

TWELVE READINGS OF THE METERS

## Telefonaktiebolaget L. M. ERICSSON

## The ERICSSON REVIEW

Responsible Publisher: HEMMING JOHANSSON
Editor: ANDERS BYTTNER
Editors Office: Kungsgatan 33
Subscriptions: one year $\$ 1: 50$; one copy $\$ 0: 50$

## CONTENTS:

The New Ericsson Telephone Pageby G. Grönwall4
Indicating Plant for Stock Exchange Quotations by E. Schewelov ..... 12
Ericsson's Selective Calling Telephone System for Railways by H. V. Alexandersson ..... 17
Condensers for Protection against Atmospheric Excess Voltages by R. Lundholm ..... 31
World Telephone Statistics by A. Lignell ..... 36
The Direct Current Track Circuits on the Electrified Lines of the Swedish State Railways by T. Hárd ..... 43
The Subscriber's Multiple and Other Multiples in the Ericsson Automatic Telephone System by S. Johansson ..... 49
Design and Use of Brush Switches by C . Kihl and S. Andersson ..... 51
Standardization of Electric Cooking and Heating Appliances
by A. Kvam ..... 56
The Ericsson Automatic Fire Alarm System Saves Millions ..... 57
Big Success of Bakelite Telephones ..... 59
Automatic Exchanges in Finland ..... 60
Elektrisk Bureau Builds Ericsson Automatic
Exchanges for Iceland and Norway ..... 61
Ericsson Technics ..... 63
Measuring Instruments ..... 64
The Duration Meter ..... 65
News from the Research and Development Department ..... 67
Centraltryckeriet, Stockholm 1933 ..... 69

New DesignsPrinted in Sweden


# Hans Th. Holm 

General Manager, Telefonaktiebolaget L. M. Ericsson

## The New Ericsson Telephone

By
G. GRÖNWALL

Head of Design Department, Telefon A.-B. L. M. Ericsson, Stockholm.


A modern design of telephone instruments must meet the needs of the local service as well as the increased requirements brought about by the rapid development of long distance telephony.
Further, modern trends in the esthetic design of the instruments must be considered, and all possibilities of simplification and economy in construction must be observed.
Taking into account the most exacting requirements of transmission technics, and by utilizing all constructive possibilities of the materials, Ericsson has designed a telephone, which in elegance of appearance as well as in articulation and quality of tone stands up as the best that modern technique can produce.

The new telephone instruments which are described below are intended for use with automatic and manual central battery systems, and are the results of extensive scientific and constructive research work.

The scientific problems have been worked out with special consideration to international long distance telephony, which has recently made rapid strides and has increased the demands on the telephone instrument's ability to effectively send and receive the spoken word. The new Ericsson telephone instruments are designed to meet all demands in this respect.

They are carefully designed, special attention being paid to the standardizing of the components with which they are built, and also to simplicity in adjusting and maintenance of the instruments in use.

They are of solid construction and mechanically durable and are made from the highest grades
of raw materials which ensures long life in service.

Standardization has been obtained by simple unit construction and the greatest possible limiting of the number of components used, and also by interchangeability. The parts used in the instruments, such as dial, handset with cord and also the internal units, such as ringer, induction coil, key and switches are similar in both table and wall instruments.

A characteristic feature of both types of instruments is the fitting of a mounting plate on which the inner parts are fixed and wired. This chassis is easily detached and replaced; its position being such that both the ringer and switch are easily accessible for inspection and adjustment.

The handset and terminal block cords and the dial cable are connected to the instrument by means of screw terminals. The wiring of the

x 1012 Fig. 1. Table telephone of bakelite, Type DE 702.

x 1013 Fig. 2. Table telephone of bakelite, Type CG 502.


Fig. 3. Wall telephone of bakelite, Type DE 200.


X 1015
Fig. 4.
Wall telephone of bakelite, Type CD 1200.
inner components is soldered. By reason of these parts having their own solder contacts, necessary changes can be made without disturbing other connections.
The outside parts of the instruments are made of moulded bakelite. This material possesses high insulating qualities, good mechanical strength and resistance to chemical action, and is capable of being easily moulded and retains a bright, hard and durable surface.
The instruments which are shown in Figs. 1, 2, 3 and 4 are supplied as standard in black. Fig. I shows a table instrument with dial. Instruments intended for use on manual CB systems are supplied without the dial which is replaced with a dial blank shown in Fig. 2. Figures 3 and 4 show wall instrument with and without dial.
Thanks to their simple and clear lines and the beautiful apearance and durability of the bakelite the new instruments present an attractive appearance and fit in with both traditional and modern styles of furnishing.

## Circuit.

The upper part of figure 5 shows the circuit diagram which is the same for both wall and table instruments. The under portion shows the wiring diagram of the table instrument. The wall instrument does not possess the terminal block shown on the right; otherwise the circuit is the same as for the table set. On instruments for central battery working the dial $d$ is not required, and a metal connection strap joins the terminals 10 and 12 . The changing of an instrument from central battery working to automatic system is therefore extremely simple. Anti-side-tone connection is used. During speech the ringer $B$ is out of circuit. Whilst dialling, the condenser $C$ in series with the resistance $5-6$ is connected in parallel with the impulse contact; this is done in order to reduce extra voltages and also to increase the efficiency of the impulsing circuit.

During the dialling the induction coil, transmitter and receiver are short-circuited in order to prevent the impulses being heard in the receiver.


Fig. 5. Principle and wiring diagram for table telephone, Type DE 702.

| B. ringer | M. microphone |
| :--- | :--- |
| C. condenser | R. receiver |
| D. dial | EB. extra bell |
| $L_{1} L_{2}$ line | IC. induction coil |

In order to make possible the connecting up of an extra ringer $E B$, if so desired, the table set is provided with a 3 -way cord to the terminal block. The extra ringer is connected to the terminals 3 and 4 in the block.

On the wall instruments the extra ringer is connected to the terminals 3 and 5 .

The electrical data given below refer to instruments intended for use with Ericsson automatic exchanges for 24 V battery voltage and $400+400$ ohm feeding coils.

## Table Telephone DE 702 for Automatic Systems.



X 1017
xig. 6. Section of table telephone, Type DE 702.

| a | case | l | spring group |
| :--- | :--- | :--- | :--- |
| c, $d$ | dial | $b, m, n$ | switch mechanism |
| $f, g$ | bell | 0 | induction coil |
| $i$ | condenser | p | terminal strip |
| k | spring for fixing the con- <br> denser | s | base plate |

Figure 6 shows a table set in section, and Figure 7 shows the chassis detached from the case. The table set is composed of the following units
I. Case,
2. Dial,
3. Chassis,
4. Base Plate,
5. Handset with Cord,
6. Terminal Block with Cord.

## 1. Case (Fig. 6 a).

A characteristic feature of the new telephones is that they are made without the traditional switch cradle for carrying the handset. Instead, the case, which is moulded in one piece of bakelite, is shaped so that the handset is carried on the upper portion which is in the form of a cradle. This arrangement has many advantages
over instruments with the usual cradle, such as: reduced dimensions, a smaller number of components, greater stability and a more pleasing appearance. The cradle formed by four projections on the top of the moulded case is shaped to guide the handset into its correct position even if carelessly replaced and is designed to withstand very rough handling.

Fitted in the handset cradle are two plungers $b$ sliding independently of each other in brass bushes; each of them operates the switch fitted on the chassis when the handset is placed in position on the instrument.

On the front lower part of the case a rectangular number frame is fitted, which has an opening of approximately $23 \times 8 \mathrm{~mm}$ covered with cellone. The number plate can be mounted and removed from the outside without opening the instrument.

Three threaded metal inserts are moulded in the inside of the case for fixing the chassis.

## 2. Dial (Fig. 6 c ).

The dial which is of the Ericsson standard type is recessed on the sloping portion of the case as shown in Figure 6. It is set at the most suitable angle for easy operating.

In order to protect the working parts of the dial as much as possible from the ingress of dust and the influence of the outside atmosphere a protecting case $d$ is provided which, with the help of a metal bridge serves to hold the dial in position on the case. The dial connection cable has 3 conductors provided with tags for connecting to the terminals 8 , 10 and 12 on the terminal strip.

The dial cable is of the following construction: Each conductor is made up of 7 strands of


[^0]twisted 0.15 mm copper wire insulated with two coverings of silk and a braiding of cotton. Three such conductors are twisted together and protected by a braiding of glazed black cotton yarn.

The dial speed and impulse ratios are as follows:
Make ratio: $40-42 \%$,
Brake ratio: 6-58\%
of the total impulse.
Speed: io impulse per second with a permissible variation of $\pm 5 \%$.

## 3. Chassis.

Figure 7 shows the chassis detached and placed at the side of the case. In Fig. 6 the chassis is shown fixed in position in the instrument.

The chassis consists of a black enamelled sheet iron on which the parts are fixed and wired. The mounting plate is fixed on the instrument by 3 screws fitting in inserts moulded in the bakelite case. Figure 7 shows the three inserts and the holes in the mounting plate for the clamping screws.

The following parts are assembled on the mounting plate:

Ringer.
The polarized ringer is of entirely new construction. In spite of the reduced size in comparison with the older types it has been possible, by the choice of suitable materials and dimensions to produce a ringer with a high effienciency and sensitivity and also a long life.

The permanent magnets are made from steel with a high cobalt content.

The two electromagnets $f$ have cores of lowremanence iron on which the bobbins carrying the windings are moulded in bakelite.

Each bobbin is provided with 2 tags moulded in the cheeks to which the outer ends of the windings are connected. Each coil has a winding of 500 ohm $\pm 5 \%$ resistance making the total resistance of the ringer 1000 ohm.

The bearings of the armature $g$ which carries the hammer stem are constructed so that friction is reduced to a minimum and wear is negligible.

The two bell gongs are made from special brass sheet and have different tones in order to attract attention more readily and are nickel plated. The ringer is adjusted so that the hammer stem at rest does not lean dead against either of the gongs but due to the spring in the hammer stem the hammer strikes the gongs alternately on the receipt of an incoming signal and
in this way a clear tone is obtained. The fixing holes in the gongs are slightly eccentric so that the positions of the gongs in respect to the hammer can be adjusted without alteration to the armature gap. Adjustment can, if desired, be made to the armature by loosening the screw $h$ and altering the air gap.

The ringer is constructed so that a biassing spring can easily be fitted, if necessary. In an installation where instruments are connected up in parallel the biassing spring prevents the ringer in the instruments not being called from tinkling when dialling is going on the instruments with which it is coupled in parallel.

## Condenser ( $\mathbf{i}$ in Fig. 6).

The capacity of the condenser is $I_{\mu} F$ with a permissible variation of $\pm$ 10 $\%$. Despite its small dimensions, $50 \times 43 \times 12 \mathrm{~mm}$, this new condenser complies with the same demands concerning insulation and break down voltage as the older and larger types.

The condenser is held on the mounting plate by two positioning clips and a spring located by the spindle of the operating arm of the switch.

## Switch.

The switch consists of a group of springs and an operating arm $l$ and $m$, Figs. 6 and 7 . The spring group which contains 5 contact springs is mounted on a separate plate and forms a unit fixed to the mounting plate by 2 screws. The contact springs are insulated from one another and from the plate by means of bakelite spacers. The operating arm $m$ fits in two lugs bent up from the mounting plate and is provided with a wedge of bakelite which is forced between rollers on two springs in the spring group when the handset is placed in position; the plungers $b$ operate the arm and in this manner switching is made.

When the handset is lifted, the wedge, by reason of its form and with the aid of a spiral spring $n$ slides out of the spring group, and both plungers $b$ are lifted by the operating arm.

## Induction Coil (o in Fig. 6).

The induction coil has a closed iron core consisting of laminations of high permeability iron.

The bobbin has cheeks of bakelite in which six soldering tags are inserted for the connecting up of the ends of the various windings.

The induction coil as shown in Fig. 5 has 3 windings, namely:

| Line Winding | $1-2$ |
| :--- | :--- |
| Balance ", | $2-4$ |
| Receiver ", | $3-4$ |

The resistance $5-6$ is an outer bifilar non-inductive winding.

## Terminal Strip ( p in Figs. 6 and 7).

The terminal strip is a bakelite moulding with 12 connection terminals numbered $\mathrm{I}-12$ having screw connections on one side and soldering tags on the other. As previously mentioned all interior connections are soldered, whereas the handset, terminal block and dial connections terminate on screws. The terminal strip has a bell mouthed entrance for the handset and terminal block cords, which are securely held by a wedge shaped clamping bridge $r$, made of bakelite, screwed to the strip.

The interior wiring is carried out in 0.6 mm enamelled copper wire insulated by a double covering of silk and a single covering of cotton impregnated with bees wax.

## 4. Base Plate (s, Fig. 6).

The base plate, which is made of black enamelled sheet iron, is fixed to the instrument by means of a bent-up edge on the chassis and a single captive screw $v$.

The base plate has perforations opposite the bell gongs and is fitted with four rubber studs $t$ which form the feet of the instrument.

By loosening the screw $v$ the base plate can be detached and the interior of the instrument inspected.

## 5. Handset with Cord.

The new handset is shown in section in figure 8 , and figure 9 shows separately the various units of which it is composed.

The handle $a$, earpiece $b$, clamping ring $c$ and the mouthpiece $d$ as well as the terminal block $e$ are moulded in bakelite. No metal parts are exposed; consequently the handset is completely insulated. The total length of the handset, 232 mm , as well as the distance between the transmitter and receiver, and also the shape of the mouthpiece, are designed with the object of obtaining the best results in transmission. A characteristic of the design is that the diaphragms of the receiver and transmitter lie in parallel planes giving the most suitable position of the transmitter during conversation.

The outer form has been designed with a view to mechanical strength and an attractive appearance to harmonize with the whole instrument.
The section of the handle is triangular with rounded corners, which shape has been found to be the most comfortable to hold. The ends are shaped to hold the transmitter $g$, the receiver $f$ and also the terminal block $e$.
Two metal wires with terminals are moulded in the handle and serve as conductors between the transmitter and the receiver. At the transmitter end a male threaded metal ring $h$ is moulded in the bakelite on which the bakelite ring $c$ is screwed. The earpiece $b$ which is shaped to fit comfortably against the ear has a female thread for clamping with the receiver inset.

The transmitter mouthpiece $d$ serves partly as a sound collector and partly for clamping the transmitter inset with the assistance of the ring $c$. The mouthpiece is fixed by means of a notch fitting in a catch on the metal ring $h$.

The terminal block is in certain respects one of the new handset telephone's foremost improvements compared with previous models. This block serves partly as a central connection point for the whole handset, and partly to protect the transmitter against damp and outside noises that might enter through the cord inlet.


Fig. 8. Section of handset.
a: handle
b: earpiece
$c$ : ring
d: mouthpiece
e: terminal block
$f_{\text {: }}{ }^{\prime}$ inset receiver
$g$ : inset transmitter

Fig. 9. Handset, disassembled.

## a: handle

b: earpiece
c: ring
d: mouthpiece
e: terminal block
f: inset receiver
g: inset transmitter

x 5003

The connecting of the cord, thanks to the terminal block, is a very simple operation as it can be made before the block is fixed in the transmitter receptacle. After the cord is connected, the terminal block is placed in position and fixed by a single screw fitting in a brass bush inserted in the bakelite moulding and in this way the cord hole is sealed.

The connections between the terminals in the block and the conductors to the receiver moulded in the handle are made by two connection straps.

Two contact springs are mounted on the terminal block and connect up the poles of the transmitter inset.

The transmitter is of the inset type and is clamped in position by the ring $c$.

The receiver is fitted in a pressed brass inset case of strong construction.

The receiver has a single powerful magnet of high cobalt content steel identical in size with the magnet in the ringer. The magnet is placed on the exterior of the inset and is held against the pole pieces by two clamps.

The receiver is of the bipolar type, the pole shoes being made of low-remanence iron. The receiver coil bobbins are moulded in bakelite.

The connection of the receiver to the conductors moulded in the handle is made over two metallic surface pressing against each other. It might be pointed out that no contacts in the new instrument are made over screw threads only.

The receiver is held in position by two screws
fitting in the terminals of the conductors from the transmitter.

The receiver diaphragm is made from special alloy steel. It is clamped to the receiver inset by the earpiece.

The space between the pole pieces and the diaphragm is adjusted by grinding, and consequently no packing ring is requiered.

The handset cord has three conductors and has a free length of 1.25 metres. The ends are looped and held by contact screws in the terminal blocks in the instrument and the handset.

In order to relieve the conductors of mechanical stresses at the connection points, a strain loop is fastened by means of the terminal block clamping screw at the handset end, and the previously mentioned clamping wedge clamps the cord on the instrument terminal strip.

The cord is of the following construction:
Each of the three conductors consists of $3 \times 6$ copper tinsel insulated with two coverings of artificial silk impregnated with black compound and braided with mercerized cotton yarn. The 3 conductors are stranded and braided over-all with a coarse black cotton yarn.

## 6. Terminal Block \& Cord.

The terminal block shown in Figs. 10 and 11 consists of 2 parts, the base and the cover. The base is made of bakelite with moulded-in terminals.

All connections including both the terminal cord and the incoming wires are made on the front side of the block whereby the bare conductors are protected from the dampness of the wall. This arrangement allows inspection and a change of terminal cord as all connection screws are accessible without the necessity of removing the terminal block from the wall.

The base is fixed to the wall by a single screw. To prevent the block from rotating, small steel spikes project from the back and drive into the wall when the fixing screw is tigthened.

The cover is made of black enamelled sheet iron. The terminal cord is fitted through a hole in the cover which consequently cannot be lost.

The cover is fixed to the base by a snap spring.
The terminal cord is of exactly the same appearance and construction as the handset telephone cord and has the same free length of 1.25 metres.

## Dimensions and Weight.

The dimensions of the table telephone are: Height without handset 129 mm

| Width | * | * | 151 |
| :---: | :---: | :---: | :---: |
| Depth |  |  | 178 |

The weight of the complete instrument including the handset and terminal block is approximately 2.5 kg .

## Table Telephone CG 502 for Manual CB Systems.

In this instrument no dial is fitted, its place being taken by a dial blank which is fixed to the case in the same manner as the dial and is


Fig. 10. Block terminal for table telephone, Type DE 702 and CG 502.

Base of bakelite, cover of black enamelled sheet iron.

Fig. 11. Block terminal with the cover removed.
All connections are made on the front of the base, which is fixed to the wall with one screw only.


X 3002
very easy to remove should the instrument be changed over to automatic working.

The total weight of the telephone CG 502 is approximately 2.3 kg .

## Wall Telephone DE 200 for Automatic Systems.

The constructive problems that present themselves in the desiging of a wall set are on many points quite different from those for a table set which is not fixed and can be moved about to the liking of the user. The wall instrument is stationary and probably at times fixed in a very inaccessible position.

It must be designed and made so that the connection of the incoming lines and the inspection and maintenance can be carried out without removing the instrument from its place on the wall. Further, it is desirable that all necessary work and repairs can be carried out from the front of the instrument, as mouldings and panels often project from walls and stand in the way of approaching the instrument from the side.

The new design of wall set fullfils all demands that could reasonably be expected in this direction.

Figs. 3 and 4 show the exterior of the wall set, Fig. 12 shows the instrument in section from the side and on Fig. I3 it is shown with the case lowered to display how the interior fittings are easily accessible.

The instrument is made up of the following parts
I. Case.
2. Dial.
3. Base Plate.
4. Chassis.
5. Handset with Cord.


Fig. 12. Section of wall telephone, Type DE 200.
a: hinge.
b: screw for fixing the case to the baseplate.
c: circular impressions, pierced to take screws for fixing the instrument to the wall

X 9001

## 1. Case.

The handset cradle is formed on exactly the same lines as on the table set and the two plungers operating the switch are found also on the wall instrument.

The number frame is placed over the dial.
The bottom edge of the case is hinged to the base plate. The case is fixed to the base plate in its normal position by a captive screw ( $b$ in Fig. I2). By loosening this screw the case can be lowered downwards and takes up the position flush against the wall as shown in Fig. I3.

## 2. Dial.

The dial and the method of fastening it in position are the same as in the table set. The connection cable between the dial and the terminal strip is held by a clamp on the base plate whereby it is prevented from coming in contact with the ringer.

## 3. Base Plate.

The base plate on which the whole of the instrument is carried is made of black enamelled sheet iron and has a central pressed strengthening rib. Three circular impressions are raised on the back of the base plate and pierced to take the clamping screws with which the instrument is fixed to the wall. These impressions are of such depth that the edge of the body is kept about 5 mm from the surface of the wall.

The bottom edge of the base plate is bent forward at nearly a right angle and forms part of the hinge on which the body swings. This bent
portion is provided with perforations for the ringer.

At the top of the instrument are two wire holes for the incoming line wires and the leads to an extension bell.

## 4. Chassis.

The mounting plate which carries the wiring and the interior fittings including the terminal strip, thus forming a detachable unit, is somewhat different from the corresponding plate in the table set. The chassis is held in position on the base plate by 3 screws that are fitted from the front.

The ringer, condenser, switch spring group and induction coil are identical with those on the table instrument. The terminal strip is practically the same as on the table set, the difference being that the bell mouthed cord hole is altered slightly in shape, the wall set having no block terminal cord.

## Dimensions and Weight.

The dimensions of the new wall instrument are:

| Width without handset . . 15 I <br> Depth . .................. 106 |
| :---: |
|  |  |
|  |  |

The complete weight including handset is approximately 2.5 kg .

## Wall Telephone CD 1200 for Manual CB Systems.

In this instrument the dial is replaced by a dial blank with the same appearance and method of fastening as on the table telephone CG 502. This telephone CD 1200 has a weight of approx. 2.3 kg .

Fig. 13. Wall telephone. Type DE 200, opened for inspection.
All parts are easily accessible from the front for inspection and adjustment. A single captive screw fixes the case to the baseplate, which is screwed on to the wall.


## Indicating Plant for Stock Exchange Quotations

By
E. SCHEWELOV

Technical Department,
Telefon A.-B. L. M. Ericsson,
Stockholm.



#### Abstract

The quotations of the Stockholm Stock Exchange are transmitted during the transactions by telephone to the brokers' offices, where they are posted for the information of the public, generally by means of hand-written lists. Ericsson has devised a system for Svenska Handelsbanken in Stockholm, by means of which the quotations from the Stock Exchange are listed electrically on panels accessible to the public, immediately after they have been reported to the Stock Exchange Department of the bank.


In the head office of Aktiebolaget Svenska Handelsbanken, Stockholm, an installation for the listing of Stock Exchange quotations by means of electrically driven machinery has recently been put in service. The plant, which has been designed and installed by Telefonaktiebolaget L. M. Ericsson, is presumably quite unique and may therefore deserve a detailed description, the more as the underlying principles are certainly applicable to other installations for similar purposes.

In solving the constructional problems, it has, of course, been necessary to take into consideration the organisation and business methods of the Stockholm Stock Exchange, which are in many respects different from those of other stock exchanges. On most of the leading stock exchanges the official quotations are not fixed


X 1024
Fig. 1. Interior view of the main hall in the head office of Svenska Handelsbanken.
The two indicator panels belonging to the quotation indicating plant are seen to the left and right of the door.
till business is over; the prices actually paid during exchange hours are compiled and a representative quotation is fixed in some way or other, e. g. by computing the arithmetic mean of the various prices. The Stockholm Stock Exchange, however, fixes the official quotations by a kind of auction, the rroup», which takes place at the beginning of the day's business before the open market proceedings. In normal times, the »roup» is repeated in the afternoon, but at present only one »roup» takes place a day. As is the case on serveral important exchanges the public is not admitted to the Stockholm Stock Ex-

x 1025
Fig. 2. Pair of panels installed in the stock department of the bank.
These panels differ only slightly from the panels mounted in the main hall (see above).


X 1026
Fig. 3. Central switchboard.
The 5 push-buttons at the top in the middle are used for disconnecting the panels which are not to be altered. The headings of the panels are changed by means of these push-buttons to the left and right. The groups of each 24 push-buttons with the corresponding signal lamps in the middle represent the 48 different stocks figured in the panels. The dial to the left selects the vertical columns in the panels. The figure drum for the adjustment of the differences in the quotation is seen at the bottom in the middle.
change, and all business is handled through brokers, especially the banks; for this reason the official quotations must be brought to the knowledge of the interested public as soon as possible, preferably already during exchange hours. To this end the banks exhibit hand-written exchange lists in their windows; for no kind of »ticker» is used in Sweden. The new plant is simply an electrically operated exchange list, which is, however, far superior to both the ticker and the handwritten lists on account of its quick working, its accuracy and its ingenious design and construction.

In the main hall of the bank a pair of indicator panels has been suspended, and the new quotations are listed on them as the >roup» proceeds. The installation is controlled from a switchboard in the stock department of the bank; there the quotations are received from the Exchange by telephone. Another identical pair of panels is installed in the stock department. Only two pair of panels have been installed so far, but the central switchboard is designed so as to allow the connection of a larger number.

As the price fluctuations on the Stockholm Stock Exchange are usually quite small relatively to the quotations, the system has been designed for the setting of differences only; at first sight it would seem more natural, first to change all figures in the panels to zero and thereafter to set up the new quotations.
The quotations are always expressed either in whole Kronor, or in whole Kronor and 50 Öre. For this reason the device for setting the Öre columns has only the alternatives $» 00 »$ and $» 50 »$.

For each stock listed on the Exchange, the following quotations must be shown on the panels: »Bid», »Asked», »Highest», »Lowest» and »Difference», i. e. the difference between the new $»$ Bid» quotation and the previous one. At present only one »roup» is made a day, but the plant is designed for a second »roup» as well. Usually, not all stocks are dealt in every day and so a special screen is provided to cover the corresponding quotations.

## The Apparatus.

The installation consists of a central switchboard and a number of indicator panels connected to it. The general layout of the system is shown in the diagram on Fig. 5.
The indicator panels are arranged in pairs, and each panel is intended for 24 different stocks, thus both panels have space for a number of stocks not exceeding 48.
From the central switchboard the quotations are sent out to the different panels which are connected in parallel; the changes of figures are checked in the central switchboard for each set of panels individually.
When the plant is not in operation, i. e. before the first or between the first and the second *roup», no current must be on. Before commen-


X 1027
Fig. 4. The central switchboard uncovered.


Fig. 5. Diagram.
A. Selectors and relays.
B. Repeater.

Columns of the panels.
cing the listing operations after a »roup», the current is first switched on to a special rotary convertor by means of a switch mounted on the distributing board of the central switchboard (seen in Fig. 6 inside the doors). Feeding current is then connected to the plant by means of another switch on the same distributing board; other switches are intended for the feeding of the motors and lamps of the panels (for details, see below).

## Central Switchboard.

All devices for changing the quotations on the panels are mounted in the desk of the central switchboard (Fig. 3). At the top, left side, there are two push-buttons $>1 »$ and $>2 »$; together with the push-button »G» to the right they effect the change of the panel headings, which normally read as following:

## „Yesterday's 2nd roup» <br> >To-day's 1st roup》 >To-day's 2nd roup»

or if only one »roup» has taken place on the previous day

## „Yesterday's 1st roup».

If the push-button $» \mathrm{G} »$ is pressed, the word »Yesterday's» appears in the heading of the panels and by means of the push-button $>1$ » or $» 2$ ", the figures $>1$ st» and $>2$ nd $>$ respectively will be set up on the panels connected to the central switchboard. No special push-button for changing »Yesterday's» into $\geqslant$ To-day's» is provided, as these words are changed automatically as soon as the push-button $\gg \mathrm{I} \gg$ is operated.

The five push-buttons in the center top part of the desk are used, if the quotations are to be
changed on certain panels only. If one of these push-buttons is pressed, the corresponding set of panels are connected, and the others are disconnected. The operations of the central switchboard are in other respects the same as if all the panels were connected.

In the middle of the desk there are two rows of push-buttons; the buttons of the first row are marked $1-24$ and those of the other 25 -48 . These push-buttons serve for selecting the horizontal position on the panels. Each stock quoted on Exchange has been given a number corresponding to its position on the


X 1028
Fig. 6. Quotation panel.
These are installed in pairs and list 24 securities each.
panels. As mentioned before, the panels are arranged in pairs. The second panel of each set is connected to the central switchboard as a direct continuation of the first, so that in the central switchboard the buttons $25-48$ correspond to the stocks figured on the second panel. Above the first, and below the second row of push-buttons there are signal lamps, the lenses of which are marked with the same figures as the corresponding buttons. These lamps control the setting up of the quotations on the panels and will not light up before the corresponding horizontal line of all the panels connected has been set correctly.

The dial to the left selects the desired vertical columns on the panels (see diagram Fig. 5).

As pointed out before, the figures in the »difference» columns indicate the difference between the preceding and the new $»$ Bid» quotation. In order to show whether these figures represent gain or loss, a device indicating $\gg$ or $»>$ is installed in all the panels.

The corresponding operations in the central switchboard are effected by means of a switch placed above the dial. For control purposes signal lamps are provided on each side of the switch; their lenses are marked $» 十 »$ and $\gg$ respectively. One of these lamps must always light as soon as the central switchboard is being set for the »difference» column.

The mechanism for transmitting the differences in quotations to the panels is installed at the bottom of the desk plate. As mentioned above, these differences are usually small and the setting device therefore consists of figure drums for setting the last two figures of each quotation and a switch for setting 50 or oo Öre. If the difference amounts to more than Kronor 99: 50, the change is effected in two steps. In front of the figure drum there is a switch, the position of which determines if the amount set up is to be added or deducted from the previous quotation.


Fig. 7. Figure mechanism
with four figures, for the quotation columns of the panels.


X 1030 Fig. 8. Figure mechanism with three figures, for the difference columns.

## Panels.

Certain details concerning the installation and appearance of the panels have already been mentioned. In order to protect the panels against dust and damage, they are mounted in a casing with a glass pane on the front side. From Fig. 6 it will be seen, that the names of the stocks quoted appear in the column to the extreme left, followed by the columns for »Difference», »Bid», »Asked», *Highest» and $»$ Lowest». The columns are controlled by individual switches operated by means of corresponding devices in the central switchboard in the same way as the horizontal positions.


Fig. 9. Figure mechanism.
This mechanism indicates only 0 or 5 ( 00 or 50 öre).

## Figure Mechanisms.

As already mentioned, the prices are quoted in whole Kronor and 50 Öre. As shown by Fig. 7 and 8, the panels have mechanisms for setting whole Kronor; the setting in this case is wholly mechanical while $>50$ " and $>00$ " Öre are set by means of direct step-by-step operated mechanisms (Fig. 9). Each panel is provided with an electrical motor for driving the figure mechanism, the motor being connected to a vertical shaft (Fig. 10). By means of a magnetic clutch, this motor operates the driving shaft of the figure mechanism. In order to control the changes in each panel, a back-impulse contact is arranged to send to the central switchboard impulses corresponding to the number of steps effected by the connected figure mechanisms. The change of 50 or oo Öre is checked electrically direct from the central switchboard.

If any security is not quoted during a $»$ roup», the corresponding figures will be screened on the panels. In the set of panels mounted close by the central switchboard (Fig. 2), the screens have openings through which the previous quotations can be seen. On all other panels the screens are made of an opaque material. The »Difference» column has no screens, but there are special devices for marking »+» or $\gg$, which are controlled direct from the central switchboard in the same manner as the mechanisms for raising the screens.
The whole series of different operations effected in connection with the quotation on the exchange is as follows. In the morning, all panels should show the latest quotations of the preceding day. The headings of all panels are to be changed into

## „Yesterday's 2nd (or 1st) roup».

This is effected by means of the above-mentioned push-button $» \mathrm{G}>$ in the central switchboard after the current has been connected to the plant. Before beginning the setting of the quotations in connection with the first roup, the aforesaid headings are changed into:

> "To-day's 1 st roup above lit lamp».

The change is effected by pressing the pushbutton switch $\gg$ » and by throwing the switch which controls the lamps in the panels into the
position corresponding to the panels connected (position $>1>$ or $>2 »$ ). While the quotations are being set, a lamp is lit beside the name of the stock, the quotations of which is being altered. The new quotations are set in the same sequence as they are listed on the panels, i. e. the pushbuttons in the central switchboard are operated in numerical order. To change a figure, the difference between the new quotation and the preceding one is set up in the central switchboard (Fig. 3); the pushbutton $>$ STK» is then pressed down and released. The white signal lamp to the left on the desk will then go out, but will light up again as soon as the corresponding changes have been correctly effected in all panels.

If, however, the quotation has not been altered in conformity with the new quotation set up in the central switchboard, a red lamp will light, showing in which of the panels the trouble is to be found.

The necessary operations in passing from the first panel to the second have already been mentioned in the description of the different parts of the installation. The setting of the quotations after the second roup is made in the manner described above.

After completion of all changes in connection with a roup all current is disconnected, so that no current is used during the interval between two roups.


X 3003
Fig. 10.
Back view of a quotation panel. The motor drives the shafts of the figure mechanisms by means of the vertical shaft, when the magnetic clutch is operated.

# Ericsson's Selective Calling Telephone System <br> H. V. ALEXANDERSSON 

Research and Development Dept.
Telefon A.-B. L. M. Ericsson, Stockholm


## Synopsis.

The main requirements for a selective calling telephone system for railway working are:
reliability in operation,
simplicity in construction and working,
flexibility in intercommunication with other telephone systems.
A general examination of these requirements shows that a system should, to fulfil these conditions, be made as a non secret parallel system with decentralized switching.
On systems with decentralized switching the main problem is the question of impulsing and operating the selectors on the subscribers own line. In general one of the following methods has been used:
The power supply for working the selectors has been available at every instrument; the system can then be worked with two conductors and no earth.
With the power supply centralized to a point on the line, one can use either direct current impulsing over both special lines and earth return or another third conductor, or also use both alternating and direct current thereby the impulses from the dial are DC impulses and the working impulses to the selectors AC impulses. The Ericsson System uses only direct current and operates on two conductors without earth return. This has been attained by using different current directions for both kinds of impulses, both impulses being consequently on the same line in a loop circuit but with different directions. Firstly on the instrument itself the impulses are separated by means of small electrical valves, as copper oxide rectifiers. One finds in this way that the normal voltage on the line can be as low as for example 24 V . Only during the impulsing is the pressure increased to a value necessary to operate the various selectors on the line. The selector used
on the system is of the two-magnet type, that is to say it is provided with a step-by-step magnet which operates with the line impulses and thereby feeds forward a toothed wheel, and also a locking magnet which, whilst the stepmagnet is working, is attracted and actuates a pawl fitting in the toothed wheel; when the impulsing stops and the current ceases to flow through both magnets the wheel is returned to its original position by a coil spring. By special mechanical construction the selector is given a capacity of 19 numbers.
The telephone instruments are especially simple and ressemble in the main normal instruments for automatic working. The special selecting equipment consists of only the selector itself and the previously mentioned rectifiers. The trembler bell is provided with a thermic delayed action in order not to give ringing signals of short duration whilst selection operation is being carried out.
The selecting apparatus is normally made in the form of a table instrument with the associated selecting equipment mounted in a small case fixed to the wall, and serves as a terminal fitting.
The Line Equipment is made up of normal relays, switches, condensers and rectifiers. For a single section the equipment consists of six relays but in a general case with an arbitrary number of sections nine relays are required and a 12-step-switch. The whole is built in a dust tight sloping case, the necessary leads being connected to a moulded bakelite block.
The capacity of the system for each section is: 8 outgoing lines - numbered 1 to 8 - and 19 instruments numbered $92-90$ and $01-00$.
Intercommunication with local exchanges is very simple to arrange especially with those of the CB type including automatic exchanges. As an example a combination line between the selective calling system and an Ericsson's automatic exchange type OL 35 can be given.
In small and medium railwaystations a simplified local exchange has been designed capable of interworking with the selective calling system. This local exchange is designed for one simultaneous call and is of the non-secret type.
Its capacity is 8 outgoing lines and 9 instruments.
The Power Installation for the section groups can be made very simple when the power distribution operates in AC current. Only a small 24 V battery with charging rectifiers is required. The higher voltage for impulsing is obtained from a special rectifier or from a radio high tension battery. The current consumption is 0,22 A per line equipment during calling periods.

## Definitions.

A selective line is understood to be a telephone line along the whole length of which are distributed telephone instruments connected in parallel, usually called »parallel system». "Series systems» are also in existence but are used to a much lesser extent. All the telephone instruments are equipped with a switching arrangement which all operate at the same time. Depending on the position of these switches only one instrument is connected at a time and in this way selective calling is obtained.

If the switching arrangements are made so that only the caller and the called subscribers instruments are connected, the system is named *secret». In cases where the calling only is selective the system is called »non-secret».

Selective calling systems are divided into two main types depending on the method of operation. The systems with centralized switching are manually supervised at some point on the line from which the operation of the selector switch occurs, generally by code impulsing. Systems with $d e$ centralized control, on the other hand, have no manual supervision and allow of selection from all instruments connected to the system. This is usually done by means of a dial. There are even systems of this kind having code impulsing.

## What Are the Principal Demands on a Selective Calling System for Railways?

The requirements that ought to be provided by a selective calling system for railways can be placed under the following headings:

Reliability,
Simplicity in construction and operation and
Flexibility or ease in working in with other telephone systems such as local exchanges.

As far as reliability is concerned the general rule holds good that simplicity in construction and operation are conditions that must be carried into effect in order to obtain a good working result. This is not altogether for the reason that a simple piece of mechanism can in general be made to function with more certainty than a complicated one, but for the further reason that the clearing of faults can be made much quicker and by less skilled labour. This condition is a very weighty one, especially in railway telephony, where the equipment in question is often spread over long stretches of line.

The long lines in this particular case give rise to special wishes concerning traffic possibilities. It is necessary to divide up the line in suitable lengths to handle the traffic, each length being in itself an independent unit but still possessing the traffic possibilities of working in both directions.

As far as secret and non-secret working is concerned from a railway service point of view, safety is the most important. Under all conditions one should be able to make a desired call, even if whilst connection is being made an engaged line is encountered. If a secret system is used the instruments can be arranged in such a way that in cases of emergency one can force oneself in on ones own section by means of breaking a seal or something similar, but in cases where any other section is engaged one cannot put a call through to that section. In a non-secret system in similar circumstances, connection can be made with the engaged section and a request made that the conversation is terminated, after which normal working can continue. The more sections through which a call must be connected the greater the possibility of an engaged section being encountered.

Interworking with other telephone systems should be possible in a simple and satisfactory manner. This refers especially to intercommunication with automatic exchanges as for example in the larger railway stations. In this case the traffic between both systems should be fully automatic in both directions as otherwise a large proportion of the advantages of automatic working are lost.

The Ericsson Selective Calling Telephone System for railways is herewith described. This system has been designed to fulfil as far as possible the conditions stated above and can therefore be put forward with every confidence as a non-secret parallel system with decentralized switching.
Impulsing on the Selective Lines.

x 1032 Fig. 1. Decentralized switching with local AC supply.
The problem, which above everything sets its stamp upon the design of a system of decentral-
ized switching is the impulsing from the dial and the consequent operating of the selectors on the line to which the instrument dialling is connected. The principles in general use are the following:

With a primary operating current available at every instrument one gets the simplest system, which is shown schematically in Fig. I.

The motive supply, which, as can readily be appreciated, is usually alternating current, is obtained from a transformer contained in each instruments, which is connected up to the mains. When the selectors are to be operated, the AC current is connected through the dial break contacts to the line by means of a push button. The whole of the selectors which are coupled in parallel operate by this alternating current and step, as the dial effects series of breaks in this current, as many steps as breaks contained in the series of impulses. As can be seen this system requires a double metallic circuit without any earth. In a single section only no central apparatus is required.

x 1033 Fig. 2. Decentralized switching with central DC supply.
If it is desired to work with a supply source available at only one position on the line the simplest course to take is to use the system shown in Fig. 2. There is constant voltage above earth on one line. All the selectors are connected in parallel between the two lines and whilst impulsing the other line is earthed through the dial. The system has amongst other things the disadvantages that the line whilst not in use is under pressure, which to enable a number of selectors to operate at a time must be at least 100 V .
In general therefore two separate sources of supply are used for calling and impulsing from the dial on the one hand and for the issuing impulses for the selectors on the other. In order to do this it is necessary to have separate circuits for the dial and the issuing impulses which can be brought about by using an earth connection or also by using two different kinds of current as for example 50 cycles alternating current for impulse sending to the selectors and direct current for the dial impulses.
According to Fig. 3 both the signals are worked in loop over the line. The selectors are connected


X 1034 Fig. 3. Decentralized switching.
Primary impulsing in loop with central DC supply. Secundary impulsing in loop with central AC supply.
in series with the condensers and the dials with retardation coils. The object of this is to get the dial and the selector to work together on one line at the same time without disturbing one another, by separating the alternating and direct current, so that all DC current goes through the dial and all AC current through the selectors. When it was found to be difficult to carry into effect the separation of the direct and alternating currents the system was modified in such a way, that the dial DC impulses and the selectors AC impulses did not occur on the line at the same time. This has been brought about by providing the central station equipment with a translator which first receives the DC impulses and after these are finished sends out corresponding AC impulses.

It is of especial importance in electrified railways that earth connection is not used for impulse sending. During the short circuiting of a power line using overhead conductors an excess voltage to earth can occur in the range of 1000 -2000 V . Even under normal conditions voltages arise which could completely destroy the possibilities of impulsing on a system working with earth return. In order to avoid complications with the translation in the central equipment it is desirable to be able to cut off the selectors during the time the dials are being operated.

The selective system to be described now gives the solution of this problem, Fig. 4.

$\mathrm{x} 1035 \quad$ Fig. 4. Decentralized switching.
Primary impulsing in loop with central DC supply. Secundary impulsing in loop with central AC supply. Ericsson system.

The selector and the dial are connected in parallel with one another. Besides this, each one is connected to its own non-return electric valve, that is to say a half-wave rectifier, as for example a copper oxide dry rectifier, which has the opposite polarity to the line.

The selectors with their rectifiers are permanently connected to the line. The polarity is arranged so that a call is not made at the central equipment, that is to say the relay $R_{1}$ is not attracted by the current passing through the rectifiers $L_{1}$. If a hand microtelephone is now lifted, a contact is closed in the cradle switch so that the line is connected to the dial and the other rectifier $L_{2}$. This rectifier has little resistance at the polarity of the line and for this reason the relay $R_{1}$ in the central equipment is attracted. Relay $R_{1}$ connects the relay $R_{2}$, which in its turn operates relay $R_{3}$; this relay is held energised over its own contacts and disconnects relay $R_{2}$ which falls after having been attracted for a short while. On relay $R_{2}$ are contacts which change the polarity of the line. With reversed line polarity the rectifier $L_{1}$ has a low resistance and the rectifier $L_{2}$ a high resistance. A current thus flows through the selectors $S$ as long as the relays $R_{2}$ remain attracted and all the selectors on their own lines move forward one step. In certain cases it may be convenient to use the first step on all selectors on the line to give the engaged signal. It should be observed that relay $R_{1}$ is not disconnected by $R_{2} . \quad R_{1}$ is retained by current through the one half of the winding as long as $R_{2}$ is attracted.

During impulsing from the dial the short circuit over the rectifier $L_{2}$ is broken at the beginning of every impulse causing the relay $R_{1}$ and in consequence even the relay $R_{3}$ to release. At the end of every impulse when the line is again connected to the rectifier $L_{2}$ the impulse relay $R_{1}$ is again attracted so that the previously described operation of relays $R_{2}$ and $R_{3}$ is repeated. After each connection of the line to the rectifier $L_{2}$ and the impulse contacts of the dial, the relay $R_{2}$ becomes attracted for a short while and thereby reverses the polarity of the line. In every time this is repeated all the selectors on the line step forward one step. In this way any desired instrument on ones own line can be directly selected by the dial. Calls coming from another line offer no great difficulties when the selectors can be operated exclusively from the exchange equipment.

The method of impulsing herewith described allows one to have different pressures in both directions. Normally the voltage on the line is 24 V which is sufficient to attain the desired operation of the impulse relay. The polarity changing impulses which operate the selectors could on the other hand be of higher voltage. The amount of voltage is decided by the number of selectors and the resistance of the line. In general one can say that approximately 100 V is sufficient. It should be noted that the high tension current supply that these impulses require need not be of any great capacity. It is only a question of delivering a series of current kicks of some io milliseconds duration at a current of some 10 mA . One can therefore, for this purpose, use a radio battery or a small rectifier which is connected direct into the mains. The connecting of the relays $R_{1} R_{2}$ and $R_{3}$ is in a somewhat modified form known in automatic telephony as „Impulse Correction Circuit» and is used to correct the incoming impulses in the impulse repeater, so that these, when sent out again, are of the correct ratio, irrespective of whether they were previously so. Besides that the relays produce the desired polarity changes, they allow further for an impulse correction which shows to advantage on traffic from one section to another and makes possible, at least in principle, unlimited impulse repeating.

## Selectors.

The selector system is built up in the previously described impulsing method. In certain details the erection is dependent on the design of selectors that are used. The details about to be described are based on the use of a selector of the two-magnet type, Fig. 5.

This selector is equipped with two electromagnets of which the one works an armature connected to a pawl which on the closing of the armature moves a notched wheel with contact arms one step. The other magnet operates a locking pawl which with the closing of the armature racks the notched wheel in a backward direction. When both the armatures lie in the forward position the notched wheel is returned to its normal position by a coil spring similar to a clock balance spring. At a certain determined position of the notched wheel a contact is closed, when the racking magnet armature lifts a contact spring against the moving contact arms. The number of steps from the home position to the position of the

$x_{1038}$ Fig. 5. Circuit diagram of two-magnet selector. In practice the two magnets are mounted beside each other. The selector is of the same size as a two-coil relay. The step-by-step magnet (A) is connected across the line and energized by the line equipment. The locking magnet (B) receives current from the local battery when the step-by-step magnet works.
notched wheel at which the closing of the contacts takes place gives the number of the telephone set to which the selector in question belongs. On telephone apparatus specially designed for railway working the selectors are furnished with two contact arms, one to give the individual number of the telephone instrument and the other to give a general call number for all the instruments.

On other systems using this type of selector the normal working is with negative impulses, that is to say the selectors are constantly energised and, when the interruptions occur, the notched wheel steps forward to the desired position in which it is kept until the current breaks. The system discribed herewith works with positive impulses, that is to say short current impulses that step forward the selector to the desired position. In order to use this selector in connection with the latter system it is necessary in some way to mark the end of the series of impulses, so that the ringing signal is sent out to the correct instrument.

The marking of the last impulse in an impulse series has been arranged so that the last impulse produced by the moving dial does not give out the final impulse issued to the selectors. From the central equipment a further impulse is sent out after these originated at the dial, at such an interval from these that it acts as the last impulse in a series of normal impulses. This impulse is made longer than the others. A bell that does not ring for currents of short duration such as normal impulses is by this means made to function and operates until the last impulse ceases after a few seconds duration of the ringing signal. How this extra-impulse is produced is shown in the following description of the central equipment.

After an impulse series is completed the selector returns to its home position. It follows that if no special steps are taken, each section can only make a maximum of 10 outgoing con-
nections consisting of those to instruments or to other sections. The number could be increased by enlarging the capacity of the dial, which would be unpractical. One can, by simple means, make the selector stop at a certain determined position after the completion of a series of impulses and from this resting position as a starting point, continue with repeated impulsing. At a desired position, for example after as many impulses to correspond with the last digit on the dial the notched wheel can quite simply be locked by mechanical means so that it does not return to its home position.

On further impulses the selector steps from this position and is returned after the completion of the impulsing to its home position by the usual means. In such a way a capacity of 19 positions with two digit numbers is obtained. In the same way, naturally, further reading positions could be obtained, but they would have no practical value as more connections per section are not likely to occur.

## Telephone Instruments.

If we now go over to the actual performance of the system we shall find that contrary to what is the usual case in selective telephony the simple principles correspond to an equally simple fulfillment of detail. The telephone instrument, the equipment of which, upon the whole, agrees with the normal instrument used for automatic telephony, is made according to figure 6 . The equipment is as follows:


Fig. 6. Circuit diagram of selector telephone instrument.
The instrument contains the equipment of a normal automatic telephone, plus the selector and the two rectifiers. The trembler bell is fitted with a thermic damping device.

Hand Microtelephone $M$ and $T$.
Induction Coil with anti-side tone winding $I R$. Dial.
Switch Hook K.
Press Button $T$ with locking and release of switch hook.

## Trembler Bell $B$.

Damping arrangement for Bell consisting of a glow lamp and a resistance $L$ and $r$.

Selector $S$ with two electro magnets $R_{1}$ and $R_{2}$.
Rectifiers $L_{1}$ and $L_{2}$.
Condenser $C_{1}$ and resistance $r_{2}$ for impulse sparking protection.

Condenser $C_{2}$ to stop the direct current through the telephone.

The fact that direct current only is used makes it possible to allow the outgoing impulses to operate the selectors directly without the use of the usual auxiliary relays as in common practice.

The working of the apparatus can be grasped without difficulty from the schematic diagram. The only details that are perhaps not quite normal are the push button and the delayed operation arrangement of the bell. With the use of the selector design described, visible means of indicating that a subscriber's line is engaged cannot be carried out in a simple manner. Instead, one must determine if the line is free by listening. In the meantime it is possible that a hand microtelephone of an instrument may be lifted at the same moment as dialling is occurring at another point on the line. The impulsing is spoilt, in this case, if special precautions are not taken. To prevent trouble of this kind the press button $T$ is introduced. When the hand microtelephone is lifted connection is made with the line, but in series with the condenser $C_{1}$ and the resistance $r_{2}$. It can be observed that the capacity connected to the line in this manner does not affect the impulsing


X 1038
Fig. 7. Telephone instrument with selector equipment case.
The instrument is normally constructed as a table telephone with the selector equipment mounted in a dust-tight sheet iron case, which serves also as a terminal fitting. The glow lamp is mounted behind a window in the case and lits up when a signal comes in.

x 1039 Fig. 8. Selector equipment case, opened.
because of the rectifier connected in series which compensates the reverse periods which otherwise would occur. With this arrangement it is possible to impulse even if, say io instruments, are connected in at once.

When the press button $T$ is depressed the condenser is short circuited and the line is closed electrically through the instrument so that a signal is given. The condenser $C_{1}$ and resistance $r_{2}$ serve during impulsing as a protection against excess voltages arising from dialling.
The trembler bell is provided with a delaying arrangement consisting of a series coupled resistance and a parallel coupled glow lamp. The lamp is of the metal filament type and is of low resistance when cold. Until the lamp has time to warm up the bell is heavily shunted which prevails it ringing when the contact arm on the selector passes over the ringing positions. When the contact arm stays for a longer period in the ringing position the lamp warms up and the bell rings.

The mechanical design and construction of the equipment is in general carried out in such a way that the selector, rectifier and bell are fitted in a special selector equipment case-which also acts as a terminal point for the telephone instrument, which is of the usual table type as shown in Fig. 7 and 8. This is especially advantageous in the event of having several selector lines at the same point as it is then possible to communicate over all the lines with only one instrument. For every selector line a similar selector equipment case is provided. The equipment is connected to a desired line by a suitably arranged push button. By fitting the glow lamp in a position on the case where


For the sake of simplicity delayed action arrangement for the trembler bell ist left out. Every time the selector moves past the ringing position the bell gives a short tinkle. As such portable telephones are not used in large quantities per section high numbers can be chosen for these instruments and by this means the tinkling of the trembler bell is reduced to a minimum.

Fig. 9. Selector telephone, portable type.
it can easily be seen a visible indication is obtained as to the line from which the signal comes.

In certain cases as for example during inspection and repairs and other work along the line a portable selective calling telephone instrument according to figure 9 is suitable for use. Such an instrument can be carried on trains and in cases of necessity be used by the train staff to get into telephone communication with any desired station.

The circuit for this instrument is as near as possible the same as that for the fixed instrument shown in Fig. 6. The whole instrument is built with a case similar to those used for field telephones.

The modifications made depend chiefly on the fact that with portable telephones contacts corresponding to those used on normal switch hooks are not found to be suitable. This depends only to a certain extent on the mechanical difficulties of such contacts in this case. On portable instruments it is much easier than on fixed ones for the hand microtelephone to be left off or fall off the switch hook under normal working conditions. As a loop on the line holds the selector system fixed or out of operation, failure to replace the hand microtelephone blocks the whole line for impulsing. In this case therefore it has been decided to replace the most important function of the switch hook by a press key fitted in the hand microtelephone.

The working of the instrument is as follows: when the instrument is used, the contact $T_{1}$ on the press key is closed and, by listening, it can be ascertained in the usual way if the line is at liberty. The locking key $T_{2}$ is then depressed. By this means the previously described condenser $C_{1}$ and resistance $r$ are short circuited. At the same time the current is connected to the transmitter and the dials short circuiting contact. The letter is made to prevent any accidental movement of the dial giving a signal on the line.

## Line Equipment.

In the simplest cases with only one section the line equipment consists of a set of six relays as shown in Fig. 10. The line equipment is placed in this case in the middle of the line so that the impulsing is carried out over the least possible line resistance.

The relays $R_{1}, R_{2}$ and $R_{3}$ are the previously mentioned impulse and correction relays. In addition to these are 3 more relays $R_{4}, R_{5}$ and $R_{6}$. The purpose of these is to send out the extra impulse, following the impulses from the dial, the length of which gives the ringing signal. As soon as the line is engaged the relay $R_{4}$ is attracted. During impulsing $R_{5}$ and $R_{6}$ are attracted. After the impulsing $R_{5}$ releases immediately and $R_{6}$, wich is provided with a pendulum contact, keeps its armature attracted till the pendulum has ceased to vibrate which occurs after 4 to 5 seconds. During this time the relay $R_{2}$ is connected again through the relays $R_{5}$ and $R_{6}$ and is attracted and sends out the long ringing signal over the line.

By suitable regulating the operating time of the relay $R_{5}$ it can be arranged that this last im-

$\times 5006$ Fig. 10. Line equipment for single section.
The line equipment consists of six relays; R1-R3 are the impulse and correcting relays, while R4-R6 are intended for sending the long-signal impulse.
pulse occurs at an interval from the last normal impulse equal to the impulse period of the whole group.

In the case of several sections the line equipment is naturally mo e complicated than in the simple case with only one section, see figure II. The number of relays is increased from 6 to 9 . Besides this, 12-stepping switches are used, 3 condensers of 2,2 and $1 \mu F$ respectively and also the rectifiers $L_{1}, L_{2}$ and $L_{3}$. The buzzer is common for all the lines in one junction point.
The main duties of the 12 -stepp-

x 5007 Fig. 11. Line equipment for an arbitrary number of sections. The equipment consists of nine relays and one selector, which latter effects the connexions when another section is being called. ing switch is to connect the sections together when communication between them is required.

The speech goes over A and B-lines from which the positions corresponding to the directing numbers to other stations are connected to their respective sections. On the C-line, the engaged signal is connected so that when an engaged section is encountered speech can be carried on but dialling is prevented until the called section is at liberty again. This is of great importance in the case of several sections because it makes possible a rapid step-by-step connection of the desired number even if, whilst connecting up, an engaged length of line is encountered.

The relays $R_{1}$ to $R_{6}$ have the same functions to perform as in the simple case of a single section. The new relays are used chiefly to make possible intercommunication to other sections.

The relay $R_{7}$ is a two-step relay and at the first step it disconnects the outgoing impulses to its own section. The second step is only completed if the section required is free, in which case the relay obtains current from the C line and the break contact of $R_{4}$ on the required section. In the second step the loop to the next section is closed through the rectifier $L_{2}$ and relay $R_{8} . R_{8}$ is connected in parallel with a resistance which, after the signal, is cut off by the relay itself so that the impedance of the bridge connected between the speech lines does not become to small.

The relay $R_{9}$ connects up the buzzer to the section immediately a call commences. The buzzer tone is disconnected as soon as the dialling starts.

In the case where a line is divided into many adjacent sections, each one is furnished with a line equipment at each end as shown in figure 14 . Therefore when a call is made the impulse relays
of both line equipments are attracted and work in parallel during impulsing. In order to prevent, as far as possible, reaction between the two impulse relays and also to diminish the damaging influence of any voltage differences between the batteries at the ends of the sections, the rectifier $L_{1}$ is connected in series with one winding of the impulse relay. Without this rectifier the result would be that the impulse relay with the weaker magnetisation would be fast in operation and the one with the stronger would be slow.

Different battery voltages at both ends would have precisely the same result. The rectifier which prevents reverse current in the impulse relay causes the impulse relays to operate as if they were connected each to separate lines.

The rectifier $L_{2}$ corresponds to the one with the same designation in the selector apparatus. The calls in other sections are made through this rectifier. But for this the high voltage surges of current for the operating of the section would be short circuited and consequently the work of the selectors would be made difficult.

The task of the rectifier $L_{3}$ is to make it possible for the relay $R_{5}$ and the selector to be driven from the same impulse contact.

In addition to the particulars given above the following details of the circuit should be pointed out.

The relay $R_{4}$ cannot be pulled up except when the selector stands in its home position. This arrangement is made so that if a new call is made on the section so soon after another call that the selector whilst restoring, has not had time to reach the home position, the restoring would be stopped by the new call if the relay $R_{4}$ was not
prevented from being pulled up before the selector reached its home position.
According to the above the line equipment is made in such a way that a long ringing impulse is added to the impulses of the dial. It is not desirable that this ringing impulse should be a long one in case the figure dialled is a directional figure which marks the traffic to another section. In this case it is desirable that the connecting up of the section be performed as quickly as possible. Therefore the long final impulse is clipped short in this case as soon as the relay $R_{7}$ is attracted.

As shown above the capacity of the section is 19 numbers. The maximum number of positions that the selector in the line equipment can search out is 9 . For the reason given below this number is reduced to 8. As previously described the line equipment is designed so that when a directing figure is encountered, the final impulse to the selectors is shortened. There is consequently nothing to prevent a selector being placed on just that directing figure, since the trembler bell has not time to operate. In order to use this for increasing the capacity of the selector system, the line equipment is designed in the following way.
The impulses from relay $R_{3}$ to the selector are carried over a line in the selector multiple in all positions except the last. In this last position the selector receives instead current from a contact on the relay $R_{6}$. All the telephones are given two digit numbers. After the first digit, 9 or 0 , the selector stands in the 9th or roth position and has gone past the 8th directional position for the connecting up to other sections.

In these two positions the negative from $R_{2}$ is connected through the selector C -line to relay $R_{7}$ which consequently operates and cuts short the otherwise long extra-impulse. Since the relay $R_{2}$ has released, $R_{7}$ is released also. After the second digit in the number is sent out the final impulse is not shortened. When the impulsing for the second digit begins the selectors are in different positions. If o is the first digit the notched wheel is locked fast in its existing position, whilst with a 9 as first figure the selector falls back to its home position. The 12 step selector meanwhile operates the same in both cases. With the impulsing for the second figure the selector moves as usual until the last position is attained after 2 respective single steps. In this last position it immediately obtains current from relay $R_{6}$, hence the armature of the selector is attracted and remains actuated until the relay $R_{6}$ is released. As
the selector is indirectly driven it does not operate until the magnet is deenergised and in this way moves to its home position again after which, consequently, a fresh call can be made and a new ringing signal received. Two or more different subscribers can be called one after the other without the necessity of the calling subscriber replacing his hand microtelephone between each call.

In this way the following capacity per section is obtained:

Number of directions from the section: 8 .
Number of telephone instruments on the section: 18 (19).

Directing numbers: $\mathrm{I}-8$.
Telephone numbers: 92-90, or-09(oo).
As a general call number the oo is used.
Should a still greater capacity be required, the following method may be used. All selectors connected to a section are divided into groups, which are designed in different ways with respect to the device for the addition of the impulse series. A group stops in the position attained, if $o$ is the first digit, whilst all the other selectors fall back to their home position, starting from this anew, when the second digit is dialled. Another group will work similarly, if 9 is the first digit, another group if 8 is taken first etc. Thus, only a certain number of selectors will have reached a new starting position after the first digit. When a long impulse is sent from the line equipment after the second digit, the bell will ring in the apparatus, the selector of which makes contact in the position selected. As the position of contact must be at a distance of at least 12 steps from the home position, the numbers available will not be ten for each first digit, but will decrease as the first digit diminishes.

| The number series |  |  |
| :---: | :---: | :---: |
| Telephone <br> number | will be <br> Number of <br> instruments | Total |
| or-00 | 10 | Io |
| $92-90$ | 9 | 19 |
| $83-80$ | 8 | 27 |
| $74-70$ | 7 | 34 |
| $65-60$ | 6 | 40 |
| $56-50$ | 5 | 45 |
| $47-40$ | 4 | 49 |
| $38-30$ | 3 | 52 |
| $29-20$ | 2 | 54 |
| 10 | 1 | 55 |

The maximum capacity is accordingly 55 numbers, if no directing numbers are required. As the low figures increase the capacity only very
little, they may suitably be used as directing numbers. If $1-4$ are used for this purpose, the remaining capacity will still be 45 numbers, which ought to be more than sufficient for all practical cases.

The line equipment is built up mechanically as shown in figures 12 and 13 . All relays and selectors are enclosed in a dust tight sloping case from which all the necessary connections are taken to a separate terminal strip of bakelite. On this strip are to be found the terminals for connecting up the selector line, battery and buzzer etc. and also the terminals for interconnecting to other sections.

Because of this standardization it is possible to increase an existing selector installation by fitting further line equipments and connecting up these to the already existing lines. This connecting up is so simple to carry out that it can be done whilst the whole installation is in use.

$\times 1040$
Fig. 12. Exterior of the line equipment. The equipment is mounted in a dust-fight sheet iron cover.

x 1041 Fig. 13. Interior of the line equipment.
The connexions are effected on a terminal strip of moulded bakelite.

## Intercommunication with Local Systems.

In larger stations in railway systems there are often local exchanges for the internal telephone traffic in and around the station. It is naturally desirable that intercommunication between the selector system and this local installation be arranged.

As the system here described works with only one loop and direct current, it is a relatively simple matter to arrange connecting lines to all kinds of CB exchanges. For LB systems the usual difficulties present themselves regarding the ring-ing-off signal.

As an example figure 14 shows a junction line for two-way traffic between an automatic exchange Type OL 35 and the selective calling system.

The traffic to the local exchange is the simplest to arrange. For this purpose no kind of special equipment is required. A call in the local system occurs in the same way as a call in another section. From the A- and B-lines are connected the
positions corresponding to the directive number given to the local exchange to the line connections for an ordinary line. On the local system the call is made in the same way as from an ordinary telephone instrument. As soon as buzzer tone is received the dialling can commence. If both the outgoing and incoming traffic goes over the same line on the OL exchange, a marking of disengaged lines must be introduced, which is done in the usual way over the C -line in the line equipment selector.

The outgoing traffic is more troublesome to arrange. The con- xsons necting line as shown in figure 14 is arranged so that no encroachment on the local system itself is necessary.

The coupling-in to the selector lines occurs immediately after the ringing signal is sent out from the switch on that subscribers line to which the junction line group is connected. Because of this the alternating current relay $R_{1}$ is attracted. $R_{1}$ connects up current to the relay $R_{3}$ which connects $R_{4}$ and also puts positive on the B-line. At this point the ringing is tripped so that $R_{1}$ releases and connects-in the impulse relay $R_{5}$. After $R_{5}$ is attracted $R_{3}$ is held energised over a contact on this relay.

The local system is now in communication with the selector system. A call on the latter is carried out immediately after the relay $R_{7}$ is attracted, which occurs when disengaged marking through LC is received.

During impulsing the relay $R_{5}$ operates in parallel with the impulse relay in the cord line of the local exchange in the same way as normally used for the main lines of this type of system. During impulsing the lines are separated by the slow acting relay $R_{6}$.

It is absolutely essential, when the selective calling system is used on electrified railways, that it is fully insulated from earth. This is also the case in the event of cables being used. As the battery used on the local system is usually earthed one must introduce a separate battery for selector installations. On the junction line as shown Fig. I4 there are circuits belonging to both systems, thus the methods of connecting up both batteries have been shown.


Fig. 14. Junction line between the selective calling system and an automatic exchange. The junction line is intended for automatic traffic in both directions and requires no alteration whatever in the exchange or the selective calling system.

It should be observed that the rectifier $L_{2}$ which has the same function as in the other circuits must be placed on the outgoing line itself and not only in the bridge (relay $R_{7}$ ). This is because the telephone instruments on the local system are not protected against the heavy discharges of the condensers $C_{1}$ and $C_{2}$ which occur at the conclusion of each impulse series. The rectifier $L_{2}$ appreciably reduces the violence of these discharges so that they do not produce unsupportable acoustic shocks at the telephone.

## Simplified Local Exchange.

In those cases where the local traffic inside a railway station is not considered sufficient to require a local exchange of the normal type but where the number of desired telephone instruments from an economic and traffic point of view is too high to be suitable for a normal selective calling system, a simplified local exchange has been designed to meet the case. This is shown in Fig. 15 and the instruments used in Fig. 16.

The capacity of the local exchange is 8 outgoing lines and 9 local instruments. These instruments work in exactly the same way as the normal selector instruments and differ from these chiefly through having no selector. Only one conversation can be carried on at a time and the call is not secret.
The system can therefore be compared to a compact section from which the telephone lines
radiate. Each instrument is connected to the switching equipment by a double line.

All of the instruments are connected in parallel to the impulse relay and remain so during impulsing. Because of this it follows that normal CB instruments cannot be used, as the impulse relay will not operate with so many bells and condensers in parallel. The ringing is therefore obtained in another way. The instruments are equipped with direct current trembler bells connected in series with half-wave rectifiers in the same manner as the selectors in the selector instruments. The ringing signal is now made in such a way that after the impulsing is com-


X 5009
Fig. 15. Simplified local exchange.
$A^{\prime}, B, C$ directing numbers, $A^{\prime \prime}$ instrument numbers. The capacity of the exchange is 9 inplete the polarity of the called line The construction of the exchange is the some as that of the line equipment, Fig. 12 and 13 . is reversed for a few seconds. Du-
ring this time the trembler bell obtains current from the switch section, whilst the other lines are cut out. Immediately after the ringing signal is sent out, the selector returns to the home position and the desired number can be called again.

Only in the case of a directing figure being used does the selector stop in the fixed position and connect in the local switch to the required section. The system is arranged that a call is only made if the required section is at liberty. Should the section be engaged it is only possible to come into speach communication with the section.

As soon as the section is disengaged the call is connected up and buzzer tone indicates in the usual way that dialling can commence.

The equipment of the local system consists of 9 relays, a 12 -stepping switch and also 3 condensers and a rectifier.

The method of working is as follows:
On a call being made the impulse relay $R_{3}$ is attracted. If the selector is in its home position the relay $R_{4}$ is then attracted and remains so until the call is rung off. Simultaneously with $R_{4}, R_{2}$ is attracted the first step with which buzzer tone is sent out to the calling instrument, which indicates that dialling can begin. During impulsing $R_{5}$ and $R_{2}$ are attracted and operate the final step so that buzzer tone is cut off. If the dialled figure is a direction figure to another section, $R_{8}$ is attracted in the usual way and gives a signal in the required section if it is disengaged. The con-
nection occurs over $\mathrm{A}^{\prime}, \mathrm{B}$ and C -lines. If it is desired to ring up one of the local systems own instruments, o is first dialled. After this $R_{9}$ is attracted and is held energised over its own contacts. The relay $R_{9}$ connects up the local system selector for local traffic. The A-wire is connected up to the $\mathrm{A}^{\prime \prime}$-line of the selector switch to which the A-wire of the local line is connected, and the B -wires connection with the B-line is cut off. When $R_{9}$ is attracted the selector switch is driven immediately to its home position through the self driving contact. When the next figure is dialled, $R_{5}$ and $R_{6}$ are both attracted. Then $R_{5}$ releases when the impulsing is completed but $R_{6}$ is held attracted for a few seconds more by the pendulum contact and connects the current to the relay $R_{1}$ which cuts of all the lines connected in parallel and through the selectors position on the $\mathrm{A}^{\prime \prime}$-line reverses the line polarity on the required local line, so that the bell in the instrument rings. After the ringing signal is sent out the selector returns to its home position, after which any local instrument can be called again.

x1042 Fig. 16. Telephone instrument for simplified
local exchange.
The instrument is designed as a CB set, but the magneto bell is exchanged against a trembler bell in series with a rectifier. The bell rings when the polarity of the line is reversed.

A call between a selector line instrument and a local instrument, according to the above, operates on both the selector and the local systems.

For instruments commonly used for such traffic the best type is that known as a double line instrument which by means of a push button can switch over from local to selector working. With this exception the telephone instruments agree with the ordinary local instruments.

## Sectionizing of Selector Lines.

It is the traffic conditions themselves that within the limits of the system decide how the division of the selector lines should take place. The Ericsson Selective Calling System is very flexible in this respect and from a point of view of sections can be divided up in practically any way desired. Figures 17, 18 and 19 show several examples of this.

Figure 17 shows the basic principles governing the dividing up of the sections. A long line is divided into a series of short stretches which are connected together like the links of a chain. The division should in general be carried out so that as many calls as possible are kept within one
section. For example the directional figures for traffic to another section could be I in one direction and 2 in the other.

Figure 18 shows a more complicated system. At the section points A and C, a single and a double brand section are introduced respectively, whilst at the point B a local switching system as previously described is connected in.

The sections in reality do not require to be carried out as direct connection lines between the sectionized points. If necessary each section can be provided with branches as is shown for example in the section between A and B. A selector installation in accordance with this skeleton scheme requires several directional figures to operate it. As an example, 5 different directional figures are required for the traffic from the section between $B$ and $C$.

In larger selector installations with heavy traffic one connection possibility is often insufficient. One can then have two or even several similarly equipped sections in parallel. As this may prove to be relatively expensive it is often quite sufficient to pick out certain instruments in the system and connect them to a separate main station line, an example of which is shown in Figure 19.


Fig. 17. Sectionizing of a long line.
Directing figures for traffic in one direçtion 1, in the other 2.


X 7004
Fig. 18. Sectionizing of a more complicated railway line.
Maximum number of directing numbers: 5 from each section.


Fig. 19. Sectionized line with parallell. not sectionized, main station line.


Fig. 20. Power installation for selective calling system.

The examples given could be multiplied and are only intended to give an insight into the possibilities of the system. How the sections in reality should be designed and carried out can only be decided as the cases arise and depends entirely on local conditions and requirements.

## Power Installation for Selective Calling System.

At every sectionized point, 24 V direct current is required to operate the relays and switches, which is obtained from a suitable accumulator that can be of low capacity because of the small current consumption. For each line equipment the current consumption during speech is 0.22 A and 0.6 A on an average during impulsing. For a call of approximately 2 minutes in length, the consumption is therefore o.or Ah for line equipment.

Dependent on the line resistance and the number of selectors a higher voltage is required for operating the selector switches. In general it can be taken 100 V is sufficient. This higher voltage can be obtained by the use of radio anode batteries of the dry cell type or from a rectifier which gives the required current direct. In the last case it is advisable to have a radio battery in reserve.

It should be observed that this higher voltage should not be connected at more than one point in the section. From this it follows that this higher voltage need not be available at the terminal point of each section but is actually only required at every other point.

In the same way a reduction of buzzer connections to the sections can be made. In this case also the connection should occur at only one point per section or otherwise variations in the tone could occur as one cannot maintain exactly the same tone from all the buzzer generators.

To avoid disturbances from power lines the battery should be insulated from the earth and this condition should also be maintained whilst the battery is being charged. In the case of a direct current system, where the charging is done through a resistance, two batteries should be used which can be alternatively charged and discharged.

On the other hand when alternating current is used the charging can be done whilst the system is working. A power installation for manual operation on alternating current is shown in Figure 20. The equipment consists of two standard rectifiers, a circuit breaker with fuses for the battery and also a change-over relay which switches over the high tension rectifier and the oo V reserve battery.

Figure 21 shows a general arrangement of a complete section with a power installation of this type.

A power installation of this kind can be made fully automatic by fitting a controlling arrangement for battery charging of Ericsson's standard manufacture.
In those cases where the higher voltage is not required at the section points in question, the rectifier and the change-over relay are naturally left out of the equipment.


X 1044
Fig. 21. Erection plan for a section equipment; line equipment and power plant.

# Condensers for Protection against Atmospheric Excess Voltages 


x 1061 Condensers for excess voltage protection at the Royal Board of Waterfalls, Gothenburg.

By R. LUNDHOLM, D. Sc. Tech., Royal Board of Waterfalls, Stockholm.


#### Abstract

The author examines briefly the nature of atmospheric excess voltages, and the demands on an efficient protection against them. The calculation of condenser protectors on high and low tension lines is exemplified. The author stresses that condensers, apart from their function as excess voltage protection. may also be used for improvement of the power factor and as voltage transformers, which is considerably less expensive than current methods at high operating voltages.


## The Nature of Atmospheric Excess Voltages.

The researches carried out on atmospheric electricity during the last few years, especially by means of Dr. Norinder's cathode ray oscillograph have considerably extended our knowledge of the nature of excess voltages thus rendering possible a much more accurate calculation and design of the protecting devices than was possible only some years ago.

As is well known, excess voltages appear on aerial lines as transient waves, which progress along the line with about the same velocity as that of light. The shape of such transient waves varies considerably but according to measurements made with cathode ray oscillographs, the most dangerous type of waves has a more or less triangular shape, approximately as shown in Fig. I .

The front of the wave is comparatively steep, so that within a distance varying generally from some hundred meters to some kilometers, the voltage rises to its peak value. The declination on the back of the wave is in the average much smaller, and the total length of the wave may amount to several kilometers. During the migration of the wave along the line, its amplitude is gradually damped. Apart from leakage losses, the charge remains unchanged and the
length of the wave increases therefore as the amplitude decreases. For this reason, waves of relatively small amplitude have in the average a greater length than those of great amplitude. The charge of a wave on a well insulated line may amount to a considerable value. The charge exceeds, however, seldom a few percents of a Coulomb. The diagram in Fig. 2 shows the amplitude of a wave on a normal aerial line with a charge of 0.03 Coulomb, as a function of the duration and the length of the wave respectively. The crosses in the diagram indicate excess voltage waves actually observed. From the diagram it may be inferred, that the charge of a wave exceeds 0.03 Coulomb only in exceptional cases and that we may therefore consider any part of a system as sufficiently protected, if the lightning arrester cuts down the amplitude of such a wave to a safe value.

## The Condenser for Excess Voltage Protection.

In principle it has long been known that a condenser is an excellent excess voltage protec-


[^1]Fig. 1.


Fig. 2. Maximum voltage and duration of measured waves arriving at a terminal station (before voltage doubling due to reflection at the line terminals).
$\rightarrow$ The arrows in the diagram indicate that the duration is not exactly known, but in all cases greater than the value indicated by the abscissa.
tion. The difficulties in the manufacture of condensers having now been overcome, Sievert's Cable Works feel sure that they are supplying a long felt need by starting the manufacture of a series of condensers intended for excess voltage protection; the following gives more detailed information about condenser protection of this type.

Lightning arresters of any kind are intended to protect some vital part of a plant, as for instance a transformer station with switch gear on a high tension line, a motor on a low tension line etc., while it is not considered economical to provide separate excess voltage protection on the lines at least as far as high tension lines are concerned.

The main purpose of excess voltage protection is to reduce the amplitude of an excess voltage wave to a safe value. Nowadays, the same importance is not attached to the smoothing out of the front of the wave; it must, however, be noted that one great advantage of the condenser is that it will also be able to round off the front of
the wave and damp all high frequency oscillations in the tension more effectively than any other kind of protecting devices. If it is designed to meet the first mentioned requirement, the second point will automatically be gained.

## Design of Condenser Protection on High Tension Lines.

A wave arriving at a terminal will be doubled by reflexion; for this reason there is, especially at the terminals, a great risk of flashover in case no excess voltage protection has been provided. If a condenser is connected at the terminal between one phase and earth, the excess voltage will be considerably reduced. Fig. 3 shows the extent to which the reduction is effected as a function of the capacity of the condenser, if we suppose that the shape of the arriving transient wave is triangular.

In the calculations below the following symbols will be used:
$E=$ amplitude in kV of the most dangerous transient wave arriving.

x 1059 Fig. 3. Condenser as excess voltage protection in a terminal station.
Symbols:
$E=$ amplitude of the arriving voltage wave.
$E_{l}=$ length of the wave in km .
$\mathrm{C}=$ capacity of the condenser in microfarads/phase.
$\mathrm{E}_{1}=\sim 125 . \mathrm{C}=$ length of a line of the same capacity as the condenser. $\mathrm{E}_{\text {max. }}=$ maximum excess voltage in the protected station. The wave resistance of the line is supposed to be 500 Ohm .
$E_{l}=$ amplitude in kV of the flash-over voltage of the line.
$E_{s}=$ amplitude in kV of the flash-over voltage of the protected switch gear.
$E_{\text {max }}=$ Maximum permissible amplitude value in kV of the excess voltage at the station.
$\lambda \quad=$ Length in km of the most dangerous wave of excess voltage.
$l=$ Length in km of a part of the line having the same capacity as the condenser.
$C=$ Capacity of the condenser in $\mu F$.
The amplitude $E$ of the wave arriving at the station is limited, and determined by the insulation of the line. From the diagram in Fig. 2 the greatest probable length of a wave of the amplitude $E$ will be found. $E_{\text {max }}$ is determined by the insulation of the switch gear. From the diagram in Fig. 3 will be found the lowest admissible value of $\frac{l}{\lambda}$ corresponding to the proportion $\frac{E_{\max }}{E}$ and if $\lambda$ is known, the value of $l$.
The aforesaid will be suitably illustrated by the following example:
A 77 kV line with suspension insulators has an excess voltage on the line of

$$
E_{l}=600 \mathrm{kV} \text { amplitude value. }
$$

The switch gear to be protected is arranged in a building and has a flash-over voltage on the supporting insulators (the point of lowest insulation) of $E_{s}=300 \mathrm{kV}$.
It is supposed that the wave is added to the normal phase voltage. Consequently the highest permissible value of amplitude of the excess voltage will amount to

$$
\begin{gathered}
E_{\max }=E_{l}-\text { phase voltage }= \\
=300-\frac{77}{\sqrt{3}} \cdot \sqrt{2}=300-63=237 \mathrm{kV}
\end{gathered}
$$

and the highest possible value $E$ may assume is $E=E_{l}$-phase voltage $=600-63=537 \mathrm{kV}$.

$$
E_{\max }=\frac{237}{537}=0.44
$$

From diagram Fig. 3 will be found

$$
\frac{l}{\lambda}=1.4
$$

According to Fig. 2 the greatest probable duration of a wave of an amplitude of 537 kV is estimated to be about 45 microseconds, corresponding to a wave length of $\lambda=$ about 13.5 km .

$$
l=\mathrm{I} .4 \cdot \mathrm{I} 3.5=18.9 \mathrm{~km}
$$

The condenser cut-out should consequently have a capacity per phase corresponding to an aerial line of about 18.9 km . or about $0.8 \cdot 10^{-2} \cdot 18.9=0.15 \mu F /$ phase.

In this manner the required capacity of a condenser protection has been calculated for different operating voltages, when assuming an approximately normal proportion between the insulation of the line and that of the station. The calculation results are assembled in the table below. If larger equipments are concerned, it is advisable to make special calculations in accordance with the principles indicated above.

Concerning lines erected on wooden poles where the insulator brackets or cross arms are not connected to earth, it must be taken into consideration that the wooden pole itself increases considerably the insulation to earth. In such case it is advisable to calculate with $E=10^{6} \mathrm{kV}$, and, according to Fig. 2 with a corresponding higher duration of the wave of 24 microseconds or

$$
\lambda=7.5 \mathrm{~km} .
$$

So far as an intermediate station is concerned, a considerably lower capacity of the condenser protecting device will be sufficient, e. g. one half down to one third of the value calculated as above.

## Condenser Protection on Low Tension Aerial Lines.

Concerning the design of condenser protection on a low tension line, there are no rigid rules to follow for the calculation. The American measurements on high tension lines have produced fairly complete statistical data on excess voltage waves at their arrival at a station, i. e. after having passed a longer or shorter section of the line; during this passage both leakage (on account of corona phenomena or the like) and damping (due to resistance in the line) occur. Such a »normal» wave having a length of some ten km cannot be contained in a low tension line of relatively short length and the whole line will instead be more or less uniformly charged while excess voltage arises. In such cases, the total capacity of the network ought, in order to be effective, to be sufficient to store the whole quantity of electricity charged in the line. The problem will therefore be to calculate the quantity of this charge. It is known that the charge of a lightning is very considerable ranging about some ten Coulomb. A direct lightning flash is, however, rather rare in low tension lines, the line will more often be damaged by excess voltage. Even on high tension lines, where lightning
flashes occur much more frequently, the quantities of electricity in a transient wave are of far lower range (about 0.03 Coulomb) than the quantity of electricity in a lightning. In practice we are on the safe side if, when low tension lines are concerned, we reckon with the same charge as for waves in high tension lines.

A line of 220 V with a voltage to earth of ${ }_{130} \mathrm{~V}$ may be taken as an example. The test voltage for low tension apparatus amounts to i 000 V alternating current corresponding to about I 400 V amplitude value. For safety we calculate with only 1000 V amplitude value. The capacity required for the line amounts consequently to

$$
\text { about } \frac{0.03}{1000}=30 \cdot 10^{-6} \mathrm{Farad} / \mathrm{phase} .
$$

At service voltage and 50 cycles, this capacity corresponds to a three-phase condenser output of 0.48 kVA , which is quite moderate.

A condenser of this kind will, especially if it is divided in several smaller batteries, of e. g. io $\mu F$ per phase, protect the whole low tension line on account of the latters small extension; it will not only protect the instruments in the proximity of the batteries, but also the low tension lines themselves, which is quite contrary to the condensers on high tension lines, the protecting capacity of which extends only some kilometers along the line.

In accordance with this principle, the capacities of the low tension line cut-out condensers have been calculated, and reproduced in the table on page 35 .

In the table suitable values are also given for the capacities of condensers on intermediate voltage lines, which values have been chosen in such way that a smooth transition occurs between the values for low tension and high tension lines.


## Combined Power Factor Correction and Excess Voltage Protection.

When considering the purchase of a condenser for improvement of the power factor, the question arises, whether it might not be advantageous to design the condenser in such manner that it may also serve as excess voltage protection. For that purpose it is only necessary to connect the condensers in star with neutral directly connected to earth. The condenser will be more expensive only in case it should be intended for very low operating voltages; the additional price is, however, very reasonable with regard to the protection against excess voltage. As much higher capacities than those given in the table are very often employed for power factor correction, the obtained protection against excess voltage will be very effective.

## Condensers Used as Voltage Transformer for High Operating Voltages.

For high operating voltages each condenser element is built up of several cells connected in series. It is therefore quite natural to design the condenser as a capacitive potentiometer by arranging on the element a special tapping on the cell nearest to earth. Between this connection and the earth is placed an intermediate voltage transformer. In this way, voltage transformation is obtained for measuring purposes, for relays etc. This arrangement will, especially, when very high operating voltages are used, be considerably cheaper than voltage transformers of the usual type. Furthermore, the condenser will also be useful as a phase advancer. The high tension condenser may thus at the same time be employed for three important purposes, viz. as excess voltage protection, voltage transformer and phase advancer.
The Sievert condenser, type BCB, for an operating voltage of 40 kV and above, may be fitted with a special tapping for connection to an intermediate voltage transformer in accordance with the above. The intermediate voltage transformer is executed with two secondary windings. For threephase arrangement, the connection is effected according to Fig. 4, one set of the secondary windings being connected in star in order to make possible
the measurement of the main voltage, and the other set being connected in open delta in order to make possible the measurement of the tension of the system to earth.

## Test Voltages etc.

As the condensers are intended to protect other parts of the system, they must be more resistant than the rest of the plant with respect to insula-
tion. In the table below are given the test voltages of the Sievert excess voltage protecting condensers. Generally speaking, condensers have a very high resistance against excess voltages of short duration, and surpass in these respects all other kinds of apparatus.
The condensers will stand direct discharge (without intermediate resistance) at the D. C. voltages indicated below.

Three-phase Condenser for Excess Voltage Protection.

| Operating voltage V | $\mu \mathrm{F} /$ Phase | kVA <br> 3-phase | Coulomb $\times 10^{3}$ per phase at operating voltage | Test voltage <br> D. C. <br> 5 min . <br> kV | Test voltage A.C. 50 cycles 1 min . kV | T y Pe | Number per phase |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 380 | $11.0{ }^{1}$ | 0.90 | 3.4 | 5 | 2.5 | ECPW-o | 1 |
| 500 | $11.0{ }^{1}$ | 0.90 | $4 \cdot 5$ | 5 | 2.5 | ECPW-o | 1 |
| 3300 | 1.50 ${ }^{\text {T }}$ | 6.00 | 4.7 | 25 | 7.5 | ECPW o | 1 |
| 6600 | 0.75 ${ }^{2}$ | 12.00 | $4 \cdot 55$ | 50 | 15 | ECPW-I | 1 |
| 11000 | 0. $50^{2}$ | 18.00 | 4.20 | 80 | 22 | ECPW-II | 1 |
| 22000 | O $25{ }^{2}$ | 37.5 | 4.50 | 140 | 35 | RCP-300/IV | 1 |
| 33000 | $0.22^{2}$ | 75.0 | 5.90 | 220 | 50 | RCP-300/IV | 2 |
| 44000 | $0.16{ }^{2}$ | 75.0 | $5 \cdot 75$ | 260 | 60 | RCP-300/IV | 2 |
| 55000 | O. $15{ }^{2}$ | 75.0 | 5.85 | 300 | 75 | RCP-300/IV | 2 |
| 66000 | O. $244{ }^{2}$ | 162.0 | $7 \cdot 75$ | 330 | 85 | BCB-300/VII |  |
| 77000 | $0.225^{2}$ | 192.0 | 7.85 | 360 | 95 | BCB-300/VI | 4 |
| 110000 | 0.ro5 ${ }^{2}$ | 330.0 | 9.40 | 430 | 130 | BCB. $300 / \mathrm{VII}$ | 6 |

${ }^{1}$ The figures indicate the total capacity output required on the line.
${ }^{2}$ The figures indicate the capacity output required in each protected station.

$x$ 700s. Fig. 5. Condensers for excess voltage protection at the Royal Board of Waterfalls, Gothenburg.

## A. LIGNELL

Director of the
Stockholm Telephone System

## World Telephone Statistics

On the basis of international telephone statistics, the telephone development of various countries during the 10 -years period 19211931 is discussed. The author treats several important problems, such as the influence of Government or private operation on the increase in the number of subscribers.

Distribution of the world's telephones, in \%.
1 St JANUARY 1921


X 10453
Fig. 1.
A publication that is always eagerly expected by people interested in the telephone industry is the American Telephone \& Telegraph Company's Worlds Statistics of the extension and use of the telephone. The latest available publication at the moment shows the position on January ist, 1931.

It may be of interest to make a general survey of its main contents and at the same time to make a comparison with the conditions existing 10 years earlier, on January ist 1921. In certain cases the annual changes during this io-years period are given.
The percentage figures given in fig. I and 2 show how the telephones in the world are distri-
buted. As can be seen, the United States of America, the foremost telephone country in the world both as to early development and number of telephones, show a falling percentage figure. The conditions in Canada are exactly the same, as this country had a large number of telephones already in 1921. The development was to be expected as the greatest possibilities of development lie in the rest of the world. The United States has lost 6.75 percent during the io years period and Canada 0.14 percent, whilst Europe has increased by 4.59 and all other countries together by 2.30 percent. The distribution of the worlds

> Distribution of the world's telephones, in \%. /st JANUARY 1931

telephones between Government systems and private companies at the beginning and the end of the 10 years period is shown in the figures 3-4.

The Government telephones which on the ist January 1931 comprised $32.9 \%$ of the telephone total have increased by $4.7 \%$.

This natural development is explained partly by the fact that Government operated enterprises are much more numerous and partly because

Distribution between Government and private operation, in \%.
Ist JANUARY 1921


X 10473
Fig. 3.

Distribution between Government and private operation, in \%. 151 JANUARY 1931


X $10+83$
Fig. 4.
these enterprises, which dominate in Europe, have at the present time the greatest possibilities of development.

The table on pages 40-4I gives the total number of telephones and the number per 100 inhabitants in the different countries at the beginning and the end of the ro-years period; it also shows the increase, both absolute and in percent, during that period.

## Europe.

Europe taken as a whole registers an increase of 5299616 telephones, or 100.2 percent. This is an average of somewhat more than half a million instruments per year. The telephone density (number of telephones per 100 inhabitants) has hereby not increased more than from 1.2 to $2.0 \%$.

The Government owned telephones show an increase of 4444570 or $90.2 \%$, whereas the privately owned haved increased by 859046 corresponding to $173.6 \%$. How this growth is distributed over the different countries is shown in the diagram, fig. 5 .

Among countries with Government operated telephones, Germany, owning approximately one third of the telephones in Europe, shows the largest increase with I 439000 telephones. As a good second comes Great Britain with over one million, and next comes France with 680 thousand instruments. The greatest percentage increase in these three countries occured in France with 143.7 \% whilst Great Britain has an increase of $102.5 \%$ and Germany $79.5 \%$. Among the remaining countries with Government owned telephones, Belgium shows the greatest growth both in total number of telephones and percentage in-
crease with 229766 instruments and $365.5 \%$. Next in the list comes the U.S.S.R. with 177586 and $88.8 \%$ followed by Sweden with 148262 and $38.2 \%$.

Among countries with privately operated telephone service Italy and Spain, who both in 1921 had partly Government telephone service and who during the 10 years under review went over to exclusive private control, have increased by 267 o15 and 152382 telephones or with 232.2 and 217.7 \% respectively.

With regard to the total number of telephones at the beginning and end of the 10 years period, Germany, Great Britain, France and Sweden have held their position I to 4. Italy has made a big jump from the 11 th to the 5 th position whereas Denmark which held this position dropped to the 7 th, being passed by the U.S.S.R. Holland, Switzerland and Austria have each climbed one rung of the ladder and stand 8th, 9th and inth position respectively. Norway has dropped from No. 9 to No. 14 in order.

Poland has held its position, Belgium has jumped 5 steps from No. 15 to No. Io and Spain from 14 to 12 .
The diagram fig. 6 shows the telephone density in a number of European countries. For the sake of comparison the United States and Canada are included, as these countries possess the greatest telephone density in the world.


X 1049


Fig. 5.

The telephone density has during the 10－years period increased：
in Canada ．．．．．．．．．．．．．．．．．．．．．．．．．from 9.8 to 14.0 or by 4.2 telephones per 100 inhabitants

| United States |  | 12.4 |  | 16.4 | ＂ | ＂ | 4. | ＂ |  |  | » |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Switzerland | ＂ | 3.8 | ＂ | 7.3 | \％ | ＂ | 3.5 | ＊ | ＊ | ＊ | ＂ |
| Belgium | ＊ | 0.8 | ＂ | 3.6 |  | ＂ | 2.8 | » | ＊ | ＊ | ＊ |
| \％Great Britain | ＂ | 2.1 | ＂ | 4.3 |  | ＂ | 2.2 | ＊ | ＊ | ＊ |  |
| ＊Denmark | ＊ | 7.7 | ＂ | 9.9 |  | ＂ | 2.2 | ＊ | ＊ | ＊ | ＊ |
| Finland | ＊ | 1.3 | » | 3.5 |  | ＞ | 2.2 | ＊ | » | ＊ |  |
| ＊Sweden | ＊ | 6.6 | \％ | 8.7 |  | ＂ | 2.1 | ＊ | ， | ＊ |  |
| ＊Germany | ＊ | 3.0 | ＂ | 5.0 |  | 》 |  | ＂ | ， | ＊ |  |
| ＊Norway | ＊ | 5.0 | \％ | 6.7 |  | 》 | 1.7 | ＊ | ＊ | ＊ |  |
| ＊Holland | ＊ | 2.4 | ＂ | 3.9 |  | ＂ |  | ＊ | ， | ＊ |  |
| ＊France | ＂ | 1.4 | ＂ | 2.8 |  | \％ | 1.4 | ＊ | ， | ＊ |  |
| Austria | ＊ | 2.2 | » | 3.4 |  | 》 | 1.2 | ＂ | ＊ | ＞ |  |

## Increase in the Number of Telephones in Europe during the 10 －years Period 1／1 1921－1／1 1931.

Number of telephones per 100 inhabitants in various countries．


Switzerland has shown the biggest increase in Europe in relation to the number of inhabitants and during 1930 passed Norway．This was un－ doubtedly the result of a determined propaganda for the increase in the use of the telephone．
The increases of 2 and $2.2 \%$ in Germany and Great Britain are worthy of note as they are the result of direct increases of 1439000 and I ог 900 telephones respectively．

Sweden in 1922 suffered a set－back in the number of telephones by reason of the cancelling of several ten thousand telephones by subscribers who had previously had two telephones of different networks in Stockholm，and who now needed only one when the private and Government enter－ prises were merged．

As shown by the curve，growth in the United States was stationary in the year 1930．In the same year Canada shows a decline．This can be put down principally to the economic depression which was an even greater influence in this direc－ tion in the year 1931．According to the American Telephone \＆Telegraph Company＇s report，the number of telephones in the United States de－ clined in the year 1931 by 292000 instruments which is about $2 \%$ ．The first six months of 1932 have brought about a net reduction of not less than 785000 instruments．The number of tele－ phones in the U．S．A．is $6 \%$ less than the highest figure reached hitherto，in 1930.

The telephone density in Europe，which seems very slight in comparison with the United States is only 2.0 against 16.4 telephones per 100 in－ habitants in the last mentioned country．When the economic crisis abates，and trading conditions start to improve it is quite possible that the tele－ phone development in Europe will be on a very large scale．

Number of telephones per 100 inhabitants in the principal cities of Europe.


Fig. 7.
The telephone position on January ist 1931 in the large cities of Europe is shown in the diagram, fig. 7 .

The number of telephone conversations, local and long distance, per inhabitant, is shown by the diagram, fig. 8.

## North America.

In North America the number of telephones during the ro-years period has increased by 7534000 or $52.6 \%$; consequently the average increase per year is 753400 against 530000 in Europe. The telephone density has increased from 9.8 to 13.0 .

Private enterprise is here predominant and the increase for this group is 7464444 telephones, and as will be seen, represents practically the whole increase. The United States, and Canada are practically responsible for the whole of new


Telephone calls per inhabitant in 1930.
figures. Mexico and Cuba have during the period increased by only 47275 and 34100 telephones, 105.6 and $99.2 \%$ respectively. Cuba shows a decline during 1930 of 8341 telephones. The growth in the United States previously pointed out came to a standstill in 1930, and during the same year the number of telephones in Canada showed a slight decline. In telephone density the United States holds the word's record with 16.4 followed by Canada with 14.0 telephones per 100 inhabitants. In the other parts of North America the telephone density is very low.
The telephone position in some of the North American cities on Ist January 193I is shown in the diagram, fig. 9. The telephone density is considerably larger than in Europe, and the only city in Europe that can be compared in this direction with American cities is Stockholm, which as regards telephone density lies between Denver and Los Angeles with 31.2 telephones per 100 inhabitants.

The American uses the telephone to a far greater degree than the European. Whilst the countries that make the most frequent use of the telephone in Europe are Sweden and Denmark, with 152.2 and 132.1 telephone calls per head during 1930, the corresponding figure for U.S.A. are 226.0 and 264.8 for Canada.

## South America.

The number of telephones on the southern continent has increased during the 10 -years period by 332875 , which is $116.0 \%$ or an average increase of 33200 per year. The telephone density has only increased from 0.4 to 0.7. Private companies are here predominant and the increase is entirely due to their efforts.
The greatest increases are shown by Argentine,

Number of telephones, and telephone density, on Jan. 1st, 1921 and Jan. 1st, 1931.


| $\pm$ | West India: <br> Cuba. $\qquad$ <br> Porto Rico $\qquad$ <br> Other West-Indian Countries $\qquad$ <br> * North American Countries | $\begin{array}{r} 464 \\ 555 \\ 2958 \\ 40 \end{array}$ | $\begin{array}{r} 33912 \\ 7415 \\ 7180 \\ 3160 \\ \hline \end{array}$ | $\begin{array}{r} 34376 \\ 7970 \\ 10138 \\ 3200 \\ \hline \end{array}$ | $\begin{aligned} & 1.1 \\ & 0.6 \\ & 0.2 \\ & 0.8 \end{aligned}$ | $\begin{array}{r} 485 \\ 602 \\ 8222 \\ 100 \end{array}$ | $\begin{aligned} & 67991 \\ & 11776 \\ & 13531 \\ & 11829 \\ & \hline \end{aligned}$ | $\begin{aligned} & 68476 \\ & \text { 12 } 378 \\ & \text { 21 } 753 \\ & \text { I } 1929 \\ & \hline \end{aligned}$ | 1.8 0.8 0.3 3.3 | 34100 4408 11615 8729 | $\begin{array}{r} 99.2 \\ 55.3 \\ 114.6 \\ 272.8 \end{array}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Total | 194144 | 14107919 | 14302063 | 9.8 | 264038 | 21572263 | 2 I 836301 | 13.0 | 7534238 | $5^{2.6}$ |
|  | South America: |  |  |  |  |  |  |  |  |  |  |
|  | Argentine | - | 116553 | 116553 | 1.3 | - | 303000 | 303000 | 2.6 | 186447 | 160.0 |
|  | Brazil | 1247 | 83844 | 85091 | 0.3 | 674 | 162000 | 162674 | 0.4 | 77583 | 91.2 |
|  | Chile.... | - | 29867 | 29867 | 0.8 | - | 48687 | 48687 | ${ }^{-1.1}$ | 18820 | 63.0 |
|  | Uruguay | - | 22381 | 2238 I | 1.5 | - | 29356 | 29356 | 1.6 | 6975 | 31.2 |
|  | Venezuela | 663 | 8233 | 8896 | 0.3 | 591 | 20931 | 21522 | 0.7 | 12626 | 141.9 |
|  | Peru | , | 8550 | 8552 | 0.2 | - | 13745 | 13745 | 0.2 | 5193 | 60.7 |
|  | Columbia | - | 6843 | 6843 | 0.1 | 2500 | 26888 | 29388 | 0.3 | 22545 | 329.5 |
|  | Equador | 1 $4^{2} 5$ | 252 I | 3946 | 0.2 | 1500 | 2700 | 4200 | 0.2 | 254 | 6.4 |
|  | Bolivia. | - | 2517 | 2517 | 0.1 | - | 2333 | 2333 | 0.1 | 184 | $7 \cdot 3$ |
|  | Paraguay | 138 | 268 | 406 | 0.04 | ${ }_{185}$ | 1905 | 2090 | 0.2 | 1 684 | 414.8 |
|  | Others | 1 898 | - | 1 898 | 1 0.4 | 2830 | - | 2830 | 0.5 | 932 | 49.1 |
|  | Total | 5373 | 281577 | 286950 | 0.4 | 8280 | 611545 | 619825 | 0.7 | 332875 | 116.0 |
|  | Asia : |  |  |  |  |  |  |  |  |  |  |
|  | British India | 13000 | 21268 | 34268 | 0.01 | 22000 | 35000 | 57000 | 0.02 | 22732 | 66.3 |
|  | China .. | 52500 | 21960 | 74460 | 0.02 | 84000 | 69000 | 153000 | 0.03 | 68540 | 105.5 |
|  | Japan | $33 \circ 597$ | - | $330597$ | 0.60 | $913157$ | - | $9^{13} 157$ | 1.4 | 582560 | 176.2 |
|  | Others . | $49473$ | $4847$ | $54320$ | 0.04 | $10888 \mathrm{I}$ | 17502 | 126383 | 0.1 | 72063 | 132.7 |
|  | Total | 445570 | 48075 | 493645 | 0.1 | 1128038 | 121502 | 1249540 | 0, 1 | 755895 | ${ }^{1} 53.1$ |
|  | Africa: |  |  |  |  |  |  |  |  |  |  |
|  | Egypt | 22280 | - | 22280 | 0.2 | 46000 | - | 46000 | 0.2 | 23720 | 106.5 |
|  | South Africa | $51402$ | - | $51402$ | $0.7$ | $112900$ | - | 112900 | 1.4 | 61498 | 119.6 |
|  | Others | $27076$ | 1 448 | $28524$ | $0.02$ | $86871$ | 1320 | 88191 | 0.1 | 59667 | 209.2 |
|  | Total | 100758 | 1448 | 102206 | O. 1 | 245771 | 1320 | 247091 | 0.2 | 144885 | 141.7 |
| m | Oceania: |  |  |  |  |  |  |  |  |  |  |
| 즞 | Australia | 224000 | - | 224000 | $4 \cdot 3$ | 520169 | - | 520169 | 8.1 | 296169 | 132.2 |
| ¢ | Dutch East Indies | 33225 | 1279 | 34504 | 0.1 | 49447 | 4598 | 54045 | 0.1 | 19541 | 56.6 |
| $\bigcirc$ | Hawaii | 为 | 14376 | 14376 | 5.6 |  | 25104 | 25104 | 6.6 | 10728 | 74.6 |
| Z | New Zealand | 88439 | - | 88439 | 7.0 | 164739 |  | 164739 | 10.2 | 76300 | 86.2 |
| ס | Philippines | 1955 | 10496 | 12451 | 0.1 | $6000$ | 20017 | 26017 | 0.2 | 13566 | 108.9 |
| m | Others | 2073 | $237$ | 2310 | 0.1 | 3638 | 776 | 4414 | 0.2 | 2104 | 91.1 |
| $\frac{\pi}{k}$ | Total | 349692 | 26388 | 376080 | 0.6 | 743993 | 50495 | 794488 | 1.0 | 418408 | I I 1.3 |
|  | World Total | 5890239 | 14960311 | 20850550 | 1.2 | 11625392 | 23711075 | 35336467 | 1.8 | 14485917 | 69.5 |

Brazil and Colombia with respectively 186447 , 77583 and 22545 telephones. Argentine in itself is responsible for more than half the increase in South America. In spite of this, the telephone density in the Argentine is not higher than 2.6. Of the larger cities Buenos Aires has 6.6 and Rio de Janeiro 2.9 telephones per 100 inhabitants.

## Asia.

The increase in the number of telephones in service in Asia is 755895 or 153.1 \%. The major portion of this increase is in Japan with 582560 telephones, and despite this very considerable step up in number of telephones the density has not risen more than from 0.6 to 1.4. The telephone density for the whole of Asia is the same for the 10-years period, o.I telephones per 100 inhabitants. The telephone service in Asia is practically all state owned as only 121500 telephones, or approximately io \% of i 249500 telephones, belong to private companies. Among the larger cities, Tokio has 4.4, Kyoto 4.2 and Osaka 4.1 telephones per 100 inhabitants, whilst Shanghai and Hongkong have respectively 3.0 and 3.4 telephones per 100 inhabitants.

## Africa.

Africa is the continent that has the lowest number of telephones, the figure being only 249000 at the end of 1930.

The Union of South Africa is at the head with 112900 telephones, a telephone density of 1.4 and an increase during the 10 years under review of 61498 instruments or $119.6 \%$. The telephone density in Africa during the 10-years period has increased from 0.1 to 0.2 .

## Oceania.

The number of telephones at the end of the year 1930 was 794488 , and the increase since


1921 418,408 subscribers or $111.3 \%$. Australia is foremost with 520169 telephones and an increase of 296169 or $132.2 \%$. New Zealand follows with 164739 telephones and an increase of 76300 , corresponding to $86.2 \%$.

The telephone density is in certain districts remarkably high, i. e. in

$$
\begin{aligned}
& \text { New Zealand ........... } 10.2 \\
& \text { Australia ............... 8.I } \\
& \text { Hawaii ................. } 6.6 \\
& \text { telephones per } 100 \text { inhabitants. }
\end{aligned}
$$

The Oceanian telephone service is principally state owned; only 50495 telephones, or not more than $6 \%$ of the total number are under private control.

The large towns have the following number of telephones per 100 inhabitants:

| Honolulu | 12.4 |
| :---: | :---: |
| Auckland |  |
| Adelaide | 9.4 |
| Melbourne | 9.4 |
| Sydney | 9.1 |
| Brisbane | 7.9 |
| Manila | 4.5 |

As can be seen, the telephone density is many times greater than in many European towns. Even the frequency of telephone calls is high. New Zealand has in this respect 208.3 and Australia 7I.I calls per head.

The development of the telephone in the whole world from the $1 / 11921$ to the $1 / 1$ 1931 shows an increase of 14485917 telephones, corresponding to about 70 percent of the number of telephones in 1921. In spite of this appreciable increase, the telephone density has not risen more than from 1.2 to 1.8 instruments per 100 inhabitants.

The A. T. T's telephone statistics concerning the frequency of telephone calls unfortunately do not differentiate between local and trunk calls. If such were the case some remarkably interesting figures would be disclosed which with certainty would show the large increase in interurban traffic in Europewith regard to the international telephone traffic during the last half of the tenyears period-and these figures would certainly show the effect of the different tariff charges between countries on the number of calls made.

# The Direct Current Track Circuits on the Electrified Lines of the Swedish State Railways 

By T. HÁrD

First Administrative Engineer, Swedish State Railways, Stockholm.

The first electrification scheme of the Swedish State Railways was completed in the year 1914 on a line of 123 km between Kiruna and Vassijaure an the Iron Ore Railways in northern Sweden. The electrification was extended few years later to cover the 304 km line between Kiruna and Luleå, making the whole of the ore traffic electrically propelled.

The power used is single phase alternating
drop arouses in the rails two mutually opposed EMF:s.

If the voltage drop in the two rails is different, which is always the case, if one of the rails is insulated at both ends so that the other rail alone acts as return conductor for the propulsion current, a foreign current is impressed on the track circuit and consideration must be given to this fact when designing the track circuit.


X 7006
Fig. $1 \mathrm{a} . \mathrm{C}=$ from the substation; $\mathrm{L}=$ trolley-wire; $\mathrm{T}=$ booster transformer.

x 7007
Fig. 1 b. $M=$ return conductor.
current of 15 cycles with a line voltage of 16000 V . The return current from the locomotive to the transformer substations which are placed 40 km apart, flows through the rails.

In order to reduce the inductance on adjacent telegraph and telephone lines booster transformers are provided, the secondary windings of which are connected in series with the rails, the primary winding being connected in the trolley line (Fig. 1a). The windings have the same number of turns so that the current in the trolley-line and in the return rail will be the same.

The current in the rails causes a voltage drop along the track depending on the volume of the return current and the resistance of the rails. In a closed track circuit consisting of two parallel rails as outgoing and return conductors, this voltage

At the time of carrying out the electrification of the Iron Ore Railway, no other track circuits than the insulated rails in lengths of only about 20 metres existed on this line. These are used in Interlocking Systems in conjunction with lockmagnets on point levers as shown in Fig. 2 a or in conjunction with stick relays and route locking magnets on signal levers, the connection being carried out according to Fig. 2b. The leads from the relay and the source of supply being connected to the track at practically the same point on the return rail, no disturbing voltage differences through the propulsion current in the rails were likely to occur, nor has any disturbance of this kind been experienced with the arrangement shown in Fig. 2.

Fig. 3 shows another arrangement with short


X 5011
insulated rails, which on this railway line was brought into use for signalling the approach of trains at highway level crossings. The armatures of two combined relays $a$ and $b$ are mechanically interlocked so that the armature that first drops prevents the opening of the front contacts of the other armature. The arrangement is such that the interlocking does not release until both relay armatures have again been operated. The contacts on the armature of relay $a$ (see Fig. 3) break therefore when a train passes in the direction $a$ to $b$, and the contacts on relay $b$ when a train passes in the direction $b$ to $a$. A line circuit controlled by a front contact of relay is operated by trains that go in the direction $a$ to $b$ but is not affected by trains travelling in the opposite direction. No disturbing influence of the propulsion current on the relays can be observed with the arrangement described, evidently dependent on the fact that the rail conductors are too short for any voltage differences worth mentioning to occur.

The track circuit problem presented no real difficulties until the beginning of the electrification scheme of the 450 km line of State Railways between Stockholm and Gothenburg which was
commenced in the year 1923 and was finished 2 years afterwards. On this line there were not only a number of short insulated rails of the same type as on the Iron Ore Railway, but also a large number of long track circuits, most of which were used for automatic signalling at road level crossings. These track circuits, which were provided with direct current relays fed from primary batteries, had in general a length of about 1 ooo meters and could not without alteration be used in connection with electric traction because of the potential differences occurring on these lengths of rail attaining values high enough to disturb the functioning of the relays.
These track circuits were scattered along the line and generally at long distances from the stations, therefore the altering of the same to alternating current supply with frequency selective track relays of common type would have necessitated not only a replacing of the relays but even special equipment for generating and transmitting power for the feeding of the track circuits. It was therefore necessary from an economical point of view to find another solution.

The new electrification scheme was carried out with certain alterations concerning the arrange-

Fig. 2 b.
$C_{2}=$ contact on the signal lever;
$\mathrm{C}_{3}=$ rail contact;
$\mathbf{G}_{2}=$ route locking relay;
$\mathrm{J}=$ stick relay .

Fig. 2 a.
$B=$ insulated point;
$\mathrm{C}_{1}=$ latch contact;
$\mathrm{F}=$ rails;
$\mathrm{G}_{1}=$ point block relay;
$\mathrm{H}=$ cross bonding;
I = insulated rail;
$R=$ resistance.


X 1052
Fig. 3. $\mathrm{L}=$ line circuit.
ment for the power supply. A special insulated conductor for the return of the propulsion current was fixed on the line poles parallel with the trolley line (Fig. 16). Booster transformers were still used, but with their secondary windings connected in series with the return conductor instead of the rails.

The return conductor was connected to the rails by special leads placed approximately half way between the booster transformers.

The return path from the locomotive is via the nearest of the above mentioned leads to the return conductor and then through this to the power station. The current passes therefore only over a distance of the rails, the maximum length of which thus being half the distance between two booster transformers (see Fig. I b). As only one or two locomotives can be on the track between two booster transformers at a time, the current in the rails is limited and the voltagedrop has a comparatively low maximum value. With 100 A current, a distance of 3000 meters between drain transformers and 0.20 ohm impedance per 1000 meters in a single rail, a voltage drop of 30 V occurs. This figure gives the voltage differences encountered in track circuits under normal conditions. A practical test with trains or with artificial loads connected between the trolley line and the rails demonstrate that this potential-drop can with every certainty be considered as a maximum.

Because of these relatively favourable condi-


[^2]tions the thought occurred to try to retain the existing direct current line circuits and repell or divert the disturbing alternating current from the track relays by the device shown in Fig. 4.

Under steam working both rails were insulated, but with electrical propulsion only one of the rails could be kept insulated because the other rail must serve as a return conductor for the traction current.

To prevent leakage from one track circuit to the other, due to defective insulated points, steps shown in Fig. 4 were taken to lead over the return conductor from one rail to the other. Heavy cross bondings were provided at the ends of each track section for this purpose. If breakdown occurs in an insulated point between two rail conductors the cross bond will short circuit the rails in one of the track circuits thus making the fault apparent.

In series with the existing track relays which have a coil resistance of 4 ohm and approximately o.i A working current and were made according to the American Railway Associations specification a choking coil was inserted which at $16^{2} /_{3}$ cycles alternating current had 2 reactance of 450 à 500 ohm with voltages up to 200 V , but for direct current only 3 ohm resistance. Because of the insertion of this choke, the direct current voltage at the relay end must be raised from 0.4 to 0.7 V .

The relay coils were found to have a natural impedance of about 60 ohm at $16^{2} / 3$ cycles. The armature started to vibrate at an AC pressure of only 2 V corresponding to something above 0.30 A alternating current through the relay, should this, at the same time, have flowing through it a direct current corresponding to the release value of the relay. In order to produce the mentioned volume of current with the choke connected in series with the relay, an AC voltage of about 15 V is necessary.

Because the potential difference in the rails could exceed 15 V it was necessary to reduce the sensibility of the system to alternating current. This was attained by connecting in parallel with the relay coil a non-inductive resistance of approximately 30 ohm. Owing to this resistance, the consumption of direct-current at the relay terminals was increased by $20 \%$, so that the working current became 0.12 instead of 0.10 amps .

The necessary increase of voltage between rails at the relay end to compensate for this shunt resistance was only from 0.70 to 0.76 volts.

With alternating current, on the other hand, due to the shunt resistance, the impedance between the relay terminals was lowered from 60 ohm to about 16 ohm, so that an AC current of 0.12 amps instead of 0.03 amps was necessary to operate the relay. With the choke in series, a pressure of about 50 to 60 V would be necessary between rails instead of 15 V . This was considered to give absolute safety as higher voltages than 30 V were not encountered.

In order to prevent the breakdown of choking coils by momentary high voltages whereby a dangerous condition could occur, a heavy insulation was provided between turns as well as between the windings and the core. A factory test of 6000 V was specified. The choking resistances was completely immersed in an oil filled iron box provided with substantial porcelain insulators for terminals.

In order to protect the relay and the choking resistance from exceptional voltages in the return rail due to short circuit currents, which are always of short duration, and therefore in themselves not dangerous from a point of view of safety, fuses were put in the relay leads. Normal ${ }_{1}$ A fuses were used at first. As in practice these were not found to have a mechanical strength, they were replaced with combined safety devices of the type often used for three phase induction motors consisting of a 6 A fuse and a thermic relay which operates when a load of I A is lasting for a few seconds.

As power supply for the type of track circuit shown in Fig. 4 a battery is used consisting of 6 caustic-soda cells with type Edison electrodes connected in series multiple $2 \times 3$. By using caustic soda cells type Le Carbone, which gives a higher potential, the number of cells can be reduced to 3 connected in $1 \times 3$. In certain cases where higher battery voltages are required six such cells have been used connected in $2 \times 3$.

The capacity of the battery for both types of cells is 1500 Ah , which is sufficient for about 6 months working; battery renewals are therefore only necessary twice a year.
The series resistance at the battery is designed with a view to withstand the current which will pass through it on account of the voltage drop caused by the propulsion current. Fuses are therefore not put in at the battery end as it has been found that the cells will stand up to this current also.

In several cases where alternating current supply has been available the primary cells have been replaced by accumulators under trickle charging from metal rectifiers (Fig. 5). The accumulators act as reserve in case of accidental failure of the AC supply but in addition assists to deflect the propulsion current from the rectifier preventing the rectifier from being overloaded by the foreign current. The rectifier alone without a battery is not considered adviseable for the reason that the propulsion current in the track circuit could be changed into pulsating current that cannot be kept from the relay by the series choking coils.


The number of track circuits of this category in use on the Stockholm-Gothenburg lines is about 140 quite a number of which have been in use for several years. The experience with them has been very favourable and has caused no apprehensions with regard to safety. In connection with the electrification now on hand on the lines Stockholm-Malmö, Falköping-Nässjö and Mjölby-Örebro, a further number of about 300 track circuits will shortly be equipped with the arrangement shown in Fig. 4. The favourable experience gained on the Gothenburg line gave rise to the arrangement shown in Fig. 4 being introduced on a number of track circuits on the Iron Ore Railway, although the voltage differences with the return system in use there was found to be greater than in the Gothenburg line. As the secondary windings of a booster transformer could not be connected in series with a track circuit (see Fig. I a) it was found necessary on the Iron Ore Railway to divide those track circuits in which an insulated point for a booster transformer was situated into two, one on each side of the booster transformer, and to repeat the track relays with a common line relay as shown schematically in Fig. 6. To avoid a line
relay, by allowing the contacts of one track relay to break the current from track battery of the other track circuit, was not suitable as in this case the propulsion current would pass through the relay contacts and injure them. Even with the working conditions existing on the Iron Ore Railway the arrangement shown in Fig. 4 has proved sufficient to prevent disturbances from the traction current.


Fig. 6. $V=$ line relay.
In order to examine the shunt value of a track circuit as shown in Fig. 4 we assume that the track relay has a working voltage of 4 V and a release voltage of 0.12 V . We assume a track circuit length of 1000 meters, a DC resistance of o.II ohm per kilometer of track and also a ballast resistance of 5 ohm per kilometer of track under the worst conditions.

In an unoccupied track circuit there is required at the relay end

$$
\begin{aligned}
& e=0.40+(3+1) \times 0.120=0.88 \mathrm{~V} \\
& i=0.120 \mathrm{~A}
\end{aligned}
$$

and at the battery end:

$$
\begin{aligned}
& p=0.88+0.12 \times 0.11+\frac{0.90}{5} \times \frac{0.11}{2}=0.90 \mathrm{~V} . \\
& u=0.12+\frac{0.90}{5}=0.300 \mathrm{~A} .
\end{aligned}
$$

With I. 30 V battery voltage the necessary limiting resistance

$$
=\frac{1.30-0.90}{0.300}=1.33 \mathrm{ohm} .
$$

With the release current passing through the track relay the voltage and current at the battery end will be:

$$
\begin{aligned}
& p_{1}=0.90 \times \frac{0.12}{0.40}=0.27 \mathrm{~V} \\
& u_{1}=0.300 \times \frac{0.12}{0.40}=0.09 \mathrm{~A}
\end{aligned}
$$

For reducing the pressure from 1.30 V at the battery to 0.27 V at the track there will be required

$$
\frac{1.30-0.27}{1.33}=0.78 \mathrm{~A} .
$$

In order to increase the current from 0.09 A to a 78 A a shunt between the rails is required at the battery end of

$$
\frac{p_{1}}{0.69}=\frac{0.27}{0.69}=0.4 \mathrm{ohm},
$$

this being the shunt value at which the track circuit functions.

To determine the rate of immunity of the relay to alternating current tests have been carried out with the aid of the laboratory track circuit shown in Fig. 7.
$M$ is a potentiometer consisting of an ohmic resistance and a sliding contact ring connected to the accumulator. By moving the contact ring, the pressure between the rails $S_{1}$ and $S_{2}$ can be adjusted to any value between zero and maximum battery voltage. In series with the rail $S_{1}$ is inserted the secondary winding of a transformer connected to a $16 / 3 / 3$ cycles alternator $G$, the voltage of which can be regulated within wide ranges by alternating the excitation. The voltage produced by the generator in the secondary of the transformer corresponds to the voltage drop caused in an actual track circuit by the propulsion current.

Between the rails $S_{1}$ and $S_{2}$ a relay $R$ is connected provided with a 20 ohm shunt and a noninductive resistance $D$ of the type previously described. In the rail $S_{2}$ a moving coil ammeter A is connected and between the rails a voltmeter V .

A 220 V lamp M is connected over the front contact of the relay.

The following tests are carried out.
Test No. I. The contact ring is set so that the relay operates whereupon the voltage is slowly reduced till the lamp $L$ goes out. The ammeter indicates then the release current of the relay.

The alternator $G$ is started and the voltage regulated till the relay armature begins to vibrate and the front contacts make, so that the lamp glows. The voltage is then read on the voltmeter which shows the disturbing alternating voltage


X 1056
Fig. 7.
required to operate the relay with the release current still passing through it.

Test No. 2. Whilst the alternator is at rest the contact ring of the resistance is set in such a position that the relay armature is attracted, i. e., the ammeter indicates the working current of the relay increased by the leakage through the 20 ohm relay shunt.

The alternator is then started and the voltage regulated till the voltmeter shows approximately the disturbing voltage read in test No. I.

The contact ring on the resistance is then moved towards the zero position until the lamp $L$ dies out completely; the alternator is then stopped and the ammeter read off. This shows the release value of the relay when the propulsion current is passing at the same time through the relay windings. The test is repeated with different voltages between the rails and the release values taken.

The tests 1 and 2 were carried out with relays of different designs and the results are given below:
A. Relay with 4 front and back contacts and the following current data with a 20 ohm shunt:

$$
\begin{array}{ll}
\text { Working current } 0.100 \mathrm{~A} \\
\text { Releasing } & 0.050 \mathrm{~A}
\end{array}
$$

With test No. I disturbing pressure of 50 V was obtained and with test No. 2 a release current which varies from 0.035 to 0.040 A during the tests using a disturbing pressure from 60 down to 15 V .
B. Relay as above, but with only 2 back contacts and the following data with a shunt of 20 ohm.

> Working current 0.100 A Releasing $\quad 0.050 \mathrm{~A}$

Test No. I showed a disturbing pressure of 72 V and test No. 2 a release current of 0.045 A during tests with disturbing pressures from 72 to 15 V .
C. Relay of the same type with 4 front and back contacts but with large contact gaps and the following data with a shunt of 20 ohm:

$$
\begin{aligned}
& \text { Working current } 0.130 \mathrm{~A} \\
& \text { Releasing }>0.050 \mathrm{~A}
\end{aligned}
$$

With test No. I no disturbance occurs at 140 V (the maximum voltage of the alternator) and the
release current in test No. 2 varied from 0.040 to 0.050 A at a disturbing voltage between 100 and 20 V .
D. Relay with 4 front and back contacts with small contact gaps and flexible back contact fingers and the following data with 20 ohm shunt:

> Working current 0.110 A Releasing $\quad 0.035 \mathrm{~A}$

Test No. I showed disturbance at 55 V and test No. 2 a release current which kept at a nearly constant figure of 0.035 A between 55 and 20 V .

From the tests made it is found that the amount of the disturbing voltage that can be allowed between the rails at the relay end without the functioning of the realy being upset, is to a considerable extent dependent on the design of the relay. The contact gap seems, according to the tests, to have a bearing on the sensitivity for alternating current, probably dependent on the bigger movement of the armature whereby the vibration is made more difficult. Further an increase in the number of back contacts makes the relay more sensitive to AC disturbances, evidently depending on the rebound against the back contacts which must be the more powerful, when a greater number of contacts are to cooperate.

Test No. 2 shows that the application of alternating voltage of the same value as the disturbing voltage according to test No. I generally causes a decrease of the releasing current, but this seems to keep within reasonable limits. The decrease in question appears to be least with relays with large contact gaps and few or flexible back contact fingers.

For the State Railway installations, relays have been used which are chosen for direct current operation without any consideration to the existence of disturbing alternating currents.

From the tests carried out with different relay types it was found that a more marked immunity to alternating current can be obtained with the arrangement shown in figure 4 by the choice of specially suitable relays for the purpose. Amongst other things an articulated finger design as now used on many modern direct current relays might offer certain advantage on account of the flexibility of the contacts which prevents rebounding and diminishes the tendency of the armature to vibrate under AC load.

# The Subscriber's Multiple and Other Multiples in the Ericsson Automatic Telephone System. 

By<br>SIGURD JOHANSSON

Engineer, Royal Board of Swedish Telegraphs, Stockholm.
(This article is reprinted with the permission of "The Technical Reports of the Royal Board of Telegraphs".)

The multiple is one of the most important parts of a telephone system. The efforts of many telephone men have been directed towards the designing of a good and cheap multiple. Which, then, are the demands on a good multiple?

## I. Design.

a) The contacts must be reliable.
b) For that reason, precision work is necessary.
c) The number of soldering points must be kept as low as possible, as they constitute sources of faults.
d) The construction must be strong and sturdy.
e) The wear should not be so considerable as to make necessary the replacement of the multiple during the lifetime of the exchange.
f) The space required for a given capacity must be as small as possible.
g) cost of maintenance should also be the least possible.

## II. Cost of manufacturing.

a) The number of soldering points must be low in order to keep down cost of installation.
b) The multiple should contain the least possible weight of material.
c) The raw materials should be cheap.
d) The manufacture should as far as possible be carried out with the aid of machines.

## III. Installation.

a) The multiple should be easy to handle without damage.


X 1062
b) The installation should not offer such difficulties as to in the work of erection.

All these demands are met by the type of multiple used in the Ericsson automatic telephone system. As is well known, this multiple is built up in the following way: 25 multiple frames, each containing 20 subscribers - or trunklines - are assembled together so as to form a fan, as shown in Fig. I. Hence, the wiper shaft belonging to a selector is able to reach $25 \times 20=500$ lines. There are 3 wires, $\mathrm{a}, \mathrm{b}$ and c , for each line, as shown in Fig. 2. The wires, which are blank, are made of manganese bronze, and the contact springs of German silver.

Each rack being as a rule made for 60 selectors, placed on top of each other at intervals of 35 mm , the number of solderings for each rack will be $500 \times 3=1500$, as each wire is soldered to one end only of the wires. Had the multiple been designed in such a way that contact banks or springs had been used instead of the long, straight, blank wires, a number of $60 \times{ }_{1} 500=90000$ solderings per rack of 60 selectors would have been necessary.

From this example it will be evident, that considerable savings are made in the soldering work and, that at the same time the number of sources of faults has been considerably reduced.

When this multiple was first proposed, it was received in the same way as so many other valuable inventions, i. e., nobody believed in it. Cross-

talk would occur between the parallel wires, for which reason quad construction as on aerial lines must be undertaken. It was feared that the wires would oxidize. Spiders would build their webs between the wires, etc. But none of all these apprehensions came true.

From this short description it will be clear precisely how most of the above mentioned demands on a good multiple have been met in the Ericsson automatic telephone system. For this reason I will confine myself to give a few data concerning telephone exchanges in service, in order to show that such requirements as I a), c) and g) are also met. Experience is the only certain way of learning something about the reliability of the contact making, wear and maintenance cost.

To begin with the last point, maintenance cost, I want to state, that during the period of 9 years that the Norra Vasa Exchange in Stockholm has been in service, the cost of maintenance for all the multiples of this construction erected in the exchange has been practically nil. No cleaning whatever has been undertaken. The multiple frames have been removed only occasionally, perhaps only once a year, the reason being, as a rule, that a screw or some other thing has in some way happened to fall between the wires.

Up to this day no traces of wear are visible on the wires. The path of the contact springs is of course clearly marked, but this means only that the thin film of oxide is worn off. The wear
accordingly amounts to only some hundredths of a millimetre, and has no practical importance whatever.

Concerning the most important point, the reliability of the contacts it is obvious that good contacts are of considerable importance in a multiple. On account of the great number of contact points contained in a multiple, the total number of faults will already at a low percentage of faults, be comparatively large, which in its turn increases the cost of maintenance. On the Norra Vasa Exchange, with a capacity of 10000 subscribers lines, there are more than 2 million contact points in the multiples. As the total of the remaining contact points-in relays and sequence switches-is only 1 million, the multiples contain $2 / 3$ of the total number of contacts in the exchange. In the 9 years during which the Norra Vasa Exchange has been in service, not a single fault on account of oxide or grease has, however, occurred in these contacts.

As no periodical cleaning of the multiples has been effected, as only sporadic faults have been located to the multiple frames, and as not a single fault in the contacts has occurred, one may say that the maintenance cost for multiples of this construction in the Norra Vasa Exchange has been practically nil during 9 years of service. This is a remarkable result, which largely explains the reliability in service of the system, and the secret of its rapid success.


X 104


X 1065

In connexion with the article above, we publish two detail views of the multiple in the Norra Vasa Exchange. The picture to the left shows the multiple frames assembled so as to form a fan; to the right is shown a selector in operating position in front of the multiple.

# Design and Use of Brush Switches 



By C. KIHL and
S. ANDERSSON

Research and Developement Department Telefon A.-B. L. M. Ericsson, Stockholm

The extensive use of the switch for telephony and radio purposes has brought forward innumerable different designs based on various principles.
The essential demands on a good switch are: low resistance of the current-carrying parts, especially of the contact surfaces, which must also be resistant against wear; smooth and even motion; distinct indication of the contact positions; high leakage resistance between current-carrying parts; the design must allow of easy cleaning and adjustment as well as the interchangeability of the components.
Svenska Radioaktiebolaget, in collaboration with Telefonaktiebolaget L. M. Ericsson, has designed a brush switch fulfilling all those requirements, and possessing appreciable advantages in many other respects as well.

The switch is one of the parts most frequently used in telephony and wireless. This is why innumerable different designs of switches, based on more or less distinct principles, have gradually been developed.
ing and disconnecting condensers, coils and resistances, and, first of all, for step-by-step connection of artificial lines. The switch most frequently used in this connection is the step-by-step, or brush switch.

The purpose of this article is to describe a type of brush switch, which has been designed by Svenska Radioaktiebolaget in cooperation with Telefonaktiebolaget L. M. Ericsson as a result of extensive tests and experiments. We will, however, confine our attention to the final design, without entering into details of the previous experimental work.

A satisfactory switch must meet among others the following requirements: the current-carrying parts as well as the contact surfaces should present the least possible electrical resistance, and at the same time possess a great resistance against wear. The motion of the switch should be smooth and even; the different contact positions should be

With respect to the mechanical design only, one will find nearly as many different types as there are manufacturers.

Since Svenska Radioaktiebolaget undertook the manufacture of telephone repeater and carrier frequency equipments, the problem of designing a satisfactory switch has been extremely pressing.

In these kinds of equipments, switches are used for all kinds of purposes, as for regulating filament currents and tensions, for connect-


X 5013


Fig. 1.
Double brush.

Single brush.
$\mathrm{a}=$ contact stud $\mathrm{b}=$ contact segment $\mathrm{c}=$ contact brush


X 3004
easily distinguishable by means of a suitable arrangement. The contact surfaces should be accessible for cleaning, and the various parts of the switch should be manufactured in such a way and with such accuracy, that they may be exchanged without special adjustment. Finally, the leakage resistance between the current-carrying parts must be as high as possible.

With respect to the mechanical design proper, the switch consists of the following parts:

Contact studs and contact segments,
Contact brush,
Ratchet device,
Various parts, as shaft, bearing, brush-holder, click-wheel, knob, and screws for assembling these parts.
The contact studs and segments are determined as to their number -the latter also as to their design -by the purpose for which the switch is intended; we will discuss this point further when treating the various uses of the switch.

The contact-brush is single or double, depending on whether the switch is intended for use on one or two rows of studs, as, e. g., the symmetrical and unsymmetrical connection of artificial lines etc. (Fig. 1).

The design of the ratchet device is determined by the number of contact positions of the switch.

Fig. 2 shows in section a switch of our construction.

In a decade resistance set, where the resistances to be connected or disconnected very often amount to a fraction of an ohm only, it is of course very important that the con-
tact resistances between the brush and the studs should be as low as possible. One does not, however, demand a very great accuracy from a decade resistance set with small resistance values, but the importance of the contact resistances should nevertheless not be overlooked.

In order to reduce the contact resistances to a minimum, the contact surface between the brush and the studs should be the greatest possible. However, this is not always feasible to the desired extent, as the space available for the switch is in general none to ample. The contact resistance depends, however, to a very great extent on the material used for the brushes, contact studs and segments. By choosing appropriate materials, it has been possible to reduce this resistance to a very low value, at the same time avoiding impracticably large contact surfaces.


X 3005

In the choice of suitable materials for the different parts, one must take into consideration the wear of the brush and the contacts, which should be as low as possible. After many experiments and long-time tests, the following materials were adopted:

For the contact brush: aluminium bronze.

For the contact studs and segments: hard-drawn brass.
In this connection we may mention that the tests have shown the most appropriate material for the contact studs and segments to be hard-rolled sheet-brass, provided that the brush is running with the grain. ${ }^{1}$ This has proved most suitable with respect both to contact resistance and wear, but cannot be used on account of the considerably higher costs of manufacture.

We may mention that the total resistance of recently manufactured switches amount to about 0.002 ohms, for clean contacts including two contact resistances as well as the resistance of the contact studs, segments and brush.

Without special precautions the contact brush, which consists of several metal springs, would very soon make groves in the studs and segments, no matter which material is used. To avoid this, the brush may be fixed in an oblique position, and will thus slide on the studs at an angle with their pitch radius (Fig. 3).
Another method, which gives the same results has been developed for our switch. The brush is placed excentrically with reference to the centre of the switch (Fig. 4).

This method has proved to offer some very important advantages over the former. Among other things, the springs are easier to manufacture, as they may be made by bending metal strips of standard sizes. Further, the insulation of the brushes from each other and from the shaft of the switch is very much simplified.

[^3]

X 3006

The correct geometrical position of the brush in relation to the centre of the shaft and the length of the brush for a given radius of the contact row is calculated in the following manner:

The radius $R_{1}$ may be arbitrarily selected. The pitch is chosen so that the contact studs will not be too far apart but should enable the brush to slide easily from one stud to the next; at the same time, the division should be such that, when the brush is in a contact position, its centre line passes two studs (Fig. 5).
The distance $Z$ is the above mentioned excentricity of the brush with reference to the centre line of the shaft.

From Fig. 5 we have $Z=R_{1} \sin \alpha$
The angle $\beta$ is made equal to $1,5 \alpha$
The radius $R_{2}$ of the contact segment is then $\frac{Z}{\sin \beta}$

The dimensions $x$ and $y$ of the brush are easily calculated as

$$
\begin{aligned}
& x=R_{1} \cos \alpha \\
& y=R_{2} \cos \beta
\end{aligned}
$$

In this connection, it should be observed that the contact segments are always divided by the centre line of the brush (Fig. 5).

These are the main geometrical principles of the design of the switch, although certain special switches may be designed in a somewhat different manner.

A smooth movement of the switch has been obtained, as mentioned above, by means of the excentrical position of the brushes. The great-
est accuracy must, however, be observed during the process of manufacture, e. g., in drilling the shafthole, to avoid a bevel drilling which, on account of increased contactpressure, would make the switch move stiffly at some points of its course. As a further security against stiff and uneven movement, the supporting surface of the brush in its holder has been reduced as far as possible in order to ensure the greatest possible freedom of movement - the brush may float in the holder.
The different contact positions of the switch are indicated by means of a ratchet device. This device must be so designed as to cause the positions of contact to be distinctly indicated and so that the brush cannot stop in an intermediate position between two contact studs. The material for the various parts of the ratchet device must further be chosen so as to avoid a deterioration of the position-indication on account of wear. The fig. 2 shows the design of the ratchet device used.

The click-wheel $S$ is made of bronze. Its top part is provided with radially milled channels, corresponding in number to the contact positions. The angle between these channels must be equal to the angle between the contact studs of the switch (in general $15^{\circ}$ ). The channels are milled in such a way that no plane surface should exist between them. A steel ball $L$, operated by a coil-spring $F$, the pressure of which is regulated from the top of the switch by means of a screw $N$, catches in these channels. The combination of the different parts may be seen from the figure. In this design the ratchet device has proved to be very reliable and sturdy, and further provides excellent indication of the contact position.

The lower side of the click-wheel has been shaped into a locking device by means of which the wheel may be secured to the shaft in the desired position. From Fig. 2 it is seen that the above mentioned steel ball must catch into one of the channels in the click-wheel when the contact brush is exactly above a contact stud. The
locking of the click-wheel at first offered various difficulties as it was originally done by means of radially placed common set-screws. These, however, produced small marks on the shaft, which prevented the small displacements needed when adjusting the click-wheel in the right position in relation to the positions of contact. This difficulty may be avoided by a simple and ingenious device which facilitates an efficient locking of the click-wheel without damaging the shaft. Fig. 6 shows the arrangement of this device, which is seen from fig. 2 although not quite so distinctly.

The inferior part of the above mentioned click-wheel $S$ is shaped into a socket, containing the locking device, which consists of two steel jaws $a$ and $b$; when fastening the screw $c$, these jaws are tightened on to the shaft, thus ensuring a very efficient locking without leaving any marks.

As shown in Fig. 2, the bearings for the switch shaft, the holder for the steel ball with its spring and the regulating screw have been assembled into a single unit. By this arrangement, we have realized the advantage, that no external influence can possibly upset the adjustment of the bearing in relation to the ratchetdevice. The unit thus assembled, the shaft-socket, is cast in bronze. The screws marked $M$ in Fig. 2 are in-


Fig. 6.


X 3008
Fig. 7. Resistance and capacity bridge, MKM 232.
tended as a stop for the switch at the end positions, for which purpose, the shaft-socket has been shaped in a suitable way. The above-mentioned requirements for the interchangeability of the various parts is perfectly fulfilled in our construction, subject to accurate manufacture. Provided that narrow tolerances of between 0,01 and $0,05 \mathrm{~mm}$ are observed, one part may simply be transferred from one switch to another. Such interchangeability may often prove necessary, as when, e. g., a brush in an installation or apparatus in service is broken. Any spare brush or one taken from another switch, should immediately fit in the broken brush's place. The exchange of a brush is a very simple matter: the screw $R$ (Fig. 2) in the knob is loosened; the knob, the brush holder and the brush, which compose a single unit, are removed and replaced with the corresponding part from, e. g., another switch. The position of the brush is fixed by means of a lock-pin $I$, which goes through the shaft and fits into a channel in the brush-holder $G$. The knob, brush-holder, and brush are

screwed together and may be individually exchanged.

On account of the ease, with which the knob as well as the brushes may be removed from the switch, the advantage of an easy accessibility to the contact surface for cleaning is also obtained.

The leakage resistance between the various current-carrying parts of the switch should be the highest possible. The switches being often used for connecting and disconnecting resistances amounting to several megohms, the resistance of the insulating material between the cur-rent-carrying parts should be great in comparison with the operated resistances. After many tests, a ma-


X 3019
Fig. 9. Impedance bridge IM 1130.
terial fulfilling this requirement for the mounting plate as well as for the brush-holder has been found.

Between the contact studs there accumulates, however, a metallic dust ground off the brush and the contacts; for this reason, in specially troublesome cases, grooves must be taken out between the contact studs (v. $S$ in Fig. 11) in order to increase the leakage resistance by means of a longer leakage path.

## Different Uses.

Among the various uses of the single contact brush switch may be mentioned the resistance and capacity bridge MKM 232 (Fig. 7), which


X 3010
Fig. 10.
contains a decade resistance variable between $O$ and I III ohms divided into 4 switches. These switches effect the connection and disconnection of $10 \times 100,10 \times 10,10 \times 1$ and $10 \times 0,1-$ ohm respectively, as seen from the diagram (Fig. 8) below.

The single brush switch is used in the same connection as above for the operation of resistances as well as inductances in several other instruments, e. g., the impedance bridge IM 1130 (Fig. 9).

The switch may also be used with advantage for the step-by-step connection of artificial lines. For Tconnected resistances, a single brush is used, for H -connected resistances a double brush is necessary (Fig. Io).

Fig. II shows how the switch is assembled together with the resistances in one unit. The frame $A$ for


X 3011
this unit is moulded in bakelite. To fulfill the requirement for a high leakage resistance, the leakage path between the contact studs has been increased by means of moulded grooves $S$. The resistances $M$ composing the artificial line are connected to the corresponding contact studs. To protect the unit against dust and damage, it is provided with a cover $D$ which is secured by means of a simple locking device $L$. The same frame is used for $H$ as well as T-connected resistances; the only difference is that in the latter case only one half of the frame and one brush are used. By certain devices in the design of the contact studs, segments and brushes, it is possible
to adapt the switch to many different functions. It would take to much space to describe all these special designs, and we will confine our description to one of them only, viz. the switch used in the decade condenser DK 431. This switch effects a step-by-step increase or reduction of a capacity as results from Fig. 12, by comparison between the parts designated by the same letters in the diagram and on the switch. By choosing the condensers composing each decade in sizes of, e. g., 1, 2, 2 and $5 \mu \mathrm{~F}$, connecting together certain contact studs and adjusting the length of the various contact segments, it is possible to vary the capacity between $o$ and $10 \mu \mathrm{~F}$. Be-
sides, the brush-holder of this switch is made of metal, so that both contact brushes are electrically connected to each other as well as to the shaft. One pole $B$ is connected to the shaft through a coil-spring. From the diagram (Fig. 12) is seen that, when no condenser is connected between $A$ and $B$, the contact brush $e$ is in zero position. In the position 1 , the $I \mu \mathrm{~F}$ condenser is connected, and when the brush is advanced to the positions $2 \ldots \ldots$. 10 , the capacity will increase from $2 \ldots 10 \mu \mathrm{~F}$.

Other designs of brush switches and their use have been described in previous issues of the Ericsson Review, to which we refer.


# Standardization of Electric Cooking and Heating Appliances 

By AKSELKVAM,<br>engineer, $\mathrm{A} / \mathrm{S}$ Elektrisk Bureau, Oslo.


#### Abstract

Elektrisk Bureau in Oslo has during several years devoted extensive and successful work to the design of modern electrothermic appliances. With the permission of the firm we reprint from their journal Elektroposten the following article, wherein the advantages for the manufacturers as well as the consumers of a standardization of the hot-plates are discussed.




Fig. 1.

Intense efforts have been made in the last years by means of lectures, newspaper articles etc., to bring the public to realize the economic importance of using electric heating and cooking to the greatest possible extent.

Two items are of special importance when endeavouring to make the use of electricity more popular with the consumers.

Firstly, the rates of current must be low; the apparatus must further be, not only reliable and convenient, but also inexpensive, so that the public may see the advantage of the electrification of their kitchens. If wee look back on the development of the last ten years, one will be agreably surprised to notice the progress made by manufacturers in the construction of really reliable cooking appliances.

There is, however, ample scope for improvements. Technical progress never stops, and the task of the engineer of the future will be to reduce still further the prices of our electric cooking appliances by improvements in their construction. Another important fact, which is too often overlooked by designers is that even the best cooking apparatus is liable to be damaged on account of faulty treatment or hidden defects in the materials. In that case, it is of course important that the repairs can be effected as quickly as possible and at minimum cost.

The main point is, therefore: if e. g., electric kitchen ranges are to be introduced in all kitchens, a standardization according to international rules of the most expensive and vital parts of the range must be carried out. At the same time, all parts liable to damage in service, must be easily interchangeable and replaceable even by inexperienced people.

The most important parts, and at the same time those mostly exposed to damage, are without doubt the hot plates. It is therefore natural that the experts should have worked out standards for these parts in first place. The fundamental work in this respect was carried out some years ago by »Deutsche Industrie Normen» (DIN) and gave the following results:

1. The diameter of the plates must be in strict accordance with the dimensions prescribed by DIN, and should not be determined arbitrarily. The standard diameters are: 30,22 , 18, 14.5 and 11 cm .
2. At the bottom the plates must be provided with fixed contact pins, that fit in a corresponding horizontal socket in the same manner as a common triple-pole plug.
3. The center pin should form a neutral contact, so as to connect automatically the body of the plate to earth when it is fixed in position.
4. The external dimension of the plate, as e. g., the diameter of the pins and the distances between them must conform strictly to DIN standards.

Let us now discuss the advantages of this standardization from the consumer's point of view.

1. The standardization will simplify the manufacture of the plates, as the manufacturer will need to keep only a limited number of different diameters in stock. This reduced number of types will make possible production in series, the costs will come down, and the production process as a whole will be rationalized. A natural consequence will be a reduction of the selling price of the electric range.
2. Even the most perfect hotplate may be put out of service on account of rough handling or hidden defects in the materials.

A plate manufactured according to the standards may easily be taken out even by an unexperienced person and sent to the nearest fitter to be exchanged against a new standard plate, which may in its turn be replaced in the range by the cook herself.

The cost to the customer will further be reduced to a minimum, as there is no need to call in a fitter, who very often is not familiar with the construction of the range, and accordingly has to find out with much trouble how the plate should be disconnected. The time used by the fitter as well as his transport


Fig. 2.
tact pins of the plates are fixed, is floating, which ensures a very reliable electric contact.

The contact pins as well as the corresponding contact springs are of such ample dimensions that even a high power hot-plate may be used for many years without the slightest traces
of burns showing on the pins. The development of technics cannot stop, and it is to be hoped that before long other manufacturers also will discover the advantages of standard size plates.

Another step will then have been taken to realize a better exploitation of our white coals - and to introduce electric cooking in every home.

# The Ericsson Automatic Fire Alarm System Saves Millions 

In less than a month's time two fires that threatened to cause huge losses, have been stopped in time thanks to the Ericsson fire alarm system. The matter has aroused considerable interest in the Swedish press, and we may be content to quote an article from one of the leading dailies of Stockholm.
»Fire calls fire brigade.
Automatic fire alarm.
Millions saved in the Svanström building.

Fire broke out Tuesday evening in a store-room at Herkulesgatan ir. The address will be familiar to our readers: is was in the storerooms of the Svanström Co. in this house that the big fire raged some years ago, when books, paper etc. of over 4 million Swedish Kronor worth were destroyed. This time, the loss consisted in a burned crate containing paper, and a scorched ceiling, to a total value of Kronor 25. The fire originated in


X 5015
The fire of the Svanström building in June 1929. A repetition of this fire was averted thanks to the Ericsson Automatic Fire Alarm System.
the crate - it appears that somebody had left his pipe there and forgotten it - but it was checked within a few minutes.

The fire might have cost several millions this time too, if it had not been for special circumstances, which deserve to be told in detail.

The store-room in question has no windows; nobody could have noticed the fire and called the fire brigade. Had the fire had time to spread, one or two stories of the house would certainly have been ravaged by the flames, said the officer in command of the fire brigade.

How, then, was the fire discovered? Well, that is just the point of the story, the fire itself called the fire brigade. In the new building, which was erected after the last big fire, an automatic alarm system invented by Mr. Ekman and built by the Ericsson company, was installed. Thermostats that function at a certain temperature automatically send an alarm signal to the fire brigade of district; they are mounted in the ceilings. In the present case, the system functioned with the accuracy
that has made Swedish system famous, and there is no doubt that the installation saved millions.
In this connection, it may be mentioned that the Ericsson automatic fire alarm has proved to be extremely reliable on several previous occasions. Among other things, a threatening fire was stopped some years ago behind the scene of Södra Teatern, while the play was going on.

The system is installed in the theatres of Stockholm as well as in many shops and warehouses, and has proved to meet in all respects the demands on an efficient fire alarm system.»
The second case happened only some weeks ago. We quote another paper:
*A fire that could easily have had serious effects, but was stopped in the nick of time, broke out Tuesday night at the Cable Works in Alvsjö. Just before five o'clock in the morning, the watchman noticed some smoke, and, fetching a chemical extinguisher, proceeded to look for the fire. Even before he had time to find it, the fire brigade had already
been warned by the automatic fire alarm system installed in the building by Ericsson, and was already on its way. When they arrived a moment later, the premises were already filled with smoke to such an extent, that it proved necessary to use gas masks in order to enter the threatened building. It was ascertained that the fire had originated on account of spontaneous ignition of oil-saturated cotton rags in a waste box. This was entirely on fire, and a delay of some minutes only would have led to a catastrophe; the cable works would have suffered considerable damage to buildings, machinery and materials, not to mention appreciable losses on account of delayed deliveries.

Thanks to the automatic fire alarm, everything turned out so well, that nothing was damaged; the company has not even deemed it necessary to claim anything on their insurance. Keeping the recent fire in the Svanström building in mind, we may safely say that for the second time in a very short period the alarm system has prevented the loss of millions of Kronor.»

# Big Success of Bakelite Telephones 

The new Ericsson bakelite telephone, which is described in detail in another secticn of this issue, has already won vast recognition from all quarters where it has been examined and its excellent technical and electrical qualities ascertained.

## The Prince of Wales Buys Ericsson Telephones.

During their visit to Sweden in October, the Prince of Wales and Prince George desired acquaint themselves with the telephone system in the world's leading telephone city, and accordingly inspected the exchange Stockholm-South. After the demonstration of the Ericsson automatic system, the new bakelite telephone was shown. The Prince found it so attractive, that he at once ordered four sets. The sets exhibited were of the de luxe design; especially the white telephone with gold plated dial made for the King of Afghanistan won the approval of the Prince, who ordered one white, one green, and two red sets.

During their visit, the Princes were accompanied by Crown Prince Gustaf Adolf of Sweden, who also liked the new Ericsson model so much that he expressed his desire to have a similar telephone set installed in his study in the Royal Castle in Stockholm.

## TheSwedish Telegraphs Select the Ericsson Model.

After exhaustive tests and investigations the Swedish Telegraphs have approved the Ericsson bakelite telephone and booked a first order for 12000 sets.

x 1066 Table telephone of de luxe design. Ordered by the Prince of Wales and the King of Afghanistan.

## Norway.

The new set has already been widely used in Norway. But then, the final design of the set is the result of a Swedish-Norwegian cooperation - it was the engineers of Telefonaktiebolaget L. M. Ericsson and Elektrisk Bureau in collaboration that built the new model.

The following towns in Norway have already been equipped with the bakelite telephone:

Haugesund,
Egersund,
Kristiansand.
The following towns will have it shortly

Fredriksstad,
Selbak,
Arendal,
Moss.

## Iceland.

In connexion with the change to automatic traffic of the Ericsson system, the towns of Reykjavik and Hafnarfjördur have been equipped with bakelite telephones. See further article below.

## The Netherlands.

We take the liberty to quote from an article in the journal of the Dutch Telephone and Telegraph Engineers. »The new Ericsson telephone.
In our issues of december 1929 and februar 1930, some new types of telephone sets were mentioned. We cannot possibly be complete in this respect and introduce each new model. Our survey would, however, be extremely incomplete, if we did not give our attention to the new Ericsson set. Besides, we are pleased to introduce it for several other reasons. Our very old relations with the Ericsson firm would in themselves suffice to justify it, and the new model, furthermore, well deserves a description.

When the modern style of telephones came on the market some years ago we at first felt bewildered: they were so unfamiliar, so different. But, sooner than we should have expected, we had reconciled ourselves with the new style; we found our faithful acquaintances old fashioned, even misproportioned. At first sight of the new Ericsson
set, we still hesitated a little, but this did not last; we soon began to admire its beauty.

The whole apparatus is thorough in construction, and shows the wellknown Ericsson dependability. We wish the firm much success.》

## Italy.

The telephone manufacturing company Fatme in Rome, connected with the Ericsson group, will shortly take up the manufacture of bakelite telephones.

## Finland.

In Finland, the Ericsson telephone is already introduced in Ekenäs and Jyväskylä, and will be installed in Tammerfors before the end of the year.

## Yugoslavia.

The Ericsson telephone wins a competition.
During the first half of 1932, the Yugoslavian Post Office arranged a competition in order to determine which was the best telephone instrument. The new Ericsson bakelite set came out a winner; 13 manufacturers took part in the competition.

The choice between the different makes was based on extensive tests and comparisons, the properties of the competiting telephones being rated according to schedules fixed beforehand.
The properties to be examined and compared, as well as their relative weight in the final score had been previously determined by fixing a coefficient of importance for each property. A determined maximum number of points had also been fixed for each of the properties to be compared, and accordingly for the total score.

After the comparative tests the number of points attained was multiplied with the coefficients of importance of the respective properties, and the price of the sets was divided by their total score. In this manner was obtained a price per
unit of value, which was decided the final order of excellence.

As already mentioned, the Ericsson telephone ranked first and attained 215 of 230 theoretically possible points. The Ericsson set got the maximum score for several of the properties examined, i. e., it was considered in this respect to realize the ideal. The most important of these properties were: general appearance, the design of the microphone, the commutator, the dial, the contacts, the internal mounting, the cord, and the mechanical construction of the various parts of the set.

## Spain.

San Sebastián, capital of the province of Guipuzcoa, is automatized with the Ericsson system. The Municipality, which owns and operates the installation, has now adopted the new bakelite model.

## Czechoslovakia.

The Böhmische Escompte-Bank und. Credit-Anstalt in Prague is
moving in to a new building, which for modern comfort will rank first in Prague, and is certainly one of the most impressire in Europe. Special care has been given to the electrical installations and the Ericsson bakelite set will be a standard feature of the equipment.

## Mexico.

Empresa de Teléfonos Ericsson, the leading telephone company in Mexico, that operates more than half the telephones of the country, will gradually introduce the new telephone sets in their plants.

## Afghanistan.

The State Telephone Administration has bought a shipment of bakelite telephones. We have already mentioned the white de luxe set intended for the King of Afghanistan.

## Siam.

The State of Siam's Telephone Administration has also ordered a shipment of the new types.

## Automatic Exchanges in Finland

Demonstration of Wholly Automatic Intercommunica-


X 3012
Fig. 1.
The automatic exchange in Ekenäs is installed in a new building erected for the purpose.

The first automatic exchanges of the Ericsson 500-line system in Finland were taken into service towards the end of 1931 and during 1932. On December 6th, 1931, the automatic exchange in Lovisa was opened, on January 3oth, 1932, the exchange in Ekeräs and on August 20th the ex-
tion between Automatic Exchanges of Different Systems.
change in Fredrikshamn. All these exchanges have a capacity of 500 lines. To the Lovisa exchange is connected an automatic sub-station erected in the village of Köpbacka, 4 km from Lovisa (Fig. 2). This latter is of the Ericsson multiple relay automatic system with 40 line selectors, with a capacity of 80 lines, and works without supervision. The traffic between the sub-station and the exchange is handled entirely automatically over two-wire junction lines. All subscriber numbers contain four figures.

The traffic with the manual exchanges connected to Ekenäs, Lovisa and Fredrikshamn is handled without an operator in the automatic

x 3013
Fig. 2.
The telephone station in Köpbacka. The exchange is erected in the low annex.
exchanges, the rural lines being connected to the automatic system, and the exchanges in the rural stations being equipped with dials.

In day-time the long-distance traffic is handled at the manual longdistance switchboards in the exchanges. By night, however, the traffic is handled by the long distance operators at the other end of the long-distance lines, i. e., in Helsingfors, Äbo, Viborg etc.

The automatic exchange in Ekenäs, which is erected in a new building (Fig. 1) was demonstrated on

February 19th, 1932 to a great number of visitors, representing the Municipality of Ekenäs, the Ministry of Communication, the Post and Telegraph Administration, various private telephone companies and the press. After the automatic exchange proper, automatic intercommunication was demonstrated between subscribers connected to the Ekenäs exchange and subscribers connected to the Helsingfors and Riihimäki exchanges, which are of the Siemens system and connected to Ekenäs by long distance aerial lines of 114 and 191 km length. The purpose of this demonstration was to show, in the presence of a representative and competent audience that automatic intercommunication is possible between exchanges of the Ericsson and Siemens automatic systems, which had previously been contested in the press and otherwise in Finland. When it had been shown how the connection between subsriber's telephones on the one hand in Ekenäs, and in Helsingfors and Riikimäki on the other is effected direct by means of the dials of the respective telephones, those present were allowed to connect themselves to any
subscriber in Helsingfors, an opportunity which was used by the reporters to report on the demonstration to their papers in the Finnish capital. On January 7th, 1933, still another automatic exchange of the Ericsson system was opened in Finland, viz. in Jyväskylä, for a capacity of 900 lines.

In connexion with the inauguration of the Jyväskylä exchange, automatic intercommunication was arranged between Jyväskylä on the one hand and Riihimäki and Ekenäs on the other. In this latter case, the intercommunication was thus carried out between two exchanges of the Ericsson system. The long distance line was not less than 500 km in length. If a long distance call comes in for a subscriber, when a local call is on, an automatic long distance disconnection of the local call is effected, simultaneously giving busy signal to the disconnected subscriber.

Telefonaktiebolaget L. M. Ericsson has for the moment under construction another automatic exchange for one of the most important towns of Finland, Tammerfors; this exchange will be opened for service toward the end of 1933 .

# Elektrisk Bureau Builds Ericsson Automatic Exchanges for Iceland and Norway 

## Five Exchanges of the Ericsson System Opened in December.

It is certainly no common thing, that five great automatic exchanges delivered by the same firm are opened for service during the same month. This feat has, however, been accomplished by Elektrisk Bureau in Oslo, as the new automatic exchanges in Reykjavik and Hafnarfjördur in Iceland, and Haugesund, Kristiansand and Egersund in Norway were put in service last December. All these exchanges are built by Elektrisk Bureau and are of the Ericsson automatic system; as several automatic exchanges for other Norwegian towns are now under construction in the factory of the firm, it may be said without exaggeration that the Ericsson exchanges


Mr. Hliddal, Director of Telegraphs. Head of the Telephone Administration of Iceland.
built by Elektrisk Bureau have stood up very successfully against the keenest competition.

## Reykjavik and Hafnarfjördur.

Iceland and automatic telephony - this juxtaposition will probably puzzle many people accustomed to associate very different ideas with the island of the Sagas in the North Atlantic -. This, however, is quite wrong, for contemporary Iceland is a very modern-minded and progressive country, and its inhabitants rank among the most highly cultivated people of our time.

The step towards complete moder-


Reykjavik.
nization of the telephone system that has now been taken has been carefully prepared. The Reykjavik telephone system was modernized as late as in 1922, and it should be pointed out that the equipment was bought from Elektrisk Bureau on this occasion as well as when the telephone was first introduced in Iceland in 1906. The final capacity of the station delivered in 1922 was 2400 lines. Due to the rapid increase in the number of subscribers,

x 3014 Interior of the new automatic exchange in Reykjavik.
it proved advantageous hovewer to replace the existing LB plant, after less than 10 years, with a modern automatic exchange of 9000 lines' final capacity. Elektrisk Bureau and the Ericsson system won the very keen competition with the world's leading telephone firms.

$\therefore=2 \pi$

The new building, which contains the Reykjavik exchange. The broadcasting station is installed in the same house.

Hafnarfjördur is a much smaller town than Reykjavik, situated at a distance of about 10 km from this latter. The final capacity of this new exchange is 900 lines. Both towns are connected by cable.

The method of handling the traffic between the towns is of particular interest; for it is carried out quite automatically. The metering of the calls is arranged in such way
that each call within Reykjavik or Hafnarfjördur is counted as 1 , while a call between the towns is counted as 6. Calls between Reykjavik and Hafnarfjördur may not last more than 5 minutes. When this period has lapsed, the conversation is automatically interrupted.

Bakelite telephone instruments of the new model have been delivered by Elektrisk Bureau for installation in both towns.

## Kristiansand, Haugesund, Egesund.

The operating companies in all three towns have been in business for about 50 years.

The oldest one is Kristiansand og Omegns Telefonaktieselskab, which opened its first exchange in 1883

x 3016 The telephone exchange
in Haugesund.

The new automatic exchange has been built for a final capacity of 5000 lines. An especially remarkable fact is that the company was able to reduce its rates appreciably in connection with the automatization - the reduction amounting to $33^{1 / 3} \%$ for private subscribers - a proof as good as any of the economical advantages of automatic service.

Haugesunds Telefonselskab started its activities in 1888 with a 50 lines' exchange of Elektrisk Bureau's make. The automatic exchange may be extended up to 5000 lines and has been installed in a building built specially for this purpose.

A/S Egersunds Telefonselskab started in 1885 . In 1896 , the company had 45 subscribers - the in-


X 1067

## Aerial view of Kristiansand.

stallation then consisted of a manual exchange of 100 lines and a long distance exchange of 5 lines. The installation was increased with 50 numbers in 1900 and with 250 numbers in 1914, after which time the development continued apace. The
newly opened automatic exchange is intended for a total of 1 ooo subscribers.

The three Norwegian towns, as well as both the Icelandic towns, are equipped with bakelite sets of the new type.

## Ericsson Technics

With the beginning of 1933 Telefonaktiebolaget L. M. Ericsson has started the publication of a series of papers, under the name of Ericsson Technics. Each issue will contain only one article, and they will appear in free sequence.

The purpose of this new publication has been to create a separate organ for the purely scientific material published up till now in the Ericsson Review; the series will give a representative picture of the scientific work carried out in the Ericsson group, chiefly by the Research and Development Department.

Each paper will be issued in one language only, as a rule in English, although French may be used for certain treatises.

When the first 1933 issue of the Ericsson appears three issues of Ericsson Technics have already been published. In each issue of the Review we will give a synopsis of the contents of the papers published; these may be ordered from the Ericsson Review, Editors Office.

Ericsson Technies 1933. No. r. H. Pleijel: Théorie générale des circuits composés.
This paper deals with the general theory of a line constituted by an
arbitrary number of quadripoles or lines connected in sequence. The general case, where individual lines are interconnected by means of impedances or where transversal impedances are inserted at the junction points of two lines has been included. Each line is characterized by the reflection factors at its terminals, and by its complex attenuation. Further, the transition factor from one line to another for a current wave must be taken into consideration.

General formulæ are deduced and


X 3017
proved, concerning the effective attenuation of a composite line, the impedance for the incoming current when assuming an arbitrary arrangement at the receiving end, the caracteristics, the equivalent impedance of the composite line, the ratio between the total outgoing current and the total incoming current, as well as the attenuation factor of a composite line.

Ericsson Technics 1933. No. 2. S. Ekelöf. On the Calculation of Relay Windings.

The problem treated is to find under different conditions the appropriate windings for a relay with round core.

In § I are deduced the fundamental formulæ for the calculation of the resistance and number of turns of a winding.
§ 2 treats the problem to calculate a winding with a maximum number of ampere-turns, when the other data of the circuit are given. It then also considers the inverse question to find a winding with a given number of ampere-turns, working on maximum external resistance.
§ 3 solves the problem to find a
winding with given number of am-pere-turns, when the external resistance is zero.

In § 4 the question treated is to find a winding with given resistance and maximum number of turns.
§ 5 , finally, is devoted to relays with two windings.

The table on page 22 contains in a form, suitable for practical calculation, the results of $\mathrm{s} s 1-3$, applied to a certain make of enamelled copper wire. The use of the table will be understood from examples.

Ericsson Technics 1933. No. 3 . H. Sterky. Power Factor and Inductance of Coils with Windings Connected in Parallel.

It is a well known fact, that in order to reduce eddy current losses at high frequencies in the copper wire, inductance coils must be wound with thin wires. To obtain a specified inductance with a low power factor such coils are often wound with many wires connected in parallel. In this article a mathematical deduction of the formula for the resulting power factor and
inductance of a coil wound with two wires connected in parallel is given. It is shown that the resulting power factor will be considerably greater, and the resulting inductance smaller, than the corresponding values for the single coilhalf, especially if the coupling factor is near unity, and the inductance ratio of the coil-halves deviates from unity. From general but somewhat intricate formule simpler formulæ are derived for special cases with aiding and opposing mutual inductance between the coil-halves.

## Measuring Instruments


x 5018:
This catalogue contains the first complete collection of the telephonometric equipment manufactured by Telefonaktiebolaget L. M. Ericsson for testing and control of telephone lines.

In the introdaction of this catalogue is it emphasized, that the rapid development of long distance telephony during the last decade has made the problem of checkingup and supervision of long distance telephone lines particularly urgent. The increasing value of investments in transmission plants has made it economically imperative for the operating telephone companies to take to their aid modern and efficient measuring instruments in
order to discover impending faults and forestall interruptions in the service through better maintenance of equipment and lines. In this way, trouble and losses on account of service interruptions may to a considerable extent be avoided.

Ericsson has been working for several years to find suitable methods and instruments for measurements with audio, as well as other frequencies. It might be observed that several of the Ericsson measuring instruments offer completely unique advantages in comparison with others commonly used. Everyone that takes an interest in the matter will find many useful designs of equipment in the present catalogue.

The name of Telefon A.-B. L. M. Ericsson guarantees the sturdy construction and the excellent electric properties of every instrument.

The contents of the catalogue are arranged in a clear and instructive manner. To each instrument is devoted a description, with good photographs and diagrams, which make clear all its various possibilities in use, the theoretical principles on which the design is based, the degree of accuracy of the results, the mechanical construction of the equipment etc. The catalogue thus also serves as a work of reference concerning the use of measuring instruments.

A detailed description of the extensive materials contained in the catalogue would be too long; we will, however, mention a few of the most important instruments. A closer acquaintance with the catalogue itself will, of course, prove profitable to every telephone engineer.

## Impedance Measuring Set, Type ZA 350.



X 3019
Fig. 1.
This instrument, of patented design, is a bridge for measuring the amplitude and phase angle of impedances. It differs from other similar instruments available in the market in that the values required can be read direct from the dials; this is a definite advantage compared with other instruments, which permit only the measurement of the real and imaginary components of the impedances, and where the re-
sults have to be computed therefrom.

The instrument is intended for the frequency range between $300-$ 4280 cycles, corresponding to the angle frequencies $\omega=1810-$ 26900 . It gives direct readings of amplitudes up to 11110 ohm and phase angle up to $\pm 90^{\circ}$. Higher amplitudes may be measured by connecting additional decade resistances. By connecting a standard inductance of $\frac{1}{2 \pi}$ Henry, the measuring set may also be used as a frequency meter.
set has the advantage that a built-in amplifier takes the place of a separate auxiliary generator when making level measurements. Hereby the advantage is obtained, that errors on account of varying frequencies and curve shapes in the main generator and auxiliary generator are eliminated. Another appreciable advantage is that no generator need be included in the equipment when making measurements with portable sets.
The instruments contained in the catalogue are normally designed as portable sets. Instruments for different measurements have, however,
been assembled on test racks in order to fit in better with the fixed equipment of a telephone exchange, and thus appreciably simplify routine measurements on interurban lines. The figure shows one of these combined measuring sets - the test rack for measurements with audio frequency and direct current, type ZG 400. In another rack-type ZG 450 - the measuring equipment for carrying out high frequency measurements has been assembled.

The catalogue is published in English and Swedish in a handy and attractive volume.

## TransmissionMeasuring Set, Type ZB 450.



X 3030
Fig. 2.
This set, which is also of patented design, is used for measuring transmission levels on telephone lines. The instrument may further be used in combination with a generator for transmitting a zero level voltage, for determining the loop attenuation of lines and for measuring the gain of a repeater. Compared with other designs this transmission measuring


X 3021
Fig. 3. Test Rack ZG 400/10.

## The Durat

There is now available in English, German and Swedish, a detailed description of the design and use of a new type of electricity meter of Ericsson manufacture, which is quite unique in its kind and offers a remarkable variety of practical applications. It has been called the Duration Meter, its prime purpose being the measuring and registration of the duration of different loads, particularly in power consumption. This is the immediate object, and its importance can hardly be overrated, but the usefulness of the instrument does not stop at this. For, owing to its ingenious design, it produces the measurements in such form as to make them directly applicable to the solution of a variety of problems in technical and economic management. To make this perfectly clear, it will be best to discuss briefly the underlying problems and principles.
Irregular loads in power production and consumption.
The most salient feature of any curve representing the power consumption of an industrial enterprise, is its irregularity. This is true not only of a curve representing some considerable period, say a year, but holds equally good for the daily power consumption, that will rise in a very short time from next to nothing during night hours to the full


X 30223
amount necessary to keep the whole plant working at full, then fall back again during lunch hours and rise anew in the afternoon, reinforced by the current consumed for lighting purposes, and finally come down to zero level after the day's work is over.

From the point of view of the individual power consumer, this rhythmical variation would not in itself constitute any important problem. The responsibility for meeting peak loads is simply shifted over to the power producer. This latter, however, can not be content to leave the matter alone. He has to take care of the total load of a whole
community, and for him the irregularity of the curve has all-important consequences. He has to design and build his plant large enough to meet the highest peak load occurring, which means that his plant will be partly idle most of the time. In order to make a profit, he must so adjust the rates that those primarily responsible for the irregularities shall also pay the extra cost incurred on account of peak loads. But the equitable distribution of overhead is closely bound up with the possibility of securing accurate statistical data both for the plant as a whole, and for the power consumption of single customers and classes of customers. Hence the need of power companies for measuring instruments giving these data promptly and compactly. The ratemaking and the economic policy in general of these enterprises has to be governed by considerations of this kind.

For the manager of industrial concerns using electric power the problem is exactly the reverse of the above. If he is not an important enough customer to enduce, the power company to make special concessions, he has to consider the system of rates prevailing in his place as fixed by forces outside his control; his particular object is then how to organize and contract for his power supply so as to make the best of existing conditions. And here again the problem of loads and their duration is at the very base of the problem. Without accurate knowledge of the load data of his business the manager has no firm ground to stand on in making his decisions on the important matter of power supply.
Thus both producers and consumers of electric power are faced by the same difficulty: to devise reliable and economical means of measuring loads and determining their time characteristics. The best method of control so far available has been the use of so-called duration curves. The computation and plotting of the necessary figures is, however, a very lengthy business,
and abridged methods do not give sufficiently reliable results.

The new Ericsson Duration Meter solves all these problems and is the only instrument of its kind on the market that permits direct reading of all the relevant data. By the use of the Duration Meter, the calculation and control of power consumption takes on a new aspect.

The important feature of the Duration Meter is that the duration of different load ranges is registered in different metering mechanisms, twelve in number. At the end of any given period the readings on these mechanisms give the number of time units during which certain load levels have been reached. The duration curve is then easily plotted by choosing the numbers of the metering mechanisms, or, still better, their corresponding load values, as ordinates and their readings as abscissæ.

$\times 3023$
Record strip from a maxigraph.
For the calculation of the annual duration curve by means of such diagrams, about 35000 figures must be grouped and added. The Ericsson Duration Meter gives the necessary data by direct reading.

## Practical Applications.

## A. Power Consumers.

For power consumers the Duration Meter, as mentioned above, has its main importance as a guide to the most economical methods of securing the current supply necessary for the operation of the plant. The problems to be solved by the Duration Meter are of different kinds depending on the rate system prevailing in the district, but they all consist in finding the best combination of the following possible sources of current supply:
I. purchasing all the necessary power from outside;
2. generating it in the plant;
3. purchasing power up to a certain load level and handling peak loads by method 2 .

The Duration Meter gives directly the necessary load data, no complicated working-up of statistics being necessary.

## B. Power Producers.

For power producers, the Duration Meter affords a simple solution of several fundamental problems.

1) It gives a compact and clear picture of the load characteristics of the plant as a whole.
2) It may be used to ascertain the influence excercised on total load by certain individual customers, or classes of customers, or sections of the distribution network.

It also serves the inverse object of measuring the effect of different rate schemes on load, thus affording a reliable check and a continous control on the soundness of the economic policies adapted by the management.
3) Apart from the above information, which applies more especially to problems of rate-making and economic policy in general, the Duration Meter, by measuring the range of load fluctuations, also gives valuable guidance in technical questions, as, e.g. in determining the suitable dimensions of conductors etc.

These are, of course the principal problems the solution of which is simplified and facilitated to a remarkable degree by means of the new Ericsson instrument. Incidentally, however, the Duration Meter allows an indefinite number of applications to all kinds of load problems. A few instances will make this clear.
a) Calculation of energy losses. Problems of this kind may be simply and accurately solved with the assistance of duration curves.
b) Gas and water works may use the Duration Meter for statistics of consumption.
c) Railway companies may use the Ericsson Duration Meter for the
control of engine speed, and utilization of engines.

The above is only a few hints about this remarkable instrument and all further details regarding its construction, use, methods of treating the data obtained for the solu-
tion of specific problems is explained at length in the booklet, that may be obtained on request. No executive interested directly or indirectly in the economics of power production, distribution and consumption can afford to neglect this new
development in metering technique, and, as we have said before, every business to which load fluctuations of any kind is a factor of importance will find valuable hints for the treatment of its own cost and organization problems.

# News from the Research and Development Department 

## A New Tuning-fork Buzzer Generator.



X 3024
Fig. 1.
The Ericsson Research and Development Department has worked out a new buzzer generator, which is caracterized by a great reliability as well as frequency stability. The great reliability is obtained by using tungstene as a contact material; this metal possesses a considerable hardness and a high melting point as well as good conductivity. A considerable stability of the frequency with respect to the working voltage and the mechanical setting has been rendered possible by the application of the tuning-fork principle, by means of which the frequency is determined chiefly by the material and the dimensions of the branches of the tuning-fork.

The new buzzer generator, which is shown in Fig. I and 2 is of the same size as a single relay, and is mounted in the same manner. It consists of a tuning-folk unit and an electromagnet which are mounted on an iron corner. The magnet is, on its front part, fitted with a pole piece formed in U , which encloses both branches of the tuning-fork. These are of steel and insulated from each other and from their support, and further provided with one
internally directed contact spring each; contact electrodes are riveted to the free top part of the springs. Set screws bring the electrodes in contact with each other at rest. When the magnet is excited, the branches are attracted by the pole pieces and are bent apart with the result that the contact electrodes separate. The winding of the magnet are connected to the contacts according to the self-interruption principle. A secondary winding placed on the magnet and adjusted for the purpose is capable of delivering a secondary output ranging from 1 to $1,5 \mathrm{~W}$ at 24 V primary voltage. It is possible to obtain a satisfactory sine shape of the secondary current by connecting in parallel with the primary winding a protecting resistance connected in series with a condenser of from 0,2 to $2 \mu F$, depending on the number of turns of the winding and the frequency. The ratio between the effective secondary alternating voltage and the primary direct voltage is approximatively the same as the ratio between the secondary and primary numbers of turns, independently of the frequency.

The support of the tuning-fork unit is provided with 4 insulated soldering lugs for connexion to the ends of the windings, and 2 lugs for the current to the branches of the tuning-fork.

The frequency of the buzzer may not be appreciably altered by adjusting the set-screws, but, however, by adapting different loading masses to the branches. In order to cover a greater frequency range than would be possible according to this method, without being compelled to use mas-
ses of exaggerated size, two different types of tuning-fork units have been designed. These types differ in the thickness of the branches of the tuning-fork. In Fig. 2, the buzzer in the middle has a frequency of about $400 \mathrm{p} / \mathrm{s}$ and those to the left and the right respective frequencies of $225 \mathrm{p} / \mathrm{s}$ and $125 \mathrm{p} / \mathrm{s}$. These latter are, as will be seen from the figure, only variations of the same type, different masses having been adapted to the branches, while the former is fitted with a tuning-fork unit of another type, having thicker branches. Both types are interchangeable.

Still another type of tuning-fork unit has been designed. It is fitted with double contacts, insulated from each other, one of them being used for the buzzer, while the other may be used for certain other purposes, as, e.g., the D. C.-A.C. conversion of appreciable outputs, by using an auxiliary transformer. The tuningfork buzzer will in this case work as an interrupter mechanism only. This tuning-fork unit also is interchangeable against the above mentioned types.

$\times 3025$ Fig. 2.

## Pendulum Relay.

In telephony and telegraphy and other related fields of activity, delayed action relays are often required.

Generally a delayed action of short duration only - ranging about some tenths of a second - is necessary. A far slower action is, however, very often required, and the usual designs, based on copper sheating of the iron core, will not prove satisfactory.

The Research and Development Department has taken up this problem and designed of a pendulum relay.

This relay consists of an ordinary relay, fitted with a pendulum contact assembled in the same manner as a spring group.
When the armature is attracted, the pendulum begins to vibrate and effects during a few seconds a series of contacts, which are sufficient to keep a normal delayed action relay attracted during the same period.
The pendulum relay may be adjusted for an approximately constant delayed action ranging up to 5 seconds.

## Instrument for Testing Dials.

This instrument has been designed in order to make possible a rapid and efficient testing of the impulse ratio and the speed of dials, these data being currently used to characterize the properties of a dial.
During the rotation of the dial, the break contact effects a series of impulses, i.e. a series of alternating contacts and ruptures. If we design the make time in milliseconds as $S$,


X 3027
the break time in milliseconds as $A$, the duration of the impulse will be:
$S+A$
the impulse ratio: $\frac{S}{A}$
and the speed of the dial $\frac{1000}{S+A}$
All necessary devices for the measurement of these data are assembled in the instrument described below.

The apparatus contains a voltmeter, a frequency meter, a triplethrow commutator, a relay with two spring groups, two adjustable resistances, a potentiometer and push buttons for the connecting of the battery and the relay. The source of energy consists af threee 1.5 V dry batteries.

In order to measure the impulse ratio, one of the resistances is adjusted so that the voltmeter is deflected to the end position ( 100 divisions of the scale). The relay is then connected; the deflection of the voltmeter will consequently be reduced to a value, which is regulated by means of the potentiometer so that the deflection of the voltmeter corresponds to the assumed make time, in $\underset{o}{\circ}$, of the dial. The dial is then brought round, and released. The current through the voltmeter will then be alternately broken and closed in cadence with the movement of the dial. The deflection of the voltmeter will accordingly correspond to the average
$\frac{S \cdot 100+A \cdot 0}{S+A}=\frac{S}{S+A} \cdot 100$,
i. e., the make time, in $\sigma_{6}$, of the dial.

If the voltmeter has been adjusted to this very value by means of the potentiometer, the needle will stand still; if not, the needle will move to the value indicating the make time of the dial, in $\%$.
The determination of the speed of the dial is effected simply by winding up and releasing the dial, after putting the frequency meter in circuit by means of the triple-throw commutator. The reed of the frequency meter corresponding to the number of impulses per second will then vibrate, and the result may be read directly.

## Automatic Control Unit for Accumulator Charging.

Voltage regulators have not been much used before for the control of automatic accumulator charging, firstly because the voltage does not, at minimum values, constitute a reliable indicator of the state af an accumulator; and, secondly, because the design of reliable and unexpensive voltage regulators is a difficult task. The Research and Development Department of the Ericsson group has, however, designed an automatic charging control unit, which depends on the tension of the battery, but still works very reliably, being based on a maximum voltage value, to which it tends to bring the charge of the battery.
The arrangement is shown in Fig. 1. The voltage relay $R_{1}$ is conveniently adjusted to the tension desired by means of rheostats $r_{1}$ and $r_{3}$. If the tension of the battery is lower, it will be charged over a mercury contact until the voltage relay is energized at the adjusted tension, thereby putting a thermic relay in circuit. This latter trips the mercury contact, and the charge is interrupted. As soon as the bimetallic spring of the thermic relay has attained its maximum deflection, the voltage relay $R_{1}$ is short-circuited, and the current through the thermic relay is cut off. The bimetallic relay will then cool down and leave the contact position; this motion is not sufficient, however, to close the mercury contact. Should the tension at this moment be high enough, the relay $R_{1}$ is connected again, the temperature of the thermic relay rises, and the above mentioned process is repeated until the tension of the battery has fallen to the operating voltage of the relay $R_{1}$. The thermic relay is then completely cooled off and reaches its inithal position. The mercury contact

is then closed and connects the charging current to the battery. The battery will thus, by means of this repeated testing, be continuously supervised.

An alarm relay connected in the charging circuit indicates if the charging current should for some reason fail at the closing of the mercury contact. This same relay also connects and disconnects a resistance, which energizes the relay $R_{1}$ at a lower voltage than the tension at which the charge is interrupted. In this way, the voltage drop on account of the internal resistance of the battery when the charge stops is compensated.


X 3038

The automatic charging control unit is shown in Fig. 2, and is normally intended for charging 24 V latteries with a maximum charging current of 6 A , but may be built for other voltages as well. The tension of the battery may be regulated with a variation of $\mathrm{I}-2 \mathrm{~V}$.

## P. A. X. for 10 lines.

Among the new designs from the Research and Development Department we find a ro-lines P. A. X. of very small dimensions.

This exchange gives a cheap and efficient solution of the problem of private intercommunication, when the number of stations is limited.

The exchange is shown in the figures with and without cover. The whole equipment consists of 3 relays, I selector, i condenser and a few resistances. As current feed for the whole installation, a number of dry cells of 1.5 V connected in series up to 8 V are required. In this way, expensive accumulators with corresponding charging units, requiring continuous supervision or must


X 3029
Fig. 1.
be automatic, are avoided. In normal service the batteries should last a couple of years.

The exchange has one cord circuit, and the calls are not secret. The exterior of the telephone instruments is identical with that of the standard automatic sets, but the internal wiring is different.

When the subscriber takes off the receiver and sets up the number desired, a ringing signal is emitted during a few seconds to the called set. When both subscribers have replaced their receivers, the selectors return automatically to rest. The telephones are connected to the exchange by means of two wire conductors.


X 3030
Fig. 2.

## New Designs

The new Ericsson bakelite set, which has already in its standard design had such well deserved success, has already been adapted to several special purposes. We give here below a short account of the principal uses.

## Two-line Instruments.

As will be seen from the figure, the case and the handset are identical with that of the standard set, with the exception of the two push buttons placed above the dial.

The apparatus contains a complete equipment for two lines, and may be connected to automatic or CB exchanges. Each line equipment consists of a polarized magneto bell, a condenser and two resistances. One of the bells is built-in in the apparatus, the other being mounted in the wall fitting.

When no call is going on, none of the push buttons is depressed; when the handset is put down at the end of a call, the buttons are automatically brought to rest. When a call arrives, the bell belonging to
the calling line rings; the microtelephone is taken off and the corresponding button is pressed down, after which the call is connected. The call is interrupted as soon as the handset is put back again.
In order to originate a call from the instrument, the handset is taken off; no connexion to the line is, however, effected before one or the other push button is depressed.

x 3031

Should the operator wish to communicate with a third person, during a call on one line, e. g., in order to ask for information or give urgent orders, this is done by pressing down the button belonging to the other line. The first line is then disconnected, but the circuit is held over a resistance; the operator may thus continue the first call by pressing down the corresponding button.

The principal advantages of the new two-line set are the following:
a) simple handling;
b) call-back device;
c) inadvertent calls are eliminated, as the connexion is not effected when taking off the phone, but only after the subsequent pressing down of a button;
d) long distance calls may be received even on the line held by callback;
e) the two lines cannot be connected together, even if both push buttons are pressed down simultaneously.

## Intercommunication Set for 10 and 20 Lines.


x 3032

As shown in the figure, the case is the same as that of the standard sets; the dial has, however, been replaced by a bakelite cover-plate.

Each set requires a separate microphone battery and, for the ringing, a signal battery common to all sets is needed.

When a call is received, the bell rings. By taking off the handset, the apparatus will be connected to the calling apparatus independently of the position of the dial.

To send a call, the dial is set to the number desired, the handset is taken off and the signal push button is pressed down. The bell in the instrument called will then ring. When the push button is released, the microphonic circuit will be connected to the called apparatus.

In order to meet the need for suitable junction boxes for intercom installations,
to and 20 lines junction boxes of very practical construction have

x 3133
Fig. 2.
Intercommunication set for 10 lines.
been designed. These blocks will certainly prove suitable for other purposes as well.

The junction boxes consist of the following parts:

1) a bottom plate of black enamelled steel, which is fixed to the wall by means of two screws,
2) a terminal strip, moulded in bakelite. On this are fixed 13 terminals (for the 10 line box), or $10+13$ (for the 20 line box), which are fixed in the bakelite.

The terminal strip as well as the terminals offer many ingenious details of design.
The cables are thus drawn in open channels alongside of the strip. Open groves in the walls of the channels guide the individual wires.


Fig. 3.
Junction box for 10 lines.


X 3035
Fig. 4.
Junction box for 20 lines.

The terminals are fitted with connecting washers placed on the top and the bottom of the strip. Guiding and locking devices allow for a convenient mounting of the cable wires. The terminals of each pair are placed in a bevel position with respect to each other in order to facilitate the connection.
3) a protecting cover of black enamelled iron, secured by means of a snap lock.

The junction boxes are supplied with cord. The line cables are connected direct to the strip.

The junction boxes permit the connexion of up to four cables, two in each channel. In this case, it will prove suitable to connect one of the cables of each side to the terminals on the top, and the others to the terminals on the bottom of the strip.


AN EXHIBITION OF REX ELECTROTHERMIC APPLIANCES.

THE REX ELECTROTHERMIC APPARATUSES HAVE GAINED A GREAT POPULARITY ON ACCOUNT OF THEIR ROBUST AND CONVENIENT CONSTRUCTION. UNSURPASSED FOR THERMIC ECONOMY.

## getek TRISK BUREAU <br> OSLO <br> NORWAY

A NEW HIGH-QUALITY THREE-PHASE ELECTRICITY METER, DEVELOPED BY OUR RESEARCH AND DEVELOPMENT DEPARTMENT.


Telefonaktiebolaget L. M. ERICSSON STOCKHOLM

THREE-PHASE TRANSFORMER,


## ELEKTROMEKANO

we manufacture condensers FOR ALL PURPOSES.
OUR CONDENSER BATTERIES HAVE been delivered for tensions UP TO 2400000 VOLTS.

## SIEVERTS KABELVERK


[^0]:    x 1018
    Fig. 7. Chassis and case for table telephone, Type DE 702.
    $f, g$ bell
    1 spring group
    $\mathrm{p}, \mathrm{r}$ terminal strip

[^1]:    X 1057

[^2]:    $\mathrm{x}_{1053}$ Fig. 4. $\mathrm{DR}=$ damping resistance; $\mathrm{IR}=$ noninductive resistance; $\mathrm{N}=$ track relay; $\mathrm{S}=$ fuse.

[^3]:    1 Acc. to tests carried out by Mr. Aste, engineer at the Nynäshamn works of the Royal Board of Swedish Telegraphs.

