCKHOLM

Telefonaktiebolaget L.M. Ericsson has in recent years been devoting close attention to the development of modern telephone selectors for PABX's and small telephone exchanges. In addition to the XY selector for 100 lines, described in Ericsson Review No 1, 1938, this work has resulted in a couple of new types, the ball selector and the selector relay. Both these selectors are step-by-step driven relay selectors with the driving device designed on a new and inteteresting principle.

By *relay selectors* are meant selectors in which the movable contacts are formed by the action of contact springs of the same type in the main as ordinary telephone relays. The best known relay selector is the crossbar switch which is a 100-point or 200-point selector and which has been adopted in Sweden and America. It has proved to be reliable in operation and to have a long life, but it is larger, heavier and more expensive than corresponding selectors of other types.

The new Ericsson relay selectors are of considerably smaller capacity and are intended for use in the smallest exchanges for which the 100-point or 500-point selectors would be uneconomical, and also as auxiliary selectors in systems made up of these larger selectors such as Ericsson's XY and OS systems.

Small telephone exchanges made entirely on the relay system are commanding more and more interest on account of their great reliability of operation. In such exchanges the selectors consist of a number of simple relays, which causes them to be expensive and to take up considerable space. By using relay selectors instead, these disadvantages are avoided while cheaper exchanges with the same good operating reliability are obtained.

From their principle, the relay selectors have particularly good contact qualities without risk for contact trouble, since the contacts as with telephone relays are formed by *pressure contact* between surfaces of precious metal, usually silver. The Ericsson relay selectors have, moreover, the advantage that they are built as relays and are mounted in the same manner, thus forming natural and compact units with them. Whether used as independent or auxiliary selectors, they make possible a particularly adaptable lay-out of the equipments.

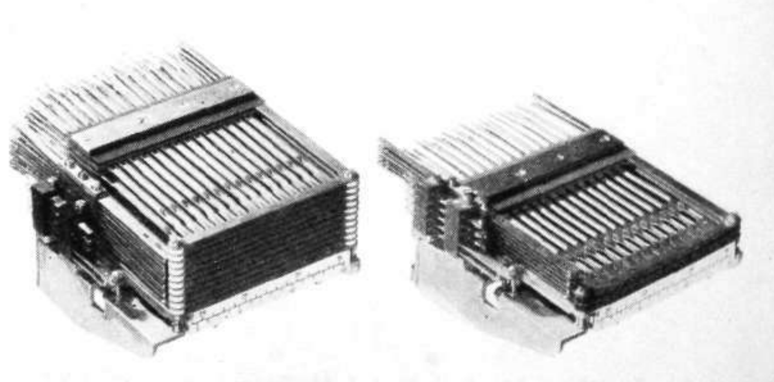


Fig. 1 X 5607
30-point ball selector
left, with five contact levels; right; with two contact levels

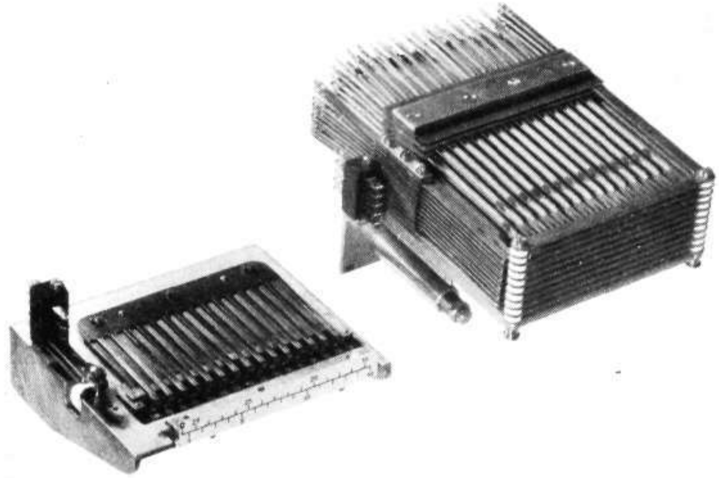


Fig. 2 X 5608
Ball selector dismantled
left, selector mechanism; right, multiple bank

As stated, the Ericsson relay selectors are step-by-step driven. Since, however, the contacts do not consist of sliding contacts, as in ordinary step-by-step selectors, but of pressure contacts, the problem as regards driving device has been to discover a design suitable for the action of pressure contacts. The solution has resulted in a driving device of entirely new design, which in particularly simple manner ensures a step-by-step movement of a contact actuating device from one position to another, with subsequent making of the desired contacts in each such position. In actual fact the new driving device consists of a step-by-step mechanism which, by means of simple armature operation as in an ordinary relay and without the intervention of a pawl-and-ratchet mechanism carries out selecting in contacts arranged either in straight or circular rows.

Two types of relay selectors have been designed on this principle. One, the *ball selector*, is a 16-point or 30-point selector, which answers the same purpose as uniselectors hitherto used and is made with various combinations of contact levels etc. The other, the *selector relay*, is built up like an ordinary single-coil relay and is intended for the more simple installation, where other relay designs would be too large and too expensive.

Ball Selector

This selector has been given its name from the mobile contact operating device in the drive, this consisting of a little steel ball, which during the driving process is moved from contact position to contact position.

The ball selector is comparatively small in size. Its width is 100 mm, while the height is governed by the number of contact levels which may be varied as required. In a 30-point selector with five contact levels, Fig. 1, which may also constitute a 16-line selector with ten levels, the height is 70 mm. In a selector with only two levels the height is 50 mm.

The selector consists of two entirely distinct parts, the *selector mechanism* and the *multiple bank*, Fig. 2. These are electrically united by means of plug and jack. The frame of the multiple bank is screwed to the rack and soldering to the relay springs is done as with an ordinary relay. The selector mechanism is inserted under the multiple bank frame and is screwed firmly to it. The contact plug on the mechanism is then engaged in the jack of the multiple bank. Consequently the selector mechanism in easy to take out for inspection and adjustment and it is only necessary to insert mechanisms in those selectors which are required for the traffic.

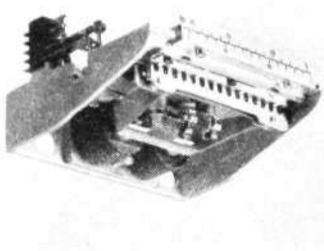


Fig. 3 X 3966
Selector mechanism
seen from below

Selector Mechanism

The selector mechanism consists of a frame of die-cast aluminium beneath which is mounted a driving magnet, consisting of two magnet coils and an armature, Fig. 3. The armature has an armature bridge in the form of a stirrup, the front portion of which supports two parallel sheet-metal bars one before the other, the upper edges of which are shaped as oblique cut *teeth*. With the operation and release of the armature these two lines of teeth move up and down.

The fore part of the frame has an oblong groove corresponding to the multiple bank width, in which is inserted a tooth system consisting of two parallel rows each of 15 oblique cut teeth with open gaps between the teeth. These rows of teeth are therefore firmly fixed in the selector mechanism. The teeth on the armature bridge fit in these gaps. On the operation of the armature these fixed and mobile teeth work together in such a way that a little *steel ball* is moved forward step by step along the rows, see Fig. 5. In each position the operating springs located on the upper side of the frame are lifted and these in their turn, since the selector mechanism is inserted under the multiple bank, lift the corresponding contact spring groups in the bank. When the ball reaches the end of the one teeth path it is transferred to the other path and continues along it but in the opposite direction as the teeth in this path are obliquely cut in the opposite way. When the ball reaches the end of this path it is put over to the first path and once more moves in this path in the initial direction. Thus the ball moves cyclically in two parallel rectilinear teeth paths.

The principle of the ball's movement may be seen in diagram in Fig. 6, which shows the movement during two successive operations and releases of the magnet armature, *i. e.* during two current impulses. When the armature is at rest, *i. e.*, released, Fig. 6 a, the mobile teeth are fully engaged in the teeth gaps between the fixed teeth. The ball lies on the inclined upper surface of a fixed tooth and rests against the side of the mobile tooth to the right of it. In that position the ball raises the operating spring above to contact position, while the remaining operating springs are unaffected. When the armature is then operated because the magnet receives current, the whole line of mobile teeth is moved to a bottom position and the mobile tooth which was holding the ball at the side slides below it, with the result that the ball under pressure from the operating springs runs down into a position, Fig. 6 b, in which it raises none of the operating springs. When next the armature is released the mobile teeth are again engaged in the gaps. The tooth lifts the ball until it

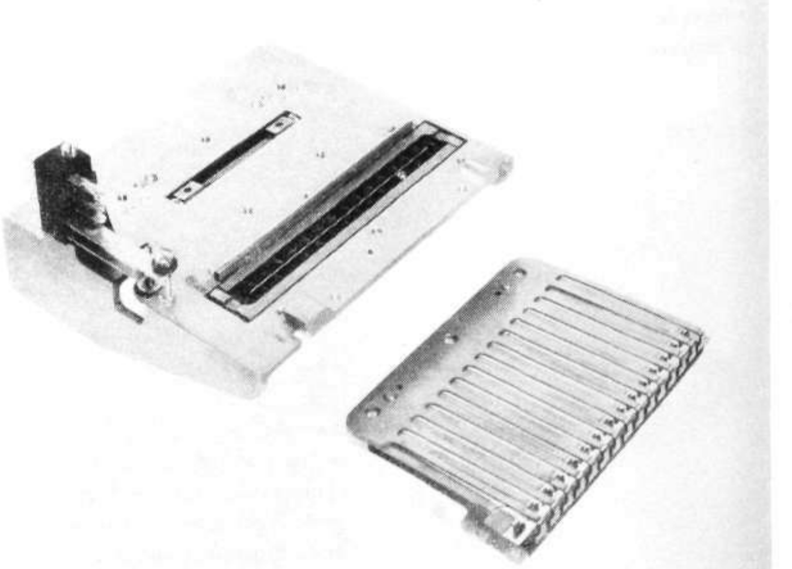


Fig. 4 X 5609
Selector mechanism with operating spring unit detached

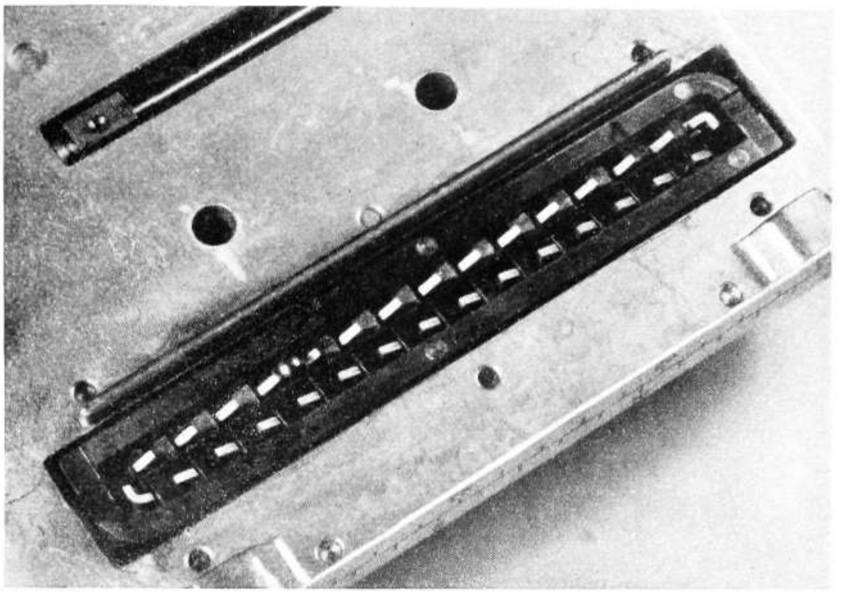


Fig. 5 X 5610
Ball path of the selector mechanism

is no longer resting with the fixed tooth on its right, but slides up along this at the same time raising the operating spring above this tooth, Fig. 6 c. At the next operation of the armature the ball slides into the tooth gap to the right, Fig. 6 d, sliding up on the next fixed tooth with the following release of the armature and raising the operating spring above. In this manner, with each impulse, *i. e.*, operation and release of the armature, the ball follows a zig-zag movement, being first moved to the side and then carried upwards into a new contact actuating position.

The only movable parts in this device besides the springs are the armature with its rows of teeth and the little light-running ball. The functioning therefore is entirely similar to that in an ordinary relay, in which the armature bridge stretches under the spring groups and actuates these as the armature is operated. In the ball selector, too, the armature bridge, *i. e.*, the lines of teeth, stretches under all the contact spring groups but it can only actuate the spring group under which the ball happens to be at the moment, the other groups being unactuated. On the next movement of the armature the ball moves along to the next spring group, actuating that, and so on. The result is that there is simultaneous selecting and contact operation.

In order that the selector magnet need not be with current after selection has been carried out, the selector is driven on the return stroke of the armature. The armature is held in released position by two adjustable leaf springs, located between the armature stirrup.

The ball consists of an ordinary ball-bearing ball of steel 3.16 mm diameter. Consequently it is exceptionally well polished and true and therefore very light-running and durable. Tests made have demonstrated that selectors after operating more than 50 million steps display but slight wear and still work perfectly.

The operating springs are stamped out of common pieces of tinplate and form a removable unit on the upper side of the frame, see Fig. 4. This unit

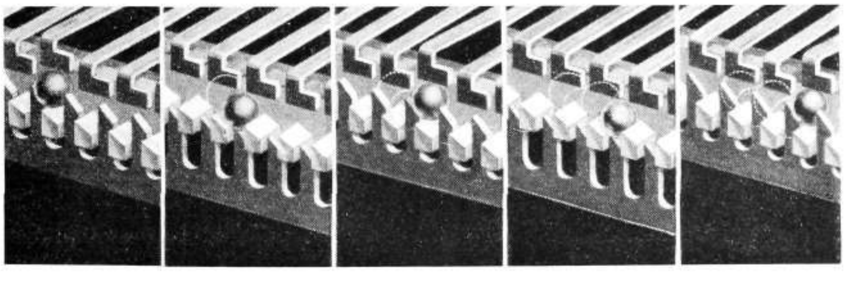


Fig. 6 X 5613
Principle of the ball movement

covers the whole hollow of the ball path, so that the ball is entirely closed in and cannot fall out. Alongside the operating springs a spring group for self-drive is fixed, this being actuated direct from the armature stirrup.

The selector is capable of exceedingly rapid action. With self-drive, speeds of 80—100 steps/s are obtained.

Multiple Bank

The multiple bank also is built up on a frame of die-cast aluminium, see Fig. 2. It contains guides on the lower side, which when the selector mechanism is inserted centre the multiple bank and the mechanism in relation to each other. The multiple frame is spring supported, the springs being fixed on two bolts screwed to the bay. This spring supporting of the selector minimises the transmission of vibrations to the bay and the noise that might arise when the selector is operated.

The contact springs of the multiple bank are of the relay spring type. In a 30-point selector with 5 contact levels, see Fig. 1, the multiple bank comprises 29 spring groups with 5 springs to each, these spring groups together forming a unit. Alongside this unit an entirely separate off-normal spring group is mounted, which comprises springs in any desired combination according to what is required from the standpoint of the circuit diagram. All springs are made with twin silver contacts. The contact pressure is at least 30 g per spring.

The multiple springs are arranged in 10 levels one above the other, each level containing 14 or 15 springs in the width. The springs are attached on bakelite sheets which constitute the insulation between the levels and serve to fix the springs on the frame. Above the spring contacts on the forepart of the frame there are fitted 10 bars lined with silver underneath, one for each spring level. The spring contacts make contact with these when they are raised. The bars constitute the common contact part of the selector, corresponding to the wipers in an ordinary uniselector. When at rest, the springs lie against insulation sheet above the bars. The bars enclose the contact springs, thus ensuring mechanical protection for them.

In alternate levels the springs project sideways half a spring division. Each five springs lying one above the other are linked by a lifting stud of paper bakelite. The lifting studs rest with their lower ends on the ends of the operating springs of the selector mechanism. Alternate springs are in a front row and alternate springs in a back row, corresponding to the two tooth rows of the ball track. Similarly the lifting studs are arranged in two rows. When an operating spring is raised by the ball, the corresponding lifting stud rises with it and raises its spring group to make contact with the bars. When next time the ball raises the adjacent operating spring its spring group is raised by the lifting stud belonging to it and so on.

When the selector is made as 16-point instead of as 30-point selector, the springs in all levels lie one above the other. There are only 15 spring groups with lifting studs in a row and these are actuated by the one row of operating springs. The other row is used for the return of the ball to home position.

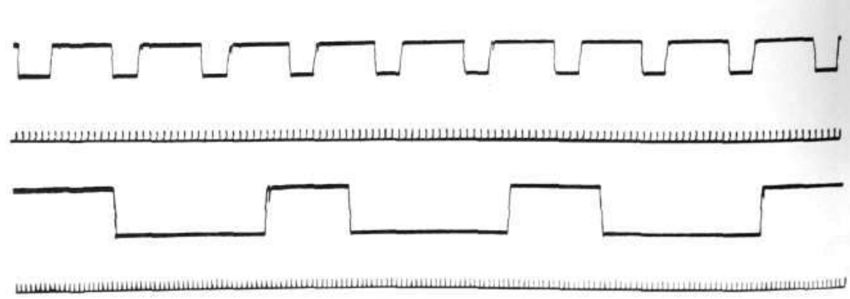


Fig. 7 X 5605
Oscillogram of the ball selector's contact making
above, with 40 step/s; below with 10 step/s

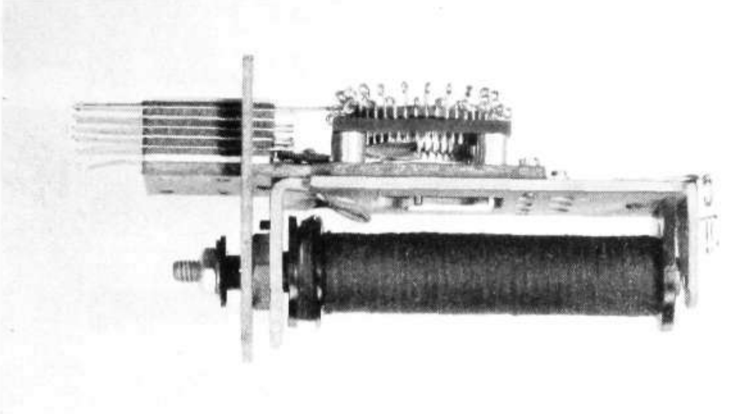


Fig. 8 X 5611
22-point selector relay

By making the ball track with a smaller number of teeth it is possible to make selectors for less than 30 or 16 lines in a simple manner. Not only may the number of contact levels vary from 1 to 10 or more, but also the type of contact. Thus, instead of simple make contacts, the selector may be made with make and break contacts, by which means the equipment for the selecting function may in certain cases be simplified.

Because of the silver contacts the contact making in the ball selector is extremely good, as may be seen by the oscillogram, Fig. 7.

Selector Relay

The driving device in this selector works on the same basic principle as in the ball selector, though its construction is different. In the ball selector the armature bridge stretches beneath the whole contact bank and the movable contact operating device, the ball, is made to move into different positions along this bridge by the joint working of its movable teeth and fixed teeth. In the selector relay, on the other hand, the armature does not cover the whole contact bank but always actuates the movable device at one and the same spot, the device then being put in the different contact operating positions by joint working of fixed teeth. Moreover in the ball selector the contacts are arranged in straight rows, while in the selector relay the rows are circular.

The selector relay, Fig. 8, consists of an ordinary frame, coil and armature in a single coil relay of the Ericsson type. The circular contact bank is arranged above the relay frame, see Fig. 9. It consists of 44 silver pins, fixed vertically round a circle in an insulation plate which is mounted over the frame by means of four pillars. The bottoms of the pins are flat and form the fixed contact surfaces; their upper ends serve as solder terminals for the leading in wires.

Inside the contact pins and concentric with them is a semi-circular toothed ring with oblique cut downwards directed teeth fixed in an insulation plate. Below this is another toothed ring with oblique cut upwards teeth fixed on an insulation plate direct on the frame. Consequently the two toothed rings have the teeth opposite each other with the teeth somewhat projecting sideways in relation to each other.

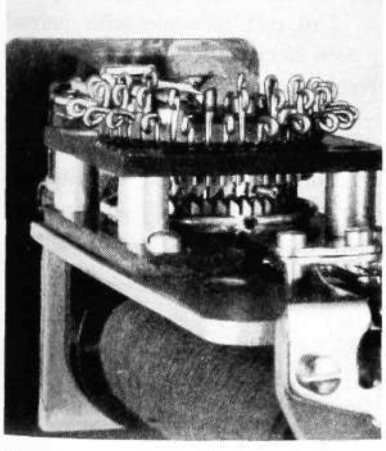


Fig. 9 X 3967
The selector relay's contact bank and driving device

In the centre of the toothed rings there is a vertical shaft which carries a thin horizontal steel wire. The ends of this pass through the space between the toothed rings, each end being fitted with a little cylindrical silver contact outside the rings, these contacts therefore being beneath the fixed contact pins. This wire constitutes the movable-wiper of the selector, at the same time serving as the mobile device of the driving mechanism. The lower end of the vertical shaft rests on the end of the armature bridge. As the armature is operated and released the shaft will be raised and lowered by the action of a flat spring that presses on the upper end of the shaft and also serves as current lead to the wiper.

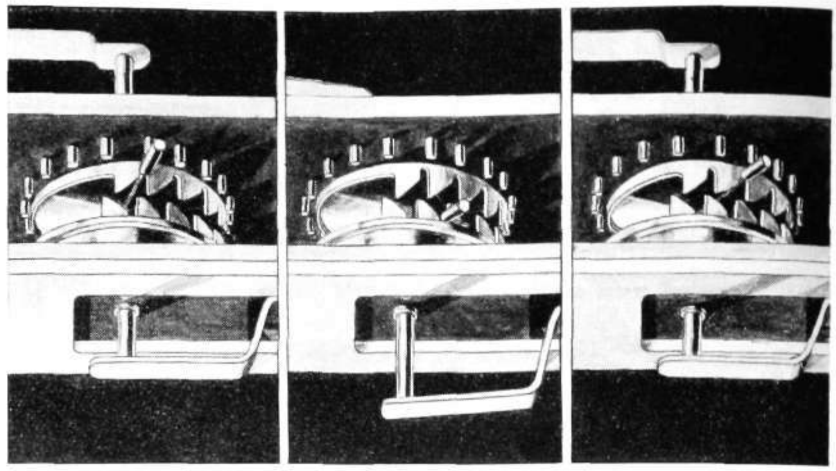


Fig. 10 X 5612
Principle of the selector relay's driving device

When the armature is operated the shaft is raised and the horizontal wire is lifted against a tooth in the upper toothed ring, sliding against its oblique surface, see Fig. 10. Through this the wire is turned to the right until the silver contacts at each end are immediately below two diametrically opposite contact pins. During the continued movement of the shaft the wire proceeds along the vertical tooth gaps, the contacts being pressed against the contact pins, making contact with them at a pressure of at least 15 g for each.

As the armature releases, the vertical shaft is pressed downwards by the flat spring. To begin with the wire moves straight downwards until it comes to the oblique tooth surface of the lower toothed ring, after which during the further downward movement it turns still further to the right. In this way it has moved one step laterally. In bottom position the silver contacts of the wiper are pressed against a silver ring. This silver ring has a gap at the home position, in which a separate contact is fitted.

When next the armature is operated the cycle of movement is repeated and the wiper in this way moves in steps from contact position to contact position. The wiper moves 44 steps for a full revolution. Since contact is made by both ends of the wiper at once against two diametrically opposite pins connected with each other, there is obtained double contact. In such case the selector is a 22-point selector. By providing the wiper with only one silver contact at one end of the wire, all the pins become individual contact positions and there is thus obtained a 44-point selector with single contact.

The selector is driven on the forward stroke of the armature, *i. e.*, the coil carries current in contact making position of the selector. The current consumption, however, is very small on account of the small mechanical power required for the operation of the selector. The coil is made with normal windings as for relays and the selector may both electrically and diagrammatically be dealt with as an ordinary relay. Hence its name, selector relay.

As may be seen the driving device in the selector relay is the simplest imaginable arrangement of a step-by-step mechanism. The relay constitutes a small, inexpensive and reliable selector design. It is employed, among other things, in small automatic party switchboards, in certain selective calling telephone plants and as switching relay in automatic systems.

Economic Stages of Extension of Telephone Networks

Y. RAPP, TELEFONAKTIEBOLAGET L. M. ERICSSON, STOCKHOLM

In a telephone plant where the capacity grows as time goes on and where progressive investment is necessitated, it is not apparent at first sight how the costs shall be defined and compared when deciding upon the method of development that will involve the lowest costs. Obviously in such case it is not possible only to take into account the first costs of installation but consideration must also be given to future extensions and their probable cost.

This paper, constituting a précis of a longer article published in Ericsson Technics No 5, 1939, shows how to determine the stages by which the extension of a telephone network might advisably be carried out.

Comparative Calculations of Costs

A telephone connection between the telephone exchange and the subscriber generally passes through quite a number of different elements. Beginning with the switching at the exchange the connection goes through heavy cables laid in conduits or armoured cables to distribution cabinets, whence it continues in cables, mostly aerial cables becoming progressively finer, until finally at the distribution box it terminates in single-pair cable or bare wire to the subscriber.

Considering a given piece of the line section running between the exchange and a distribution box, there is therefore a number of different methods of laying to choose from. The best method as a rule will be that which involves the smallest costs.

If the plant is to be constructed to cover a certain constant demand no difficulty is encountered in calculating the costs, these being determined by the interest on the capital employed, depreciation and maintenance costs, and may be expressed either as annual costs or as the present value of a sum of money laid out for an imagined unlimited period for the first installation, for replacement of obsolete parts of plant and for maintenance of the plant.

The annual cost Y, the present value of the amount invested in the plant N and the rate of interest r have the ratio

$$Y = N \cdot r$$

Thus the annual cost is proportional to the present value of the costs and it is immaterial whether annual costs or the present value of the costs are taken in making comparative cost calculations. Frequently, however, the treatment of more complicated problems will be simpler if the present value of costs is taken.

It is very seldom that the demand in a telephone plant is constant, but the number of subscribers is always increasing. To provide the telephone service, therefore, new investment must be made to keep pace with the increasing demand. In calculating costs for plants with ever growing demand it is not sufficient to take into account the first installation costs alone, but consideration must also be given to future extensions and what will be the cost of these.

This may be done by defining the costs in the same manner as the present value of the costs for providing for a constant demand. The costs for a plant which will be growing in value of plant, therefore, are determined by the present value of the amounts invested in the plant for installations and extensions, replacement of obsolete parts and maintenance of the plant.

Economic Stages of Installation

If the demand in a certain part of the plant, *e. g.*, the number of lines in a cable section, be taken as growing at a constant rate with the progress of time, Fig. 1, this demand may be provided for either in such a manner that large installations are made at long intervals or smaller installations at smaller intervals, *i. e.*, the plant may be extended in large or small stages of installation to provide for one and the same final demand.

Thus if it is estimated that the demand in a cable section will grow by 50 subscribers per annum, then to cover the increase in demand a 200-pair cable may be drawn each fourth year or a 400-pair cable each eighth year. In this case, therefore, it is possible to choose a stage of installation of 200 pairs to cover 4 years or a stage of 400 pairs to cover 8 years.

Practical investigation has demonstrated that it is possible to express most of the cost elements in a telephone network in the form

$$K = a + b \cdot p$$

where K represents the costs per metre, a and b are constants and p is the demand, *i. e.*, the number of pairs in a cable or the number of ducts in a conduit section.

This means in our example that a 400-pair cable does not cost double as much as a 200-pair cable, but something less than double. Consequently if the cable section is extended by 200-pair cables at a time more capital will be expended than if it were extended by 400-pair cables. But, if 400-pair cable is employed the capital must be expended earlier than with 200-pair cable, and this tends to make the present value of the costs greater. As a general rule it may be said that small stages of installation make the costs higher on account of the demands on capital while large stages of installation causes the costs to be higher on account of the capital requiring to be expended on the plant earlier.

It is thus possible to show that for each plant there is a stage of installation which calls for the lowest costs for a future increase of subscribers. This *economic stage of extension, e. g.*, for a cable section, is independent of the plant's useful life and the maintenance costs and is governed solely by the future annual increase in demand c for the cable section in question. The same applies to the *economic range* of a plant corresponding to the economic stage of installation.

The economic range t_x for a given interest rate is a function of the constants a and b and of the annual growth of demand c and it may be expressed

$$t_x = F\left(\frac{a}{b \cdot c}\right)$$

The relation between $\frac{a}{b \cdot c}$ and t_x may be seen in the diagram, Fig. 2, the application of which may be illustrated by the following example.

The cost for the laying of a cable in conduit may be summarised in the equation

$$K = 1 + 0.02 \cdot p$$

The anticipated growth in demand in the stretch is 100 lines per annum and the economic stage of installation is to be found. We then get

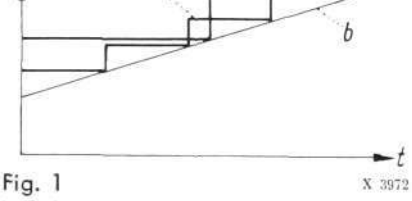


Fig. 1 X 3972

Number of installed lines L as function of the time t for different stages of installation

a stages of installation
b demand

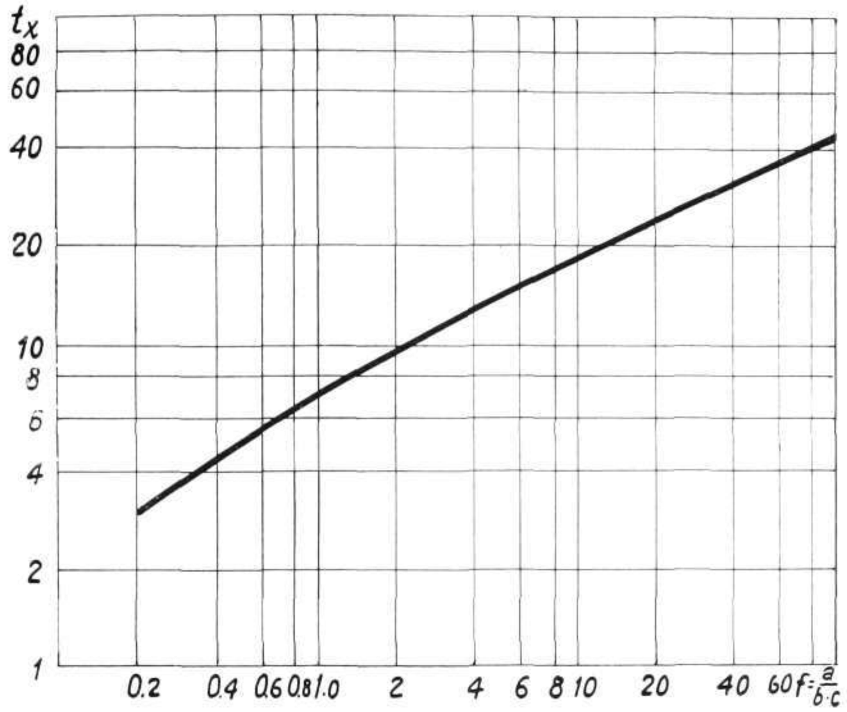


Fig. 2 X 5618
Economic range t_x as function of the constants a and b and the annual growth in demand c for an interest rate of 5 %

$$\frac{a}{b \cdot c} = \frac{1}{0.02 \cdot 100} = 0.5$$

We get from the diagram that the economic range is 5 years and the economic stage of installation will therefore be $5 \cdot 100 = 500$ pairs.

All familiar with building telephone lines know that when planning ample provision should be made for the outskirts of a town. Closer investigation with the aid of the diagram confirms this and at the same time gives a guide as to the length of range the cables should be dimensioned for. It is found that it is economical to draw from the exchange to certain points in the network 600-pair or heavier cables with a range of 2 to 10 years, while from those points to the cabinets and distribution boxes cables should be drawn providing for the demand 10 to 30 years ahead. The consequence is that comparatively large spares should be laid at convenient points in the network. These spares, which in themselves constitute a saving in costs for a telephone undertaking with operations increasing constantly, do not need to lie idle, however, but may be utilised for equalisation of the subscriber growth, always more or less irregular, in the different cabinet districts and the outer parts of the network.

Fig. 3 gives an example of how such an equalisation might conveniently be carried out. The cables from the feed point to the cabinet are armoured. Here the equalisation cables have been joined up in a single system. At the beginning none of the spare cables are connected to the equalisation cabinet, but they are allowed to lie idle in the cabinet manhole, since at the start it is not known which cabinet or cabinets will require a future equalisation. It is probable that only a few of the cabinets will need to be connected to the equalisation cabinet to make the grade of utilisation in the junction cables to the exchange rise appreciably. For cabinet districts at a distance from the exchange it is then convenient to take 100 pairs per cabinet and 6 to 8 cabinets to an equalisation cabinet; an equalisation cabinet for 300 to 700 pairs will then be adequate. For cabinets near to the exchange 50 pairs per cabinet are taken and 4 to 6 cabinets are linked to an equalisation cabinet; in this case 150 to 300 pairs per equalisation cabinet will be quite sufficient. Equalisation may even be done for cabinets situated as close as two to three cabinets distant from the exchange, *i. e.*, as close as 300—500 m.

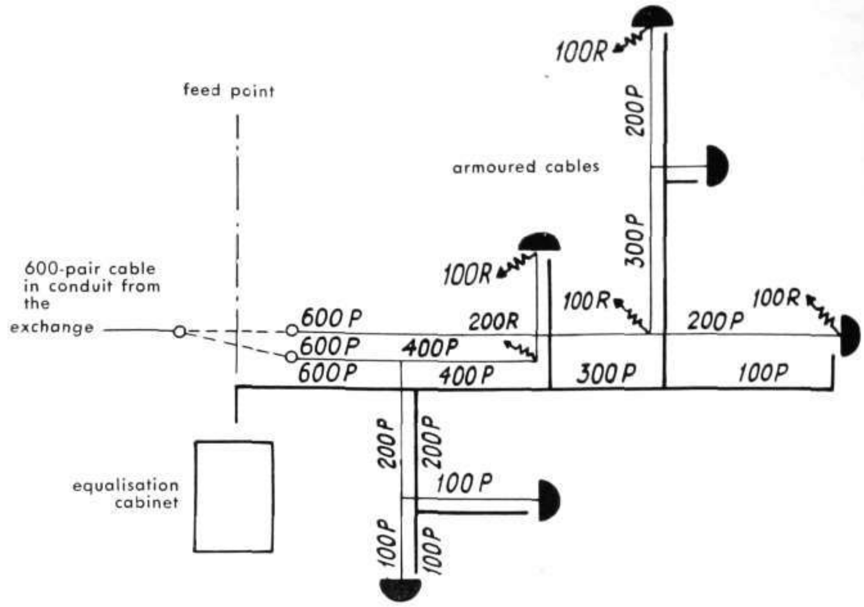


Fig. 3 X 5617
Equalisation of subscriber growth by means of idle spares

When armoured cable is used between the feed point and the cabinet it is frequently an advantage with subscriber growths greater than 10 pairs per cabinet and year to install the cabinets for 300 pairs at the first installation. This may be done conveniently by connecting 200 pairs per cabinet in one cable and the remaining 100 pairs per cabinet in an equalisation cable. With the first installation there would be drawn from the exchange as a rule not more than 100 to 150 lines per cabinet. The result would be that 50 to 100 pairs per cabinet would remain idle in the cables between the feed point and the cabinets, in addition to the equalisation spares. In later extensions cables from the exchange are spliced to these spares. At the same time the facility is available of relieving the equalisation cabinet as much as possible by resplicing in the splicing box at the feed point. The splicing boxes at the feed points, therefore, should be of spacious construction, so that resplicing may be carried out easily when required. With anything like accurate planning such resplicings should not need to be done more than every third or every fifth year.

Finally it should be stated that there is great freedom in the selection of the economic cable size, without the costs of extensions varying by more than a few per cent. This means that it is possible, within certain limits, to link up cables of various sizes to a fixed system with a common range.

It also means that error in estimating the future subscriber growth per annum will not have such a great influence on the costs. For example, if it should prove that the subscriber growth is twice as much or half as much as that anticipated, the costs will only be about 10 % more than the costs that would have been incurred had the dimensions been made to agree with the actual subscriber growth. It has been found by experience that very frequently it is possible to estimate the subscriber increase with this degree of accuracy for a period of up to 10 years.

When drawing up projects it is advisable to estimate the subscriber growth for 10 years ahead, but not longer, and to make use of the average subscriber growth per annum thus obtained, when estimating the economical size of cables.

Some Swedish Remote Control Installations for Railways

E. A. LYNGE, TRAFFIC INSPECTOR, DANISH STATE RAILWAYS, COPENHAGEN

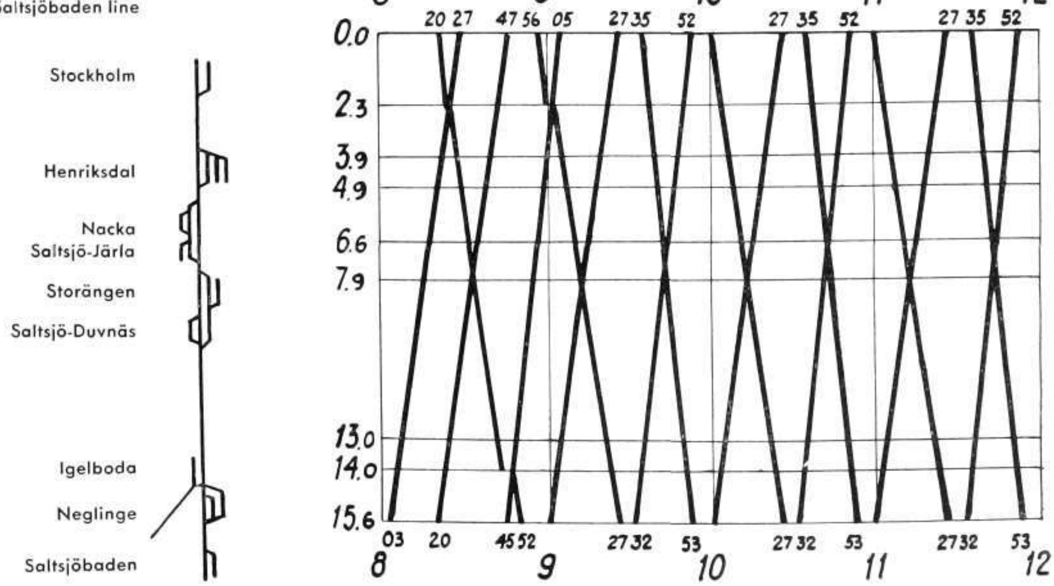
Nothing is so instructive and interesting as to see how things are arranged by other countries in domains where problems are also encountered at home. Direct comparisons should, nevertheless, be avoided, since conditions — especially in the complicated machinery of railways — may differ widely in character and things small in themselves may be decisive in determining whether one innovation or another may be serviceable or applicable. Here will be given some impressions of a visit to Swedish railway control installations, previously published in Dansk Jernbaneblad, June 1939.

The Stockholm—Saltsjöbaden line in recent years has had a remote control installation which very much simplifies operation. The line is 15.5 km long and has electric traction with one train per hour in each direction, supplemented by further trains at the rush hours, namely in to Stockholm in the morning and return from Stockholm in the afternoon. As may be seen from the diagram time-table, Fig. 1, traffic is rather dense, it being observed that the trains depart at about the same times from the terminal stations. The line is single-track except between Nacka and Saltsjö-Järla and between Storängen and Saltsjö-Duvnäs where the track is double. The section from Henriksdal to Neglinge, 11.7 km is operated by automatic interlocking and automatic raising and lowering of level-crossing barriers, and the whole section is remote controlled from a dispatching office at Neglinge, which as regards signals is partially operated by the automatic interlocking plant. The terminal stations, Stockholm and Saltsjöbaden, are both controlled locally.

Examination of tickets is done on the train and sale of tickets to passengers from the remote controlled stations likewise is done on the trains, in summer also at the newspaper and sweet stalls located at each station. This is possible because only 5 % of the sale of tickets on the line affects the unattended stations, the balance of 95 % taking place at Stockholm or Saltsjöbaden.

Fig. 1
Graphic time-table
for the Stockholm—Saltsjöbaden line

X 5577



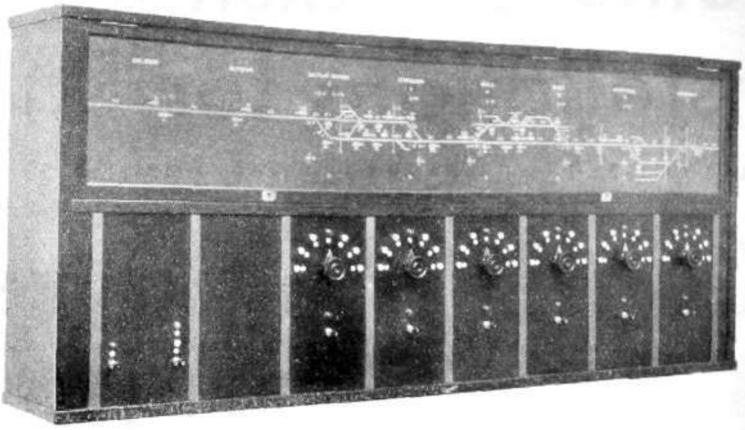


Fig. 2 X 5583
Central panel
with illuminated track diagram and compartments with operating knobs for each CTL-station

The dispatching office, from which the stations supervised by the centralised train dispatching system (CTL-system) are controlled is located at Neglinge, as already stated. The plant has been installed by Signalbolaget and consists of a central panel, Fig. 2, connected by telephone cable with one CTL-station installed at each of the stations Saltsjö-Duvnäs, Storängen, Saltsjö-Järla and Nacka. A CTL-station consists of a series of relays, telephone selector type, etc., fitted in a cabinet and comprising an operating receiver and a control transmitter. In addition two CTL-stations are connected to the cable at Henriksdal where the number of appliances, barriers etc., to be operated by the CTL-system is too large to be served by a single CTL-station.

The central panel has an illuminated track diagram, showing all meeting tracks, double tracks, points, signals etc., and also a compartment with a knob for each CTL-station, six compartments in all, for transmitting the control signals given below. The progress of the train along the line is followed on the track diagram, by the darkening of the illuminated strip sections corresponding to the track intervals, and the positions of the points also appear on the diagram.

The operating receivers are in general adapted for the reception of the following seven order signals from the control panel at Neglinge, *viz:*
train road a^{I}, entrance on the straight track,
train road a^{II}, entrance to the meeting track,
train road *b*, departure from the straight track,
train road *c*, departure from the meeting track,
permission for local operation of entrance points,
suspension of train road blocking for roads a^{I}, a^{II}, *b* or *c*,
switching on the control transmitter, by which the transmitter at the station concerned starts up and repeats the position of the apparatus concerned, which repetition normally may be done when an order signal has been sent out and the order executed.

Each operating switch of the central panel has seven positions, each corresponding to one of the seven order signals. On throwing the switch into a certain position and pressing a button in the switch the appropriate order signal is transmitted by a series of impulses to the operating receiver of the CTL-station concerned, the receiver then attending to the execution of the order, whereupon the control transmitter of the station by emission of a number of impulses causes an indicator on the central panel track diagram to move as evidence that the order has been correctly carried out. When a train *A*, following the opening of the train road by the central panel, has run into a station where it is to meet, and the meeting train *B* is on the way, the central panel — even though against operations rules — may send the order signal »departure for train *A*» but the departure signal shows »clear» only when train *B* has arrived and the track points have been moved. With irregular operation, changes of meeting tracks and so on the engine-driver runs *entirely* by signals and receives no notification of alteration of meeting tracks. The driver then becomes the dispatcher for the train and is responsible for the train's running.

The plant cost some 300 000 kronor and the central panel is operated by one man. The train dispatcher is the station-master at Neglinge. The advantage with such an installation, which in the years it has been in use has operated without any fault worth mentioning, is naturally of an economic nature in the first place.

In a space alongside the dispatching place at Neglinge there was installed on trial a recording instrument, a centralograph Fig. 3, which, control of the functioning of the track relays being desired, was connected provisionally with these, so that it recorded the occupation and clearing of the different insulated track sections. In this way there was obtained at once an automatically drawn graphical presentation of the actual situation, as the apparatus stamped in under the appropriate headings of a paper strip the time the track insulation corresponding to the heading was occupied. Such a recording instrument could be, *e. g.*, connected to the signals of a block section and made to register each time a block signal was set at »stop» after a train, thus causing diagrams to be drawn for supervision of the train running. A centralograph could also be of great use in supervising the train running on certain electrified sections during irregular traffic; on the other hand supervision of electrical running without variation during regular traffic would hardly be necessary.

Another typical example of remote control may be seen at Upsala. Here there is a fairly new and modern central panel, on the Signalbolaget system, with a single interlocking cabin for the whole station and this cabin serves all points, dwarf signals etc. at the station. The whole station is insulated throughout and all movements of trains and setting of signals are shown on the track diagram. There is automatic block working between Upsala and Stockholm (double track line). In addition to Upsala itself this cabin also serves Upsala N, a cross-over station situated 3 km to the north, which thus has no attendance for train dispatching, point changing, signalling etc. Finally from Upsala northwards there are no fewer than eleven level crossings and the barriers for these eleven roads are remote controlled likewise from the cabin at Upsala. It must not be supposed that it is a question of roads with little or no traffic; most of them are streets in Upsala town itself and fairly busy, while one of them even carries a tramway.

When the barriers are to be closed, a switch is thrown (each barrier has its own switch). At the barrier there lights up a red light in the direction of the road to stop the road traffic and a bell begins to ring, the barriers falling 20 seconds after. The procedure in setting signals is normally as follows:

The train road is set, the switches for the barriers are thrown and *immediately* afterwards the signal switch is thrown to »clear» position. The signal remains, however, at »stop» until the barriers are down, then going to »clear». This arrangement means considerable facility for the staff who can carry out the necessary operations at one time without any need to wait, *e. g.*, to be sure the barriers are down. As a further precaution for the level crossings there is set up at each side of the roadway a daylight signal displaying a red light to the track, which does not go out until the barrier is right down. This, therefore, is only a notification for the engine driver and the one light may well apply to a number of tracks. Immediately a train has passed a level crossing the barriers rise automatically, and then the switch at the dispatching cabin can be restored.

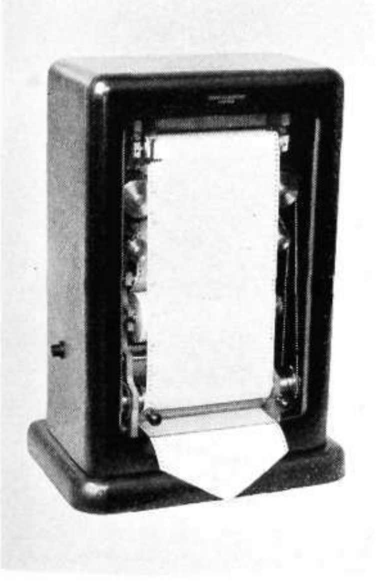


Fig. 3 X 3952
Centralograph
for recording the running of trains

This remote control plant, which may be said to be both comprehensive and bold in conception, has now been in service for about a year and during that time there has not been any kind of failure or drawback in the installation, nor has there been collision with the barriers or similar accident. It is obvious that such a plant requires to be *reliable* in operation, and this requirement too seems to have been met in the plant described. There is not any doubt that road-users display more caution at level crossings because of the fact that *it is realised* that the *only* signals are the light and sound signals and that it means a catastrophe if these are not strictly obeyed.

Stockholm has likewise only one central apparatus to deal with the whole of the large station area. There is automatic interlocking both northwards and southwards from Stockholm and all shunting is done by dwarf signals. Attendance in rush traffic is four men with a leader, at less busy times only two men and in the night one man only.

It is with feelings of admiration that you leave this post after having watched these men at work for a couple of hours. Switches are moved unceasingly, without it being possible to see the train movements that have been permitted by them — otherwise than on the illuminated track diagram. Hardly a word is exchanged, each one knows that when *that* movement comes to *that* point, then it must proceed to *that* shunting road and points and dwarf signals are set accordingly, while the track diagram is kept constantly under observation. It may happen that a loud-speaker at the train dispatcher's place makes an inquiry; it is a shunting foreman on the spot who is inquiring and the dispatcher answers in a microphone. It is not like a telephone call; it is like a chat between two persons in the same room and it is carried on rapidly and easily. Everything seems very complicated but it is naturally routine work in the highest sense and it demands thorough acquaintance with the track lay-out and the work.

Finally mention should be made of an arrangement for running on the right hand track (that is »wrong» track for the general direction of running) between Stockholm and Upsala. For this »wrong» running dwarf signals are provided applicable to this direction of running and the throwing of a switch in the central panel makes running on »wrong» track by signal possible without shunting in and out. It was stated that such running is employed not only when one track is unavailable because of accident, but also to a considerable extent when maintenance work is proceeding on the line.

Railway Interlocking Plant in Portugal

N. ALMGREN, L. M. ERICSSONS SIGNALAKTIEBOLAG, STOCKHOLM

The first railway interlocking plant in Portugal on the Signalbolag system was built at Ermezinde station near Oporto and was described in Ericsson Review No 4, 1937. Since this plant has been completed Compañia Española Ericsson has received an order for another plant for the same railway at Rio Tinto station, situated on the double track line between Ermezinde and Oporto. The erection of this plant was completed during last year.

The interlocking plant at Rio Tinto is of the relay switching type with central press button operation and operated entirely electrically without dependence on any mechanical device. The plant comprises only some ten signals and about the same number of point machines.

The control apparatus is installed in the station building, Fig. 1, and is built into the wall between the office room and the relay room in such a manner that the front of the apparatus is in the office and the back with the line terminals is in the relay room. The front of the control apparatus consists of a vertical bay, divided into two panels, the upper of which contains an illuminated track diagram and the lower one the control buttons and the control switches. Below the control panel the apparatus forms a desk for the train dispatcher, see Fig. 2.

The illuminated track diagram has a skeleton track system of bright metal strips and is provided with pilot lamps for supervising the signal lights, the point positions, the track circuits and the train roads. The pilot lamps on the diagram are placed alongside the tracks and combine to form miniature signals.

Each point has three marking lamps, one in the bifurcation point of the track and one in each branch of the track. The lamp at the bifurcation point remains constantly lit. Of the other two lamps the lamp is lit which is in the track

Fig. 1 X 5614
The station building at Rio Tinto

for which the points are set, providing that the point machine is locked and the points tongue lies to the rail. If the point is in course of being changed or if it has been forced, then only the lamp at the bifurcation point is lit.

The track circuit lamps show which of the station track sections are free and which are occupied by trains or rolling stock.

The train road lamps light up when the train road lever has been thrown, provided the train road locking relay is energised, the train road points are in proper position and the track circuits required to be free for the train road are unoccupied; after the train road has been locked and the signals set the train road lamp remains lit until the train road has been released.

The control panel comprises all the buttons and switches for the operation of the plant, with the exception of the equipment required for control of the power plant. The panel is provided with two point changing buttons for each single point and for each pair of coupled points and in addition has two signal buttons for each home, starting and shunting signal, by means of which these may be set at »clear» or »stop».

A locked train road which for some reason has not been released by a train may be released by special release buttons, which are normally kept sealed. In this plant there are also special switches which in home position break the current circuit to the train road relays; these train road switches must be thrown before a train road can be locked and the signals set.

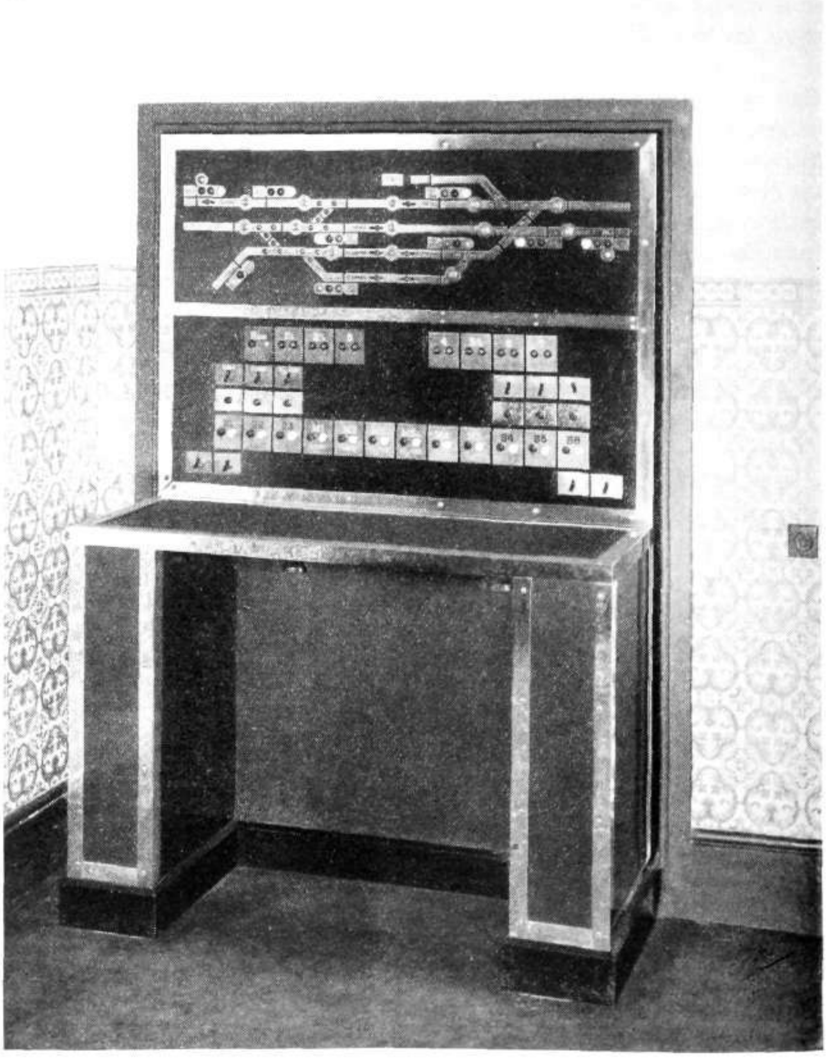


Fig. 2 X 5620

Control apparatus

above, illuminated track diagram; below, buttons and switches

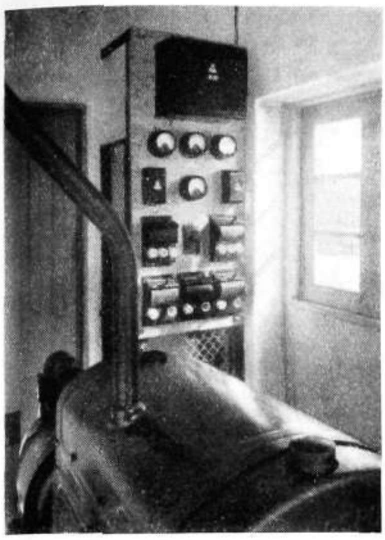


Fig. 3 X 3968
Power plant

A through road switch is provided for each main through track. When the plant is not operating the starting, home and distant signals all show red light. When an incoming track is laid and the home signal »clear» button is pressed, both the home and the distant signal change from red to green light. When an outgoing track is laid and the starting »clear» button is pressed, the starting signal changes from red to white. If both home and starting signals for the same train track are set then the distant signal and the home and starting signals will show green, green and white respectively. If the train track through running switch is then thrown, the distant signal and the home signal will change from green to white; the signals of the train track will therefore all show for through running a fixed white light. The distant signal is automatically controlled by the home signal and by the track circuit between the distant signal and the home signal. Nevertheless the distant signal may be set at »stop» at any moment.

The signals are normal daylight signals, though the starting and shunting signals are combined on common masts and with common »stop» light. The starting signal's white »clear» light is placed highest on the mast immediately above the red light, while the yellow shunting light which has a smaller light aperture is placed a little distance down on the mast, so that the two lights will not be confused.

The distant signals are furnished with lamps having blue light, located below and to the left of the signal lights proper. This blue light, which must always be shining and which is supervised by a pilot lamp on the illuminated track diagram, has the purpose of preventing an engine driver going past the signal without observing it if the signal light is unlit for some reason.

The point and track driving devices, the track circuit equipment and the relay equipment are of Signalbolaget's normal design. There is a storage battery charged by a metal rectifier for feeding the DC relays. Normally the plant is connected to the main transformer of the station, but as reserve in the event of failure there is a petrol engine driven three-phase generator, Fig. 3, which is housed in a separate building along with the power plant, close to the station building.

Telephone Instrument Tester and Microphone Resistance Tester

F. JONSSON AND A. PETERSÉN, TELEFONAKTIEBOLAGET L.M. ERICSSON, STOCKHOLM

The most important property of a telephone instrument is its transmission performance. Consequently, when manufacturing instruments, both the sending and the receiving efficiency must be closely controlled. Formerly this was done by speech test, which was not only timewasting and therefore expensive, but also called for specially skilled staff.
Therefore, to obtain a more routine-like and appropriate testing of the efficiency of telephone instruments, the speech test has been replaced by mechanical testing devices. Such a form of apparatus was first designed by the British Post Office. Later on Ericsson, following the same principles, designed a new type of telephone instrument tester such as will be described in the present article.

Principle

The efficiency of a telephone instrument is characterised partly by the ability of the microphone to convert speech into electric pulsations — sending transmission — and partly by the efficiency of the receiver as converter of such pulsations into sound waves — receiving transmission. For mutual matching of microphone, receiver and line there is in the telephone instrument a transformer, the induction coil, the properties of which are comprised in both sending and receiving transmission.

In speech tests formerly employed the efficiency of a telephone instrument was judged by means of hearing, with the human voice constituting the source of sound. In the mechanical transmission tester the speaker is replaced by a loud-speaker which is fed by a special frequency mixture. The listener has been replaced by a sensitive instrument, graduated in neper, on which the sending and the receiving efficiency of the instrument may be read direct.

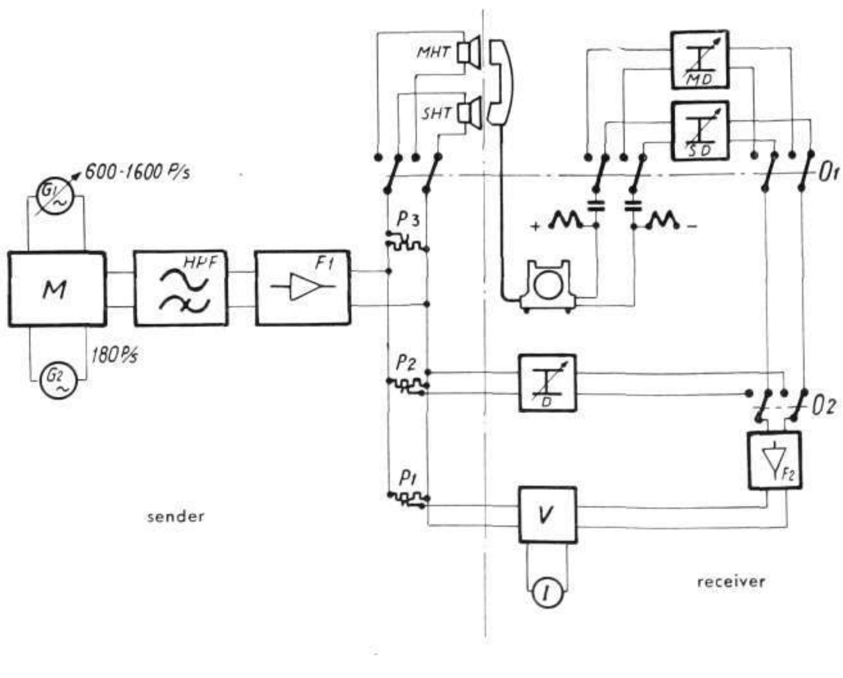


Fig. 1 X 5600
Diagram of telephone instrument tester

D	attenuator
F_1, F_2	amplifiers
G_1, G_2	generators
HPF	high pass filter
I	sensitive instrument
M	modulator
MD	attenuator
MHT	loud-speaker
O_1, O_2	switches
P_1, P_2, P_3	potentiometers
SD	attenuator
SHT	loud-speaker
V	differential voltmeter

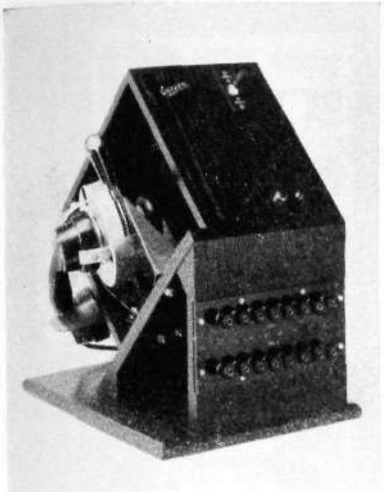


Fig. 2 X 3965
Loud-speaker stand

The Ericsson telephone instrument tester, see diagram, Fig. 1, consists of two main parts, the transmitter and the receiver. In addition to this there are checking devices etc.

Transmitter

The frequency mixture with which the loud-speaker is fed is produced by means of two generators *G1* and *G2*. The former consists of an interference generator, the frequency of which, by means of a motor-driven rotating condenser, varies six times per second from 600 to 1 600 c/s. Generator *G2* furnishes 180 c/s AC. These frequencies are mixed in a modulator *M* with a modulation degree of 50 %. Since the low frequency AC is used only for modulation, a high pass filter *HPF* with a cut-off frequency of 180 c/s has been inserted after the modulator. After the filter, the AC current, therefore, consists of three frequencies: the variable frequency and the variable frequency + 180 c/s and — 180 c/s. This frequency mixture is delivered to a power amplifier *F1* which via a potentiometer *P3* feeds one of the loud-speakers *SHT* or *MHT*, according to whether the sending or the receiving efficiency is to be tested.

The handset of the telephone instrument under test is fixed in a separate stand, see Fig. 2, holding the two loud-speakers, one facing the microphone and the other facing the receiver. The position of the handset is the one prescribed by the CCIF for speech tests (White Book, part IV, page 184).

When measuring the receiving efficiency the receiver has to act as a microphone. This testing method has proved to give the same result as if the receiver functioned in the ordinary manner. The acoustic load which the human ear exercises on the receiver has, however, a certain effect on the measurement. This load is here produced by a dummy ear, which also is built into the loud-speaker stand.

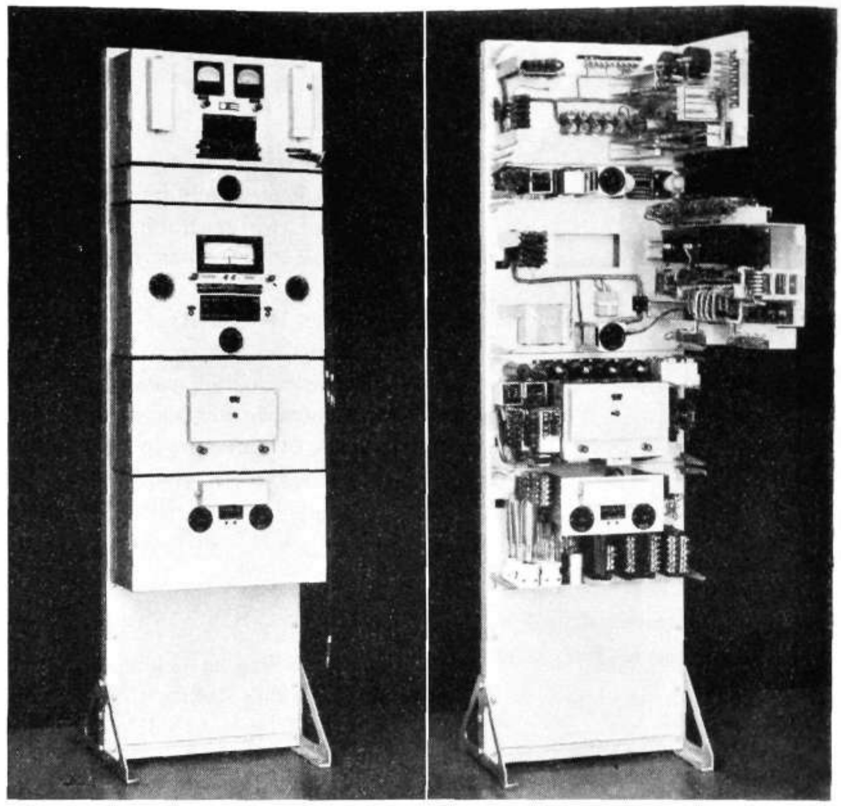
The feeding of the loud-speakers is controlled by a step-by-step driven selector together with relays, including in their function the actuating of the switch *O1*. When testing the sending efficiency, sound impulses of 2 s duration and 2 s interruption are employed. The object of this is to prevent the microphone being packed, which would occur if it were continuously affected by a constant sound intensity. Also, the microphone must be stabilised before reading is taken. Tests have shown that five sound impulses are required for this stabilization.

The current to the loud-speakers is regulated by the potentiometer *P3* and can be read off on a control instrument. It is given such a value that the sound pressure will be 11 μB, equivalent to the sound pressure corresponding to normal speech.

Receiver

The AC current produced in the microphone of the receiver of the telephone instrument passes an ordinary exchange equipment, represented by feeding coils and condensers, and a variable attenuator characteristic impedance 600 ohm/0°) *SD* or *MD* for sending or receiving tests respectively. The AC current is then delivered to the amplifier *F2* from the output side of which it is fed in to one side of a differential voltmeter *V*. The other side of the voltmeter is fed from the sender over a potentiometer *P1*. A sensitive instrument *I* is connected to the voltmeter. The scale of the instrument has the zero in the middle with a positive and negative graduation of 0.1 neper on either side.

The differential voltmeter, therefore, is fed at one side with constant voltage from the sender and at the other side with a voltage, the value of which is depending on the sending and receiving efficiency of the telephone instrument.



X 5606

Fig. 3
Transmission tester
left, with covers, right without

The measuring instrument shows the difference between these two voltages, and the deflection, therefore, will be a measure of the transmission efficiency of the telephone instrument.

By means of ordinary telephone instruments, checked by careful speech tests the instrument is adjusted to zero deflection. By appropriate setting of the variable attenuator the deflections obtained on the measuring instrument may be given direct against SFERT.

Control Devices

By means of voltmeters and milliammeters DC and AC, the valve voltages and currents can be tested as also the voltages of the generators, the currents through the loud-speakers etc.

For the testing of the receiver there is a calibrating device, which is to be connected in by the switch *O2*. The amplifier *F2* is fed with a constant voltage from the sender, via potentiometer *P2* and a variable attenuator *D*, instead of the voltage from the telephone instrument. It is possible by means of the calibrating device to check the zero point of the sensitive instrument, as well as the neper scale.

Construction

The different components are of Ericsson standard construction. Generators, amplifiers, testing devices etc. have been built up as units on panels, combined on a floor stand, Fig. 3. The panels are provided with covers. All parts are mounted to be easily accessible for adjustment and inspection. It is necessary to remove the covers to set the potentiometers and other adjustment devices. This prevents the setting of the apparatus being inadvertently altered.

The frequency of the mains supply must be 50 c/s. Mains transformers are switchable for all usual mains voltages. The tester is provided with stabilizing devices for levelling comparatively large mains voltage variations. Storage batteries are used for feeding the telephone instruments and the relays. The battery voltages can also be tested.

Range of Employment

It is possible with this telephone instrument tester to test the sending and receiving efficiency of LB, CB and automatic telephone instruments. In order to test telephone instruments for various feeding systems, the tester is provided with exchange equipments for the following systems:

voltage, V	24	24	48	50	60
feeding coils, ohms	300+300	400+400	800+800	200+200	500+500

A 3 V dry cell battery is supplied for testing LB instruments.

Separate microphones and receivers may also be tested. For this purpose six of the more common instrument connections are built in. These are connected up by switches. The microphone or the receiver under test is inserted in a handset. They constitute together with the instrument connection in the stand a complete telephone instrument and are tested in the same manner.

The telephone instrument tester may be combined with another test set — the telephone instrument component tester — with which other necessary tests of telephone instruments may be carried out.

The apparatus is also provided with devices for operating a microphone resistance tester employed for testing the DC resistance of transmitter insets.

Testing Operation

When the telephone instrument to be tested has been connected to terminals on the loud-speaker stand, see Fig. 2, and the exchange equipment designed for the type of instrument has been switched in, the handset is fixed in the loud-speaker stand by a simple grip. After pressing a starting button, sound impulses are sent out from the loud-speaker in front of the microphone. On the fourth sound impulse an indication lamp lights up on the stand and on the fifth impulse another lamp lights to show that the sending efficiency is to be read off. Immediately afterwards the loud-speaker in front of the receiver is connected in for about 6 s, and the receiving efficiency is read off. An illuminated sign indicates whether sending or receiving efficiency is being tested.

By adjusting the setting the two variable attenuators *SD* and *MD* to fit the telephone instrument type under test, centre reading may always be obtained on the sensitive instrument, provided the telephone instrument has normal transmission properties. If, however, a deflection is obtained the transmission properties of the telephone instrument are above or below standard. The deviation from standard may be read in tenths of neper and by adding or subtracting the setting of the attenuators the sending or receiving efficiency may be obtained direct against SFERT.

If it is desired to test sending or receiving only, a switch is thrown. The desired test only will then be executed.

Testing Capacity

Compared with speech test a considerable amount of time is saved by this telephone instrument tester. About 100 telephone instruments may be tested per hour. Moreover the accuracy will be considerably greater. The tester is easy to operate so that the tests may be carried out by comparatively unskilled staff.

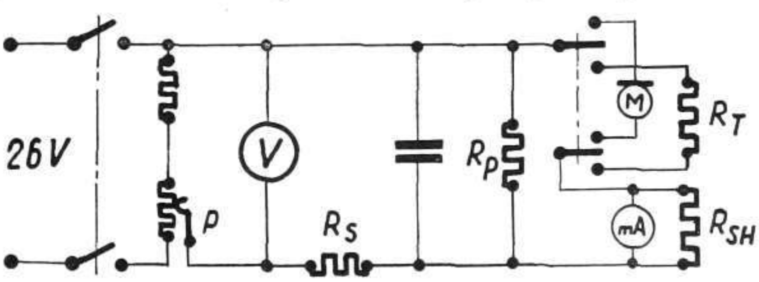


Fig. 4 X 5601

Diagram of microphone resistance tester

M microphone
mA milliammeter
P potentiometer
R_P shunt resistance
R_S series resistance
R_{SH} shunts
R_T resistance
V voltmeter

If the tester is combined with the component tester mentioned, both transmission and other tests can be carried out by one man only without time wasting connections, and this considerably facilitates a progressive manufacture.

Microphone Resistance Tester

Formerly when measuring microphone resistance the inset was placed in a special connection, so arranged that a microphone with normal resistance received normal microphone current. The resistance must be measured under normal working conditions, *i.e.* during speech. Therefore a person spoke in the microphone and read off at the same time the deflection on a milliammeter, connected in series with the microphone. The resistance value was then obtained by means of a calibrating curve.

In the Ericsson microphone resistance tester the connection of the microphone has been largely kept unchanged; thus the microphone is traversed by normal microphone current but the human voice is replaced by the sound from a loud-speaker which is fed with the same frequency mixture as used in the telephone instrument tester. The same sound impulses also — *i.e.* 2 s duration and 2 s interruption — are used as when testing sending efficiency.

In the measuring device, see diagram, Fig. 4, the test voltage is 24 V. The tester is connected to a 26 V storage battery, in order that the test voltage may be adjusted to exactly 24 V by means of a potentiometer P. This voltage is supervised by the voltmeter V, which is connected in all the time. The microphone M, which is connected in series with a milliammeter mA, is connected to the test voltage over a shunt and a series resistance, R_P and R_S respectively. The deflection of the milliammeter will then be governed by the microphone resistance. Provided the test voltage is 24 V constantly the instrument may be graduated direct in ohms. To make the scale more distinct the milliammeter has the zero point suppressed. The instrument is adjusted in such way that middle deflection is obtained at normal microphone resistance. There are two scales, one of which multiplied by a constant gives the microphone resistance direct, the other the deviation in percentage from the normal value.

The measuring device is switchable, so that transmitter insets for normal resistances of 40, 60, 100, 150 and 200 ohms can be measured. In addition there is a reserve measuring range. By suitable dimensioning of the series and shunt resistances R_S and R_P and the shunts R_{SH} of the milliammeter the two scales of the instrument can be used for all these ranges of measurement. For testing purposes it is possible to connect an external resistance R_T instead of the microphone.

The microphone resistance tester is made as a case, Fig. 5, with the loudspeaker accommodated in a separate compartment which is soundproof. It is connected to the telephone instrument tester. The terminals are placed at the back.

The inset under test is placed in a holder which is inserted in a tube where it is so guided that the microphone gets a certain fixed position in relation to the loud-speaker. The holder is then given a half turn, which make a contact and causes a starting impulse to be sent out to the telephone instrument tester which then begins to transmit current impulses to the loud-speaker. On the fifth impulse a lamp lights up, as indication that the instrument is to be read. The rotating of the holder provides, in addition to the emission of the starting impulse to the transmission tester, a necessary shaking up of the microphone.

The microphone resistance tester makes a rapid, accurate and uniform testing of the resistance of the microphone possible. The testing capacity is 100 to 120 insets per hour.

Fig. 5 X 2964
Microphone resistance tester

Service Boxes for Gebe Fittings

E. JENSEN, SIEVERTS KABELVERK, SUNDBYBERG

In their latest catalogue Sieverts Kabelverk include a special section for connecting boxes, designed for connecting single conductor bare wire to Gebe (V. I. R. lead covered) cable. Since two of these are bakelite boxes of quite new design, a brief description of them will be given here.

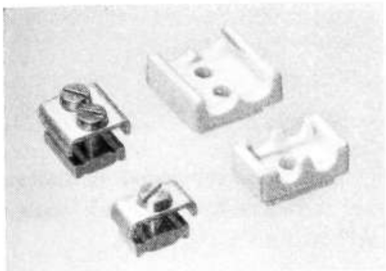


Fig. 1 X 3970

Terminal clamps with steatite bases

above, for up to 6 mm² conductors; below, for up to 16 mm² conductors; the smaller clamp may be used in either box

The connecting boxes made earlier by Sievert were intended for mounting on walls or poles. There was also a demand for boxes that could be employed on the top of a tube pillar. The new box has been given a shape making it suitable for all three methods of mounting.

In view of the fact that there is a series of Gebe packings for conductors to 6 mm² and another series for conductors of 10 to 16 mm², it was only natural that one box should be made for up to 6 mm² and another for conductors not exceeding 16 mm².

The box may be furnished with terminals, Fig. 1, which are inserted in pockets specially made for them, one for each conductor. The terminal may also be fitted in a base of steatite so shaped that the base also fits in these pockets. The terminal has a shaped lower part of rolled brass, a binder of anti-rust treated sheet iron and 5 mm terminal screw. The underpart has two grooves on the one side for up to 6 mm² and two for 10 to 16 mm² conductors on the other side. For the thinner conductors the clamps are 10 mm long, have only one screw and the smaller grooves face the binder. For the heavier conductors the clamps are 20 mm long, have two screws and the thicker grooves face the binder.

The box itself, Fig. 2, comprises a base in the centre of which the Gebe conductor enters from below and a domed cover with an internal screw-thread for screwing it to the base. To ensure that the cover takes the screw without fail it has a cylindrical guide-piece outside the screw-thread.

For leading in the single conductors to the box the base has four holes marked out in thinner material, in which holes can be punched for the number of conductors to be inserted in each case, Fig. 3. The lead-in hole for the Gebe conductor is shaped as a comparatively deep throat which, after the insertion

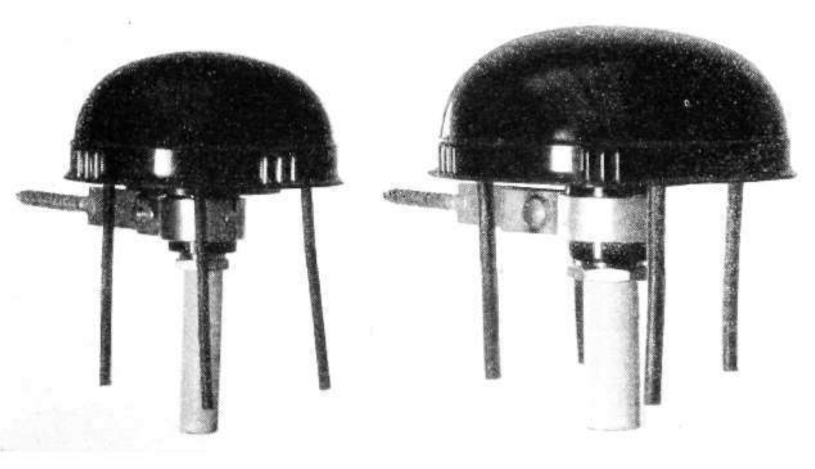


Fig. 2 X 5615

Connecting boxes

left, small type; right, large type

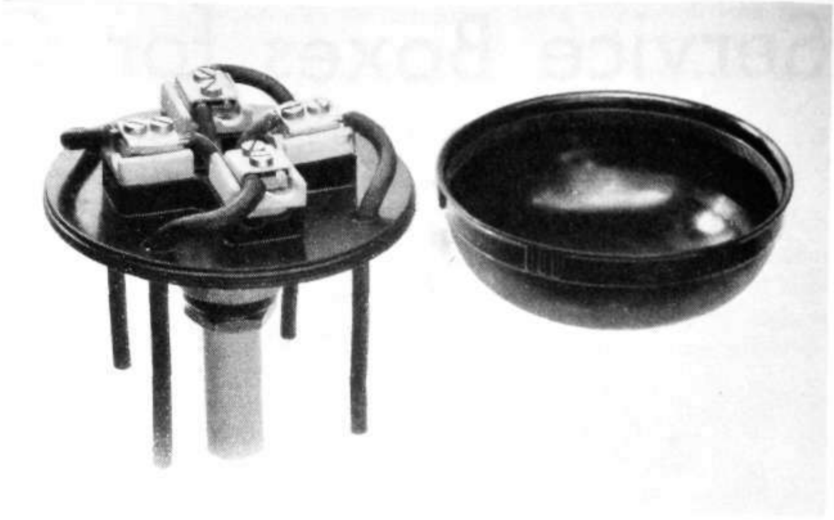


Fig. 3 X 5616
Connecting box with cover removed
and conductors led in and fixed to terminals

of the conductor, can be sealed with soft insulating compound if desired. Concentric to the lead-in hole there is another throat underneath, wide enough to take a 2″ tube. The smaller throat-hole will fit into a $1^3/_4$″ tube.

When the box is to be mounted on a pole or a wall a stainless steel bracket is used, one end being shaped as a wood-screw and the other as a clamp fitting the throat of the box. The clamp is divided and is held together by a screw and nut. If the Gebe conductor is already connected when the box is to be fixed, the clamp is opened sufficiently to allow the conductor being put in without threading through, see Fig. 4.

In view of its design the manufacturing and stocking of the box is a simple matter. In addition to the socket-screw and packing which are common to ordinary Gebe material, each box requires two bakelite parts, a terminal clamp, a steatite base and a bracket. The manufacture of the two types of terminal takes the same profile material, hoop iron and screws. It would of course be possible to employ one large box for all conductors, thus saving two expensive bakelite tools and still further simplifying manufacture and stocking. However, since the catalogue price would have been increased by about 30 % for the thinner conductors, users who have to pay for the boxes will appreciate that Sievert has not carried simplification further than has been done.

Fig. 4 X 3971
Connecting box with divided bracket
for mounting on pole or wall

The box being of bakelite, it might be objected that such material cannot be employed out of doors as it would be affected by sun and rain. The reply to this is that by adopting a suitable design, selecting suitable type of bakelite, employing high quality material for the moulding and doing the moulding in correct technical manner, there is every reason to anticipate that the bakelite will not be affected by exposure to outdoor conditions. In actual fact it will stand far more exposure than the general run of material to be found in outdoor fittings. Good experience gained with the employment of bakelite in Gebe fittings provides sufficient guarantee of the high quality of these connecting boxes.

Europe's Largest Rotating Clock

S. RICHTER, L. M. ERICSSONS FÖRSÄLJNINGSAKTIEBOLAG, STOCKHOLM

An advertising or publicity sign to serve its purpose must be so constructed that it attracts the attention of the public. If, in addition, it is made in such a manner that the public deliberately turn their eyes to it, the publicity obtained will naturally be so much the more valuable. Consequently clocks have for long been employed in conjunction with publicity and this form of advertisement has become still more appreciated since the introduction of the electric clock, whose reliability commands the confidence of the public.

Therefore, when one of the large department stores of Stockholm decided upon an advertising sign of giant dimensions judged by European conceptions, this was combined with an electric clock. Ericsson, who had already executed a number of tower and façade clocks, was entrusted with the execution. The steel frame-work and the neon light plant have been carried out by other specialised firms.

In the rotating giant sign which Nordiska Kompaniet has had set up on the old telephone tower at Brunkebergstorg, Stockholm, Fig. 1, the clock-face has a diameter of 7 m, making it the biggest of its kind in Europe, perhaps in the whole world.

The clock-face consists of angle-iron work welded through-out and faced with sheet-iron. In the centre of the frame-work which the construction forms there is built in the gearing for the hands. The face and the hands are fitted with neon lighting in red and at the back of the face is the NK emblem neon-lighted in green. The sign, that is the rotating part, is borne on a seamless steel tube mast about 35 cm outside diameter which is anchored in the tower. In this tube runs the driving shaft of the sign, consisting of three concentric seamless steel tubes. The sign runs on ball-bearings and rotates at a speed of 4 r/m. The driving power is furnished by a three-phase geared motor of 1 hp. The machinery is located in a specially constructed machine-room, situated 12 m below the centre of the clock-face. The whole sign weighs 7 tons.

Fig. 1 X 5603
The telephone tower at Stockholm with the advertisement clock

Construction

The plant is controlled by a master clock, fitted with precision pendulum and automatic electrical winding; the clock has a contact device which at the conclusion of each full minute sends out an electric impulse to the control apparatus. This comprises connecting device for the operation of the clock motor and a secondary clock mechanism which actuates the connecting device by means of the minute impulses arriving from the master clock.

The clock motor consists of an asynchronous motor of 0.1 kW, 2 800 r/m; it is linked over an electrical connection with a bevel gear having the gearing ratio 1 : 15 000, this gear being wholly enclosed in an oil bath. The movement of the motor is transmitted to the hand gearing by bevel gears and a shaft 12 m long, provided with a special coupling device to allow for variations in length due to changes in temperature.

The gearing does the necessary gearing down for the hour hand movement. On account of the great stresses, about 150 kg/m^2, that may be transmitted to the hands through wind load, and the limited space at disposal for enclosing the gearing, the shafts for the hands have been made of high content chrome nickel steel. The hands are made of steel tube to reduce aerodynamic resistance and they are also statically and aerodynamically balanced — aerodynamically by the tail ends of the hands being sheet metal faced. To provide transmission of the AC current to the transformers for the neon lighting, which is built in to the hands, each clock-hand shaft has a pair of slip-rings. The tension is transmitted to the minute hand by a cable drawn through the centre of the minute-hand shaft, and to the hour-hand by cables laid in milled out grooves on the hand.

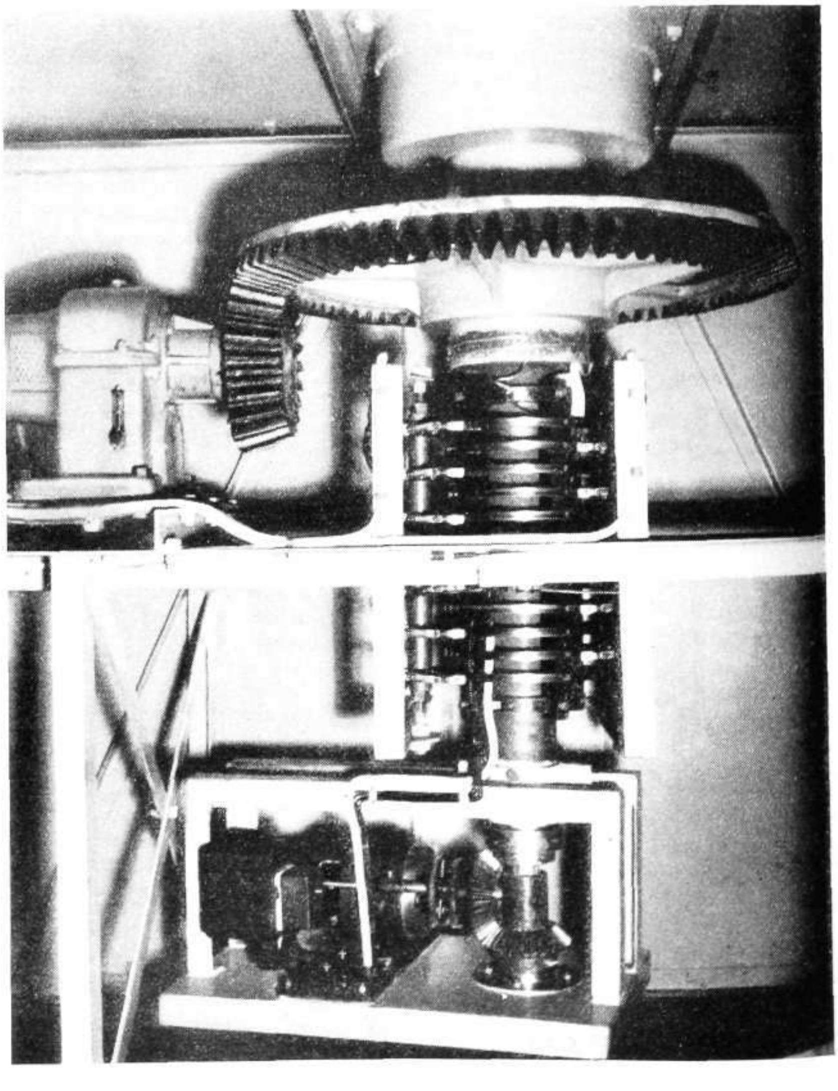


Fig. 2 X 5604

Interior of the machine chamber

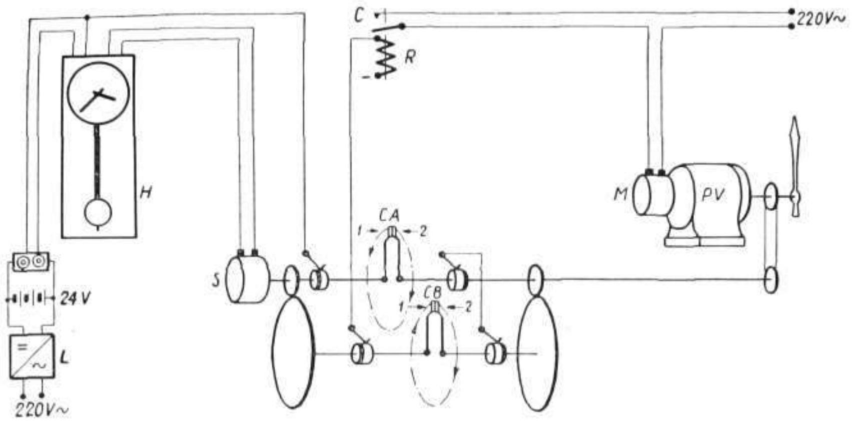
above, to left, geared motor for the clock's rotation; below, centre, clock motor with control apparatus

X 5602

Fig. 3

Diagram of the clock plant

C	contact
CA, CB	connecting devices of the control apparatus
H	master clock
L	charging device for continuous battery charging
M	asynchronous motor
PV	bevel gear
R	operating relay
S	secondary clock mechanism



The motor machinery, *i.e.*, the motor and the operating apparatus, are mounted on the console bracket fixed to the lower shaft pin of the rotating part, see Fig. 2. The clock motor is driven by 220 V AC and the other appliances by 24 V DC, provided by an alkaline storage battery, maintained charged automatically. These tensions, as also the minute impulses, are transmitted to the motor machinery via brushes and slip-rings mounted on the lower shaft pin.

Since the accuracy of running of the master-clock is the decisive factor for the value of the whole clock plant, it has been housed in a well protected chamber in the building below the tower; this arrangement ensures practically absolute reliability of operation for the clock plant as a whole.

Operation

The method of operation of the plant may be seen by the diagram, Fig. 3. The master clock *H* emits each minute a current impulse to the control apparatus secondary clock mechanism *S*. When this mechanism receives the impulse, the wiper *CA1* moves a sixtieth part of a revolution while at the same time the contact *CA* breaks the circuit to the relay *R*. The contact *C* then makes, whereupon the motor *M* is started and moves the hands forward.

Since the clock motor shaft is mechanically coupled to the control apparatus, it carries with it as it rotates the shaft which supports the wiper *CA2*. When this comes back to a point right opposite wiper *CA1*, the hands will have covered a distance on the dial equivalent to one minute. The current to relay *R* is restored and the contact *C* is broken, whereupon the motor stops. The operating time amounts to about 5 s.

If there is interruption in the AC circuit, the wiper *CA2* will not be moved. The wiper *CA1* will, however, continue to traverse a sixteenth part of a revolution for each minute impulse sent out by the master clock. Thus after 60 min interruption of current the two wipers will once more meet. In series with contact *CA* there is another contact *CB* which in relation to *CA* is geared down in the ratio 1 : 12. When the wipers *CA* once more meet after 60 min current interruption, the wiper *CB1* will then have moved a twelfth part of a revolution and by this prevents the closing of the circuit of relay *R*. When the tension returns the motor is immediately started and continues to run until the wipers *CA2* and *CB2* have moved the same stretch as the corresponding wipers *CA1* and *CB1*. In this manner the impulses arriving during interruption of current are stored up in the control apparatus, in order that immediately tension returns they can set the hands right in agreement with the time shown by the master clock.

Ericsson Technics

Ericsson Technics No 4, 1939.

T. Laurent: Frequency Transformation of Transmission Lines

Many who are not familiar with the methods and possibilities of frequency transformations assert that such transformations are of so special an interest that they can only appeal to certain experts. There are, however, few mathematical tools of the advanced theory of electrical engineering which are so universally useful as the frequency transformations and which, upon a closer knowledge, prove so profitable. In the present work there will be shown how the frequency transformations may advantageously be used also within the theory of transmission lines. Thus, *e. g.*, certain interesting relations concerning the *Thompson* line found by *S. Ekelöf* and *N. Svartholm* will be verified. These results will be further developed by means of frequency transformations and thus the existence of an infinite number of different types of ideal lines is discovered. Finally it will be pointed out that the mathematical theories derived are bound to be of great practical importance for the dimensioning of automatic telephone exchanges in such a way that they, in conjunction with the transmission lines, form distortionless systems.

Ericsson Technics No 5, 1939

Y. Rapp: Economic Stages of Extension for Telephone Networks

In a telephone plant which grows with the passage of time and where successive investments are required it is not always immediately clear how the costs shall be defined and compared when deciding on the extension policy that will lead to the lowest costs. Obviously it is not merely the first cost of the installation that has to be considered in such a case. A certain amount of attention must also be directed to later extensions and their probable cost.

The aim of the present article is to furnish a guiding method for estimating comparative costs for undertakings with ever growing activities and which for this reason require continuously increasing investments, and to show how on the basis of such calculations the appropriate stages of extension of the various parts of a telephone network may be determined.

First, attention is given to costs estimates for plants designed to provide for a constant demand. The treatment is then widened to cover plants which are to provide for a demand constantly increasing with time. On the basis of this there is shown a method of estimating economic stages of extension for different parts of the plant, *i.e.*, the size of extensions that should be made at various points of time to ensure the costs being the smallest possible. The treatment is illustrated by simple examples.

The results obtained are applied to a case with cost data taken from actual practice. Comparative estimates of costs are made and the economic extension stages determined for conduits, cables in conduits, armoured cables and aerial cables. Finally there is given an example of how the spares in the outer parts of the network may be utilised to equalise the growth of subscribers in different cabinet districts.

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