# ERICSSON Review

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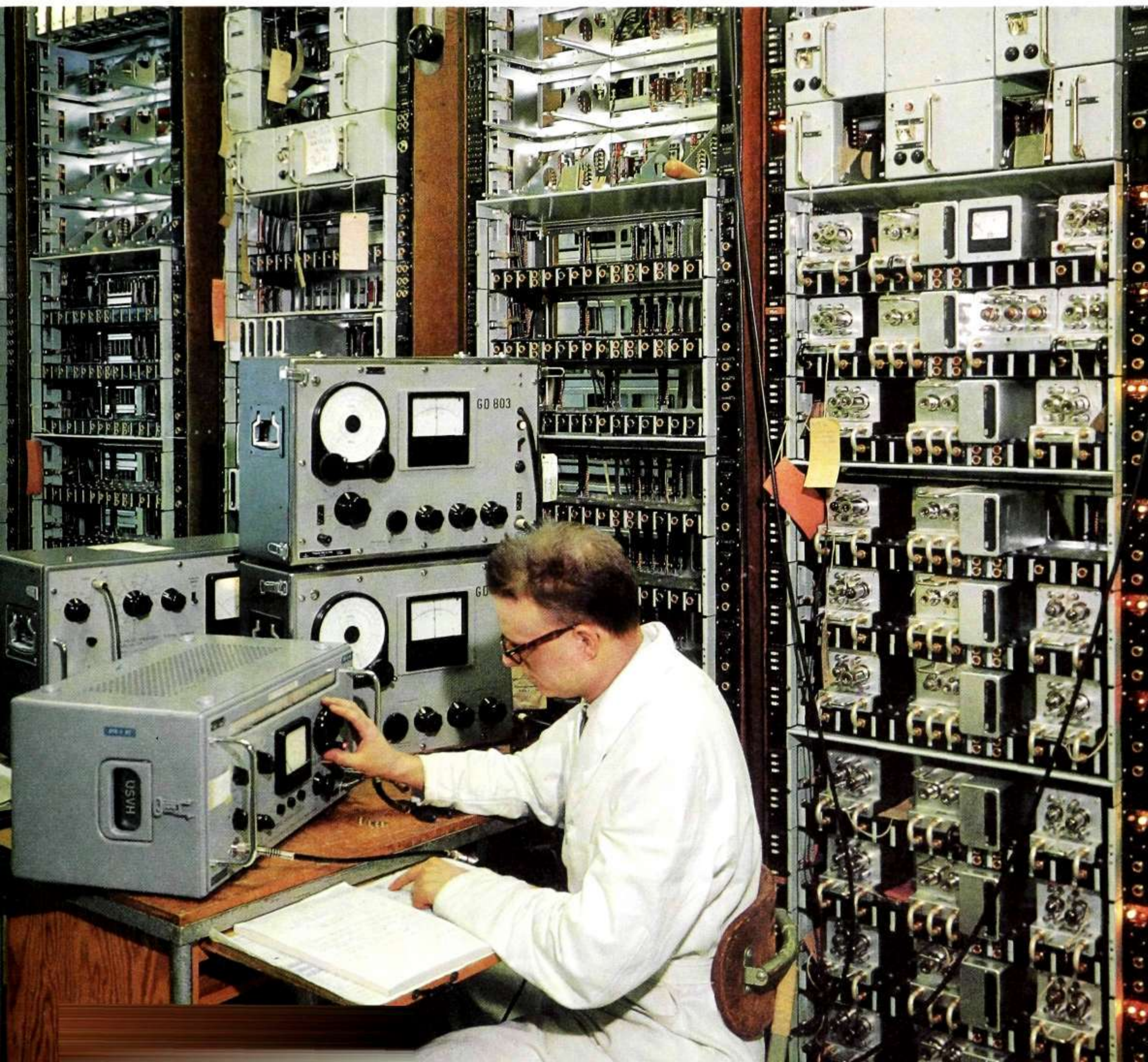
1963



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Vol. XL 1963

RESPONSIBLE PUBLISHER: HUGO LINDBERG
EDITOR: SIGVARD EKLUND, DHS
EDITOR'S OFFICE: STOCKHOLM 32
SUBSCRIPTIONS: ONE YEAR $ 1:50; ONE COPY $ 0:50

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## CONTENTS



On cover: Final Testing of Bays for L M Ericsson's 2 700-circuit Carrier System.

# Terminal Equipment for 2 700-circuit Carrier System

## I. Modulation Equipment

S TRONSLI, TELEFONAKTIEBOLAGET L M ERICSSON, STOCKHOLM

UDC 621.395.44
LME 8424

*The present article deals with L M Ericsson's equipment for modulation from the basic supergroup to the line frequency band of the 12 Mc/s system. A brief description of the system is given and the most important technical data are presented.*

*The associated equipment for carrier frequency generation will be dealt with in an article to be published in a future number of Ericsson Review. The modulation equipment for the formation of the basic supergroup has been described in Ericsson Review, No. 1, 1961 and No. 2, 1962.*

### Introduction

The introduction of coaxial systems into long distance networks at the end of the 1940's in the form of 4 Mc/s systems (960 circuits) was followed by a large expansion of the long distance traffic. The reasons were the general industrial and economic development in many countries and the introduction of subscriber trunk dialling in the middle of the 1950's. Administrations were very soon presented with the problem of further expanding the trunk networks and as the laying of new cables is very expensive, there arose a demand for increasing the capacity of coaxial cables which were already in use. The most economic solution proved to be to reduce the repeater spacing in 4 Mc/s systems by half so that the repeater station buildings which already existed could also be used in the new system.

As the attenuation of a coaxial cable increases with the square root of the frequency and approximately the same amplification could be realized, it was soon appreciated that the maximum frequency transmitted could be increased by a factor 3. See the article in Ericsson Review No. 4, 1962, by E J Eriksen entitled "The Development and Future of Wide Band Carrier Systems".

This resulted in the standardization by CCITT of the 12 Mc/s system, which has a capacity of 2 700 telephone circuits in the frequency band 312/316 kc/s–12 388 kc/s.

Together with the Swedish Board of Telecommunications, L M Ericsson took an active part in the work of CCITT in standardizing the 12 Mc/s system. This gave us at an early stage of development the possibility of fixing important system characteristics, and led to L M Ericsson being the first company in the world to put terminal equipment of this type into operation in 1962 in the cities of Stockholm, Västerås, and Örebro.

The function and construction of this equipment is now described.

### Modulation Plan

For technical and traffic reasons, the channels are not modulated directly to the prescribed line frequency range 312/316–12 388 kc/s. Instead, the modulation is carried out in stages up to larger and larger groups.

The size of the group and the position of the frequency band are standardized by CCITT.

| English nomenclature | Frequency band | Number of channels |
|---|---|---|
| basic group | 60 –108 kc/s | 12 |
| basic supergroup | 312 –552 " | 60 |
| basic mastergroup | 812 –2 044 " | 300 |
| basic supermastergroup | 8 516–12 338 " | 900 |

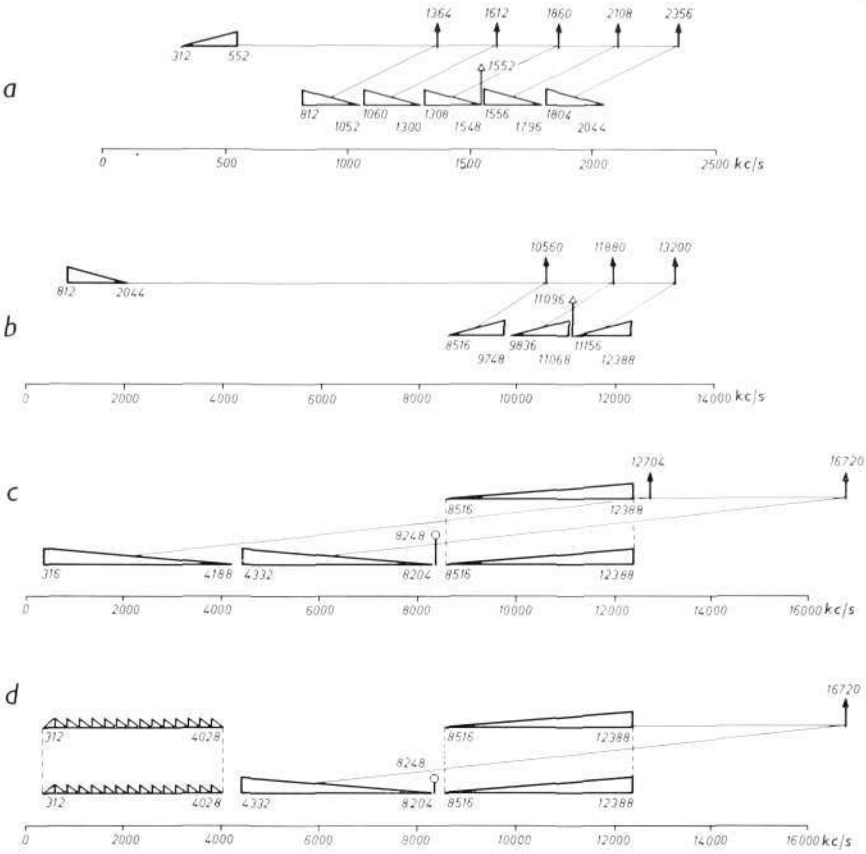



**Fig. 1** X 8339

**Modulation plan for 12 Mc/s system**

a) modulation of basic supergroup to basic mastergroup
b) modulation of basic mastergroup to basic supermastergroup
c) supermastergroup modulation to form line frequency band, alternative 1
d) formation of line frequency band, alternative 2
All frequencies are in kc/s

The line frequency band in the 12 Mc/s system containing 2 700 channels consists of 3 supermastergroups, equivalent to 9 mastergroups, each mastergroup containing 5 supergroups and each supergroup containing 5 groups.

The modulation equipment for the formation of the supergroup (channel translating and group translating equipment) is described in previous articles in Ericsson Review (No. 2, 1961 and No. 2, 1962) and will not be dealt with here.

The modulation plan is shown in figs. 1a, 1b, and 1c.

Five basic supergroups in the frequency range 312–552 kc/s are modulated with the respective carriers 1 364 kc/s, 1 612 kc/s, 1 860 kc/s, 2 108 kc/s and 2 356 kc/s. The lower sidebands are extracted and combined to form a basic mastergroup in the frequency band 812–2 044 kc/s. The channels are inverted in this frequency band.

Three basic mastergroups are then modulated again with carriers 10 560 kc/s, 11 880 kc/s and 13 200 kc/s. The lower sidebands are extracted and combined to form a basic supermastergroup in the frequency band 8 516 kc/s–12 388 kc/s with the channels erect.

The line frequency band 316–12 388 kc/s is formed by modulating two basic supermastergroups with the carriers 16 720 kc/s and 12 704 kc/s respectively, extracting the lower sidebands and combining these with a basic supermastergroup in the range 8 516–12 388 kc/s. An alternative to this method of forming the line frequency band is obtained by putting in a normal 4 Mc/s band (the first supergroup is removed) consisting of 15 supergroups in the frequency range 312 kc/s–4 028 kc/s, instead of the supermastergroup which is translated to the frequency range 316 kc/s–4 188 kc/s using the carrier 12 704 kc/s. See fig. 1d. This permits the integration of earlier type equipment in a modern 12 Mc/s network in a simple manner.

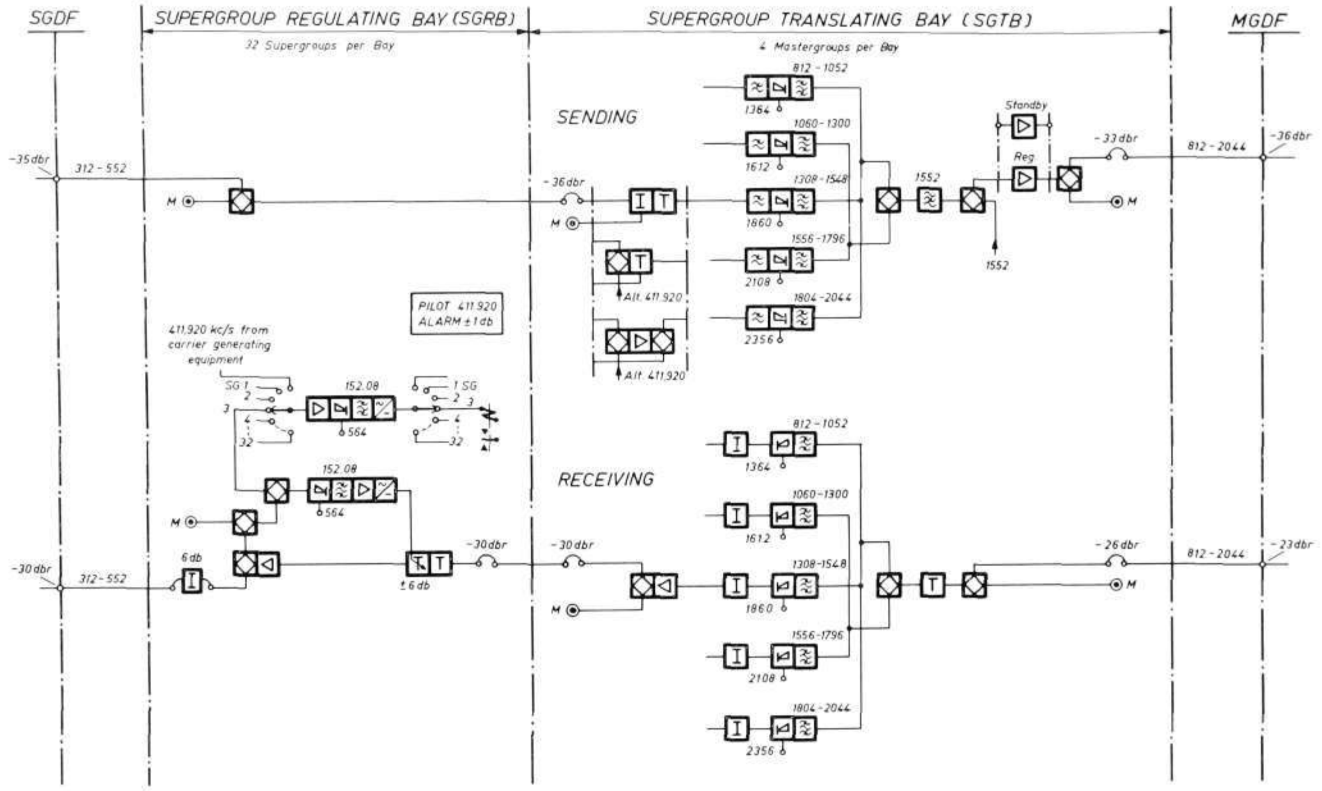



Fig. 2 X 7872

**Block schematic for supergroup translating equipment and supergroup regulating equipment**

All frequencies are in kc/s

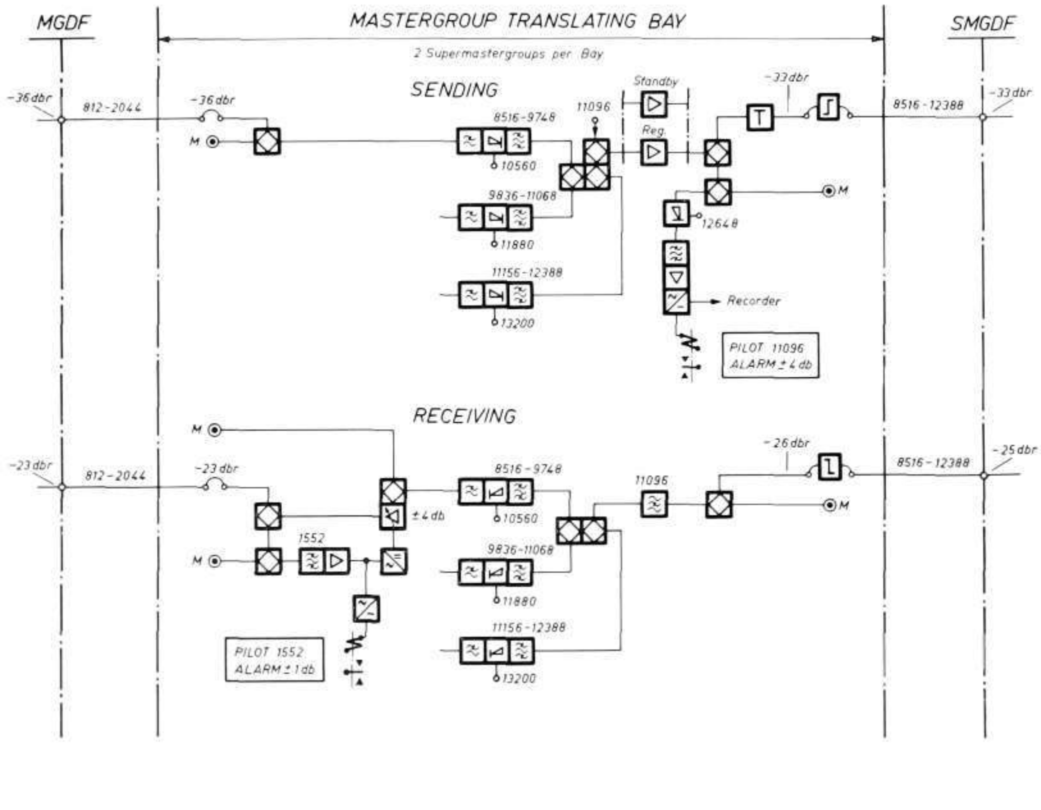
Fig. 3 X 7873

**Block schematic for mastergroup translating equipment**

All frequencies are in kc/s.

# Modulation Equipment

Figs. 2, 3 and 4 show the h.f. block schematics for the different equipment parts, with nominal signal levels given. It will be seen that each modulation stage is in principle built up in the same manner.



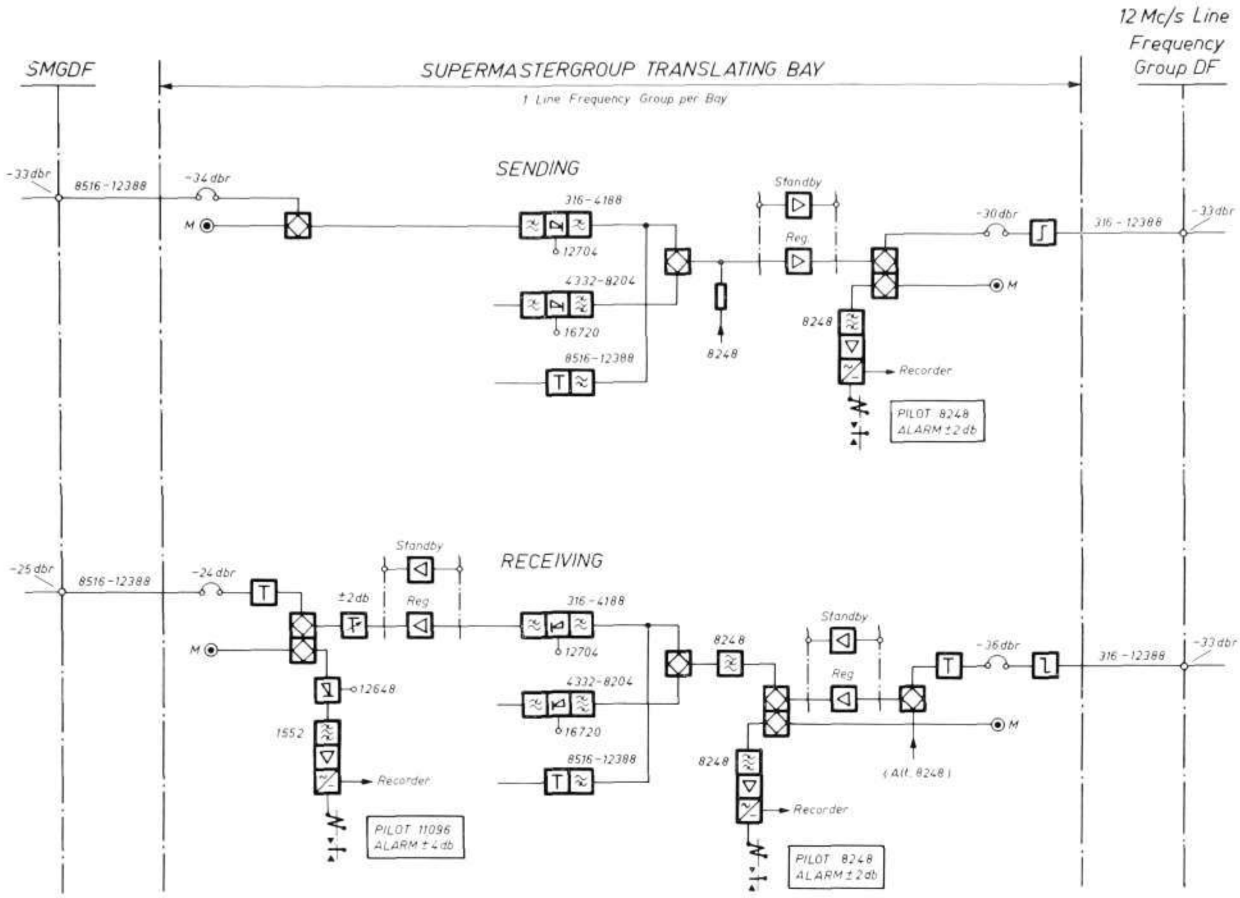



**Fig 4 a** X 7874

**Block schematic for supermastergroup translating equipment for line frequency band alternative 1**

**All frequencies are in kc/s.**

On the sending side, the signal is connected direct to the modulator units, and is then amplified after combination of the signals from the sideband filters, the combination being made in the conventional manner with a hybrid (differential transformer).

On the receiving side, the incoming signal goes direct to a hybrid connexion where it is split up and after demodulation is amplified. This division of the amplification gives good level conditions resulting in good noise characteristics. In addition the modulators and demodulators have approximately the same levels which has enabled these units to be made identical in most cases.

The attenuation at the high frequencies which occurs in transmission over the station cabling can no longer be neglected and to be able to maintain the fixed levels in the distribution frames, the modulation equipment has been designed to permit a certain amount of level adjustment. A cable attenuation of up to 3 db can be allowed for on the terminal side of the distribution frames for the mastergroups, supermastergroups and 12 Mc/s line groups. A cable attenuation of 1 db is permitted between the supermastergroup distribution and the supermastergroup translating equipment.

Due to the frequency dependence of the attenuation, a certain amount of equalization must be carried out, and the mastergroup translating and supermastergroup translating equipment has therefore been provided with plug-in type equalizing networks on the supermastergroup and 12 Mc/s line group sides. Equalization for the mastergroup is not necessary.

## *Modulators*

Conventional ring modulators have been used in the supergroup and mastergroup translating equipment. These modulators are simple and good linearity has been obtained with reasonable carrier power.

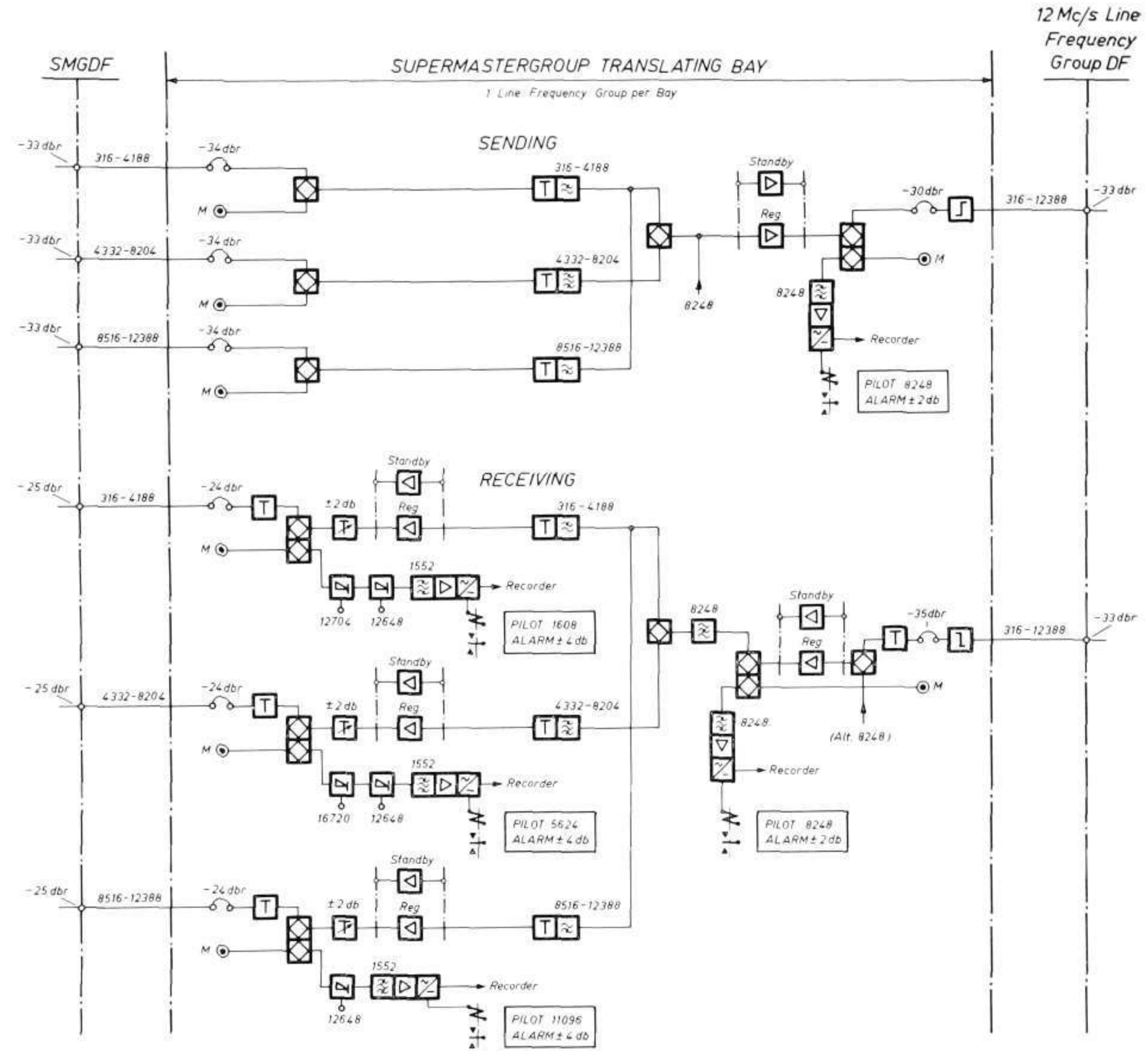



**Fig. 4 b** X 7875

**Block schematic for supermastergroup translating equipment for through routing of supermastergroups in the line frequency band**
All frequencies are in kc/s.

A circuit patented by L M Ericsson is used in the supermastergroup translating equipment. The circuit is characterized by the reverse voltage which is available for the non-conducting diodes not being limited to the voltage drop across the conducting diodes. Better linearity with the same carrier power is obtained in this way.

In this way the great linearity required for the supermastergroup can be obtained with reasonable carrier power.

High grade diodes are used to ensure extreme stability and long length of life. The filters are calculated and manufactured using the most modern principles. High quality ferrite cored coils and capacitors give low losses and great stability.

## *Amplifiers*

The amplifiers in the equipment are transistorized as far up as the basic supergroup (upper frequency 552 kc/s). As there is insufficient operational experience of the length of life of high frequency transistors, the wide-band amplifiers in the h.f. range are designed using tubes, even if transistorization is theoretically possible. Uncertainties must be reduced to a minimum when dealing with amplifiers for such a large number of channels. Tube technique is nowadays completely mastered and for the tubes of L M Ericsson's manufacture, an average length of life of 30 000 hours has been guaranteed, although in practice this figure is 40 to 50 000 hours i.e. about 5 years. To obtain increased reliability the tube amplifiers have been designed with two amplifying loops across a feedback network, which means that a fault in one loop does not appreciably affect the transmission. It is not possible to use this principle in the case of transistorized amplifiers. Each tube current is continuously supervised and an alarm is given when the limits of tolerance are exceeded.

Owing to the relatively small number of amplifiers in the equipment the power consumption is not of great importance.

The two amplifying loops in the supermastergroup and 12 Mc/s line group amplifiers are fed from separate mains supply units which also further contributes to operational reliability.

Stand-by amplifiers placed in the respective equipment may be connected practically without causing interference in operation (interruption time is less than 2 ms). This is important as certain checks can only be made with great difficulty on amplifiers in traffic (e.g. linearity test).

## *Test Points*

Even if all precautions have been taken to obtain the highest possible operational reliability, a certain amount of preventive maintenance is required. To ease this work, special test points for maintenance have been arranged. These are denoted by *M* on the block schematics.

The test points which are connected to the transmission path by means of hybrids are not affected by short-circuits and are not affected by poor impedance matching in the transmission path which could otherwise give rise to incorrect results. Maintenance measurements can therefore be made without the risk of causing interruptions to operation caused by faulty measuring equipment. As the test points have been placed so as to be directly accessible in the sides of the bay front, the gangways are not blocked by doors which would have to be opened to carry out measurements. To permit the rapid localization of a unit when it becomes faulty, fault finding test points have been provided at strategic points in the equipment. These test points are placed at the front ends of the plug-in units and are normally covered by the bay dust covers. The fault-finding test points are as a rule pure parallel test points. For fault-finding and commissioning purposes all inputs and outputs to and from the bay have been provided with coaxial break-type U-links.

The modulator filter units and amplifiers have been designed as plug-in type units. Rapid exchange of any possible faulty unit can easily be made. The manufacturing tolerances on each unit are very close and no readjustments are necessary in the system after an exchange has been made. The high stability and close manufacturing tolerances have made it possible to reduce the number of adjusting points in the system to a minimum thereby eliminating a very important fault source.

# Equipment for Level Supervision and Regulation

When sending over long distances it is not possible to avoid a certain variation of equivalent over the transmitted band. This so-called attenuation distortion can vary depending, for example, on rearrangement of traffic on other routes, through connexions, temperature variations of cable routes, aging of amplifying elements, etc. Even if certain variations are automatically compensated, residual errors still occur which are not constant over the transmitted band and which can add up to give excessive values. When it is impossible to predict how this loss will vary with frequency, regulation after the line band has been divided up into groups is the most suitable: such regulation can then be independent of frequency (linear).

These groups are in turn divided into smaller groups which can also be provided with linear level regulation, and by going down sufficiently far in the size of the group, variations in the nominal level can be made smaller–see fig. 5.

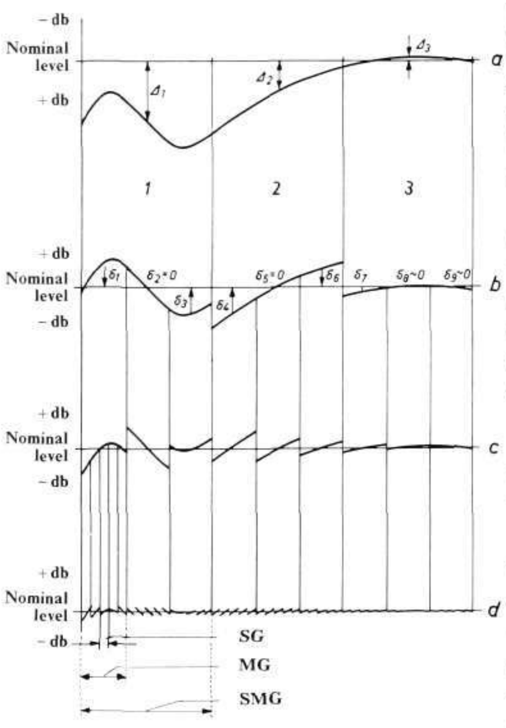



**Fig. 5** X 2380

**Example of level regulation**

**a) incoming line frequency band, level deviation from nominal value**
**b) level deviation from nominal value in the supermastergroups after supermastergroup regulation**
**c) level deviation in the mastergroups after mastergroup regulation**
**d) level deviation in the supergroups after supergroup regulation**

## *Pilots*

To be able to check the equivalent in a group while in traffic and to be able to arrange its automatic level regulation, each group has been allocated a reference pilot frequency. This pilot follows with its group through the transmission network from the point where the group is formed until it is split up into smaller groups.

It will be seen in the block schematics figs. 2, 3 and 4 how the injection of the reference pilot is arranged immediately after the combination of the groups on the sending side. The pilot therefore passes through the sending amplifiers.

The reference frequencies are as follows:

| | | injected in: | |
|---|---|---|---|
| supergroup | 411.92 kc/s | group | translating equipment |
| mastergroup | 1 552 kc/s | supergroup | " " |
| supermastergroup | 11 096 kc/s | mastergroup | " " |
| 12 Mc/s line group | 8 248 kc/s | supermastergroup | " " |

The CCITT have not made any recommendation for the 12 Mc/s line group pilot. The equipment has been provided with the possibility of injecting the frequency 8 248 kc/s as the 12 Mc/s line group reference pilot. 8 248 kc/s has actually been allocated for use as an additional measuring frequency for the h.f. line, but CCITT have recommended two frequencies in the same interstice, 8 248 and 8 472 kc/s, and the 8 248 kc/s pilot can therefore in most cases be used as a reference pilot without causing inconvenience.

## *Level Supervision*

Level supervision with alarm facility can be arranged by means of selective pilot receivers for the reference pilots in accordance with the following.

At the end of the supergroup translating equipment, receiving side (fig. 2).

At the output of the receiving side of the mastergroup translating and supermastergroup translating equipment. See figs. 3 and 4.

It has been considered suitable to provide the possibility of supervising each amplifier individually in equipment for supermastergroups and upward. Pilot receivers can therefore be fitted after the sending amplifiers in the mastergroup translating and supermastergroup translating equipment and after the 12 Mc/s line group amplifier, receiving. See figs. 3 and 4.

The pilot receivers for supervision of the supermastergroups and the 12 Mc/s line groups have been provided with outputs for recorders in addition to the alarm facility. In the case where the 8 248 kc/s pilot cannot be sent to the receiving station, for example due to branching, a point for injection of 8 248 kc/s has been provided at the input of the supermastergroup translating equipment on the receiving side.

The alarm limits can be chosen so that selective alarm is obtained.

The frequency 1 552 kc/s is obtained by modulation of the 11 096 kc/s pilot with 12 648 kc/s, and the same pilot receiver can therefore be used for the supermastergroup and mastergroup reference pilots.

## *Level Regulation*

The supergroups and mastergroups can be provided with automatic or manual level regulation. As the supermastergroup constitutes such a large part of the line frequency band, automatic regulation is not warranted and only manual level regulation has been anticipated. The regulation is smooth and cannot cause interruptions. The equipment for regulation and supervision of the supergroups is placed in a special bay, whereas that for the mastergroup and supermastergroup regulation is built together with the respective translating equipment.

The automatic level regulating equipment is of the continuous type; the pilot current from the pilot receiver controls the gain in the signal path via a reference circuit and a thermistor network.

To allow the functioning of the level regulation to be checked, a maintenance test point is brought out at the input of the level regulating equipment. Measurement of the unregulated level and the output level (regulated) provides information about the regulation state and whether there is a fault in the equipment.

Owing to the large number of supergroups in a 12 Mc/s station, the supergroup control functions have been made automatic. A separate pilot receiver carries out the level regulation for each supergroup. A common pilot receiver for supervision investigates the regulated supergroup levels in turn. At each cycle the pilot receiver is connected to the local supergroup pilot from the carrier and pilot generating equipment and checks itself in this manner. See the block schematic, fig. 2.

The pilot level and thermistor heater current can also be measured on an instrument built into the bay.

### *Suppression of Reference Pilots*

When a group is split up at the end of a group link, the reference pilot of the group must be suppressed as otherwise it would be demodulated and could pass through to another system via through connexion of smaller groups.

Suppression must be made on the terminal side of the respective group distribution frame, and can be realized either on the receiving side of the translating equipment, in the through connexion filter or in the sending side of the translating equipment before the point where the pilot is injected.

The 1 552 kc/s mastergroup reference pilot, which lies in the centre of an 8 kc/s interstice between two supergroups, will be stopped automatically in the supergroup through connexion filter since CCITT has already recommended stopping the h.f. line intersupergroup pilots for 4 Mc/s systems in this manner and these lie at 4 kc/s from the supergroup bands. The suppression is, however, not sufficient if there is through connexion from a 4 Mc/s system to a 12 Mc/s system, as the difference in level between the reference and intersupergroup pilots is 10 db. Extra attenuation at the supergroup reference pilot frequency is provided on the sending side in the supergroup translating equipment, see fig. 2.

The 11 096 kc/s supermastergroup reference pilot is stopped on the receiving side in the translating equipment, fig. 3. The pilot does not lie symmetrically in the interstice and it is therefore not suitable to stop it in the mastergroup through connexion filter. In addition, the stopping should not be carried out in the sending side of the translating equipment as it would result in a somewhat lower input level for the sending amplifier, resulting in an increased noise contribution.

The same argument applies for the siting of the stop filter for the 12 Mc/s line reference pilot, fig. 4.

## Power Supply and Alarm

All equipment normally receives its operating voltages from separate mains supply units in each bay. The advantages of this principle are that the currents in the power cabling of the station are smaller and the operational reliability increases as the mains supply units supply a smaller part of the equipment. The mains supply units have been mounted at the top of the bay so as to avoid heating up the rest of the equipment by dissipation. The fusing of the bays is carried out in such a way that there is the least possible interference to operation in the event of a fuse blowing. As an example, each "half" of an amplifier is individually fused. The fuses are provided with alarm contacts combined with a visual signal and are placed so as to be easily seen, at the sides of the bay beside the respective equipment.

### *Alarm Unit*

Alarms from the level supervision equipment and alarms for blown fuses, etc. are combined in a central alarm unit in each bay. In this unit there are also relays for supervision of the operating voltages. Two types of alarm are sent out from the alarm unit to the station alarm system. These are for so-called urgent alarm (A-alarm) and for non-urgent alarm (B-alarm) depending on whether the fault causes an interruption to traffic or not. At the same time clearly visible bay alarm lamps placed at the top left of the bay front are lit; one lamp for the A-alarm and one for the B-alarm. In addition, secondary alarm lamps are lit which give more detailed information of where the fault occurs. These lamps are located at the sides of the bay front beside the respective equipment.

To ensure the reliability of functioning of the alarm system when the bay supply voltages fail, provision has been made for connexion of an auxiliary voltage.

## Through Connexion Filter Equipment

It is not usual that all carrier circuits coming into a station are terminated there. In most cases, a large number of circuits are through connected to other stations.

It would be particularly uneconomic to demodulate these channels to the voice frequency band 300–3 400 c/s and then after through connexion to remodulate these channels to their position in the transmission band. An unnecessarily large amount of equipment would be required and furthermore an unnecessary reduction in quality would be obtained. Each stage of modulation gives for example an unavoidable contribution to noise.

Whole groups are instead routed to other group sections. When this is arranged in the basic frequency range of the groups, the procedure is called through connexion and because each group has its particular standardized basic frequency range, as given in Section 2, very great flexibility in connections is obtained.

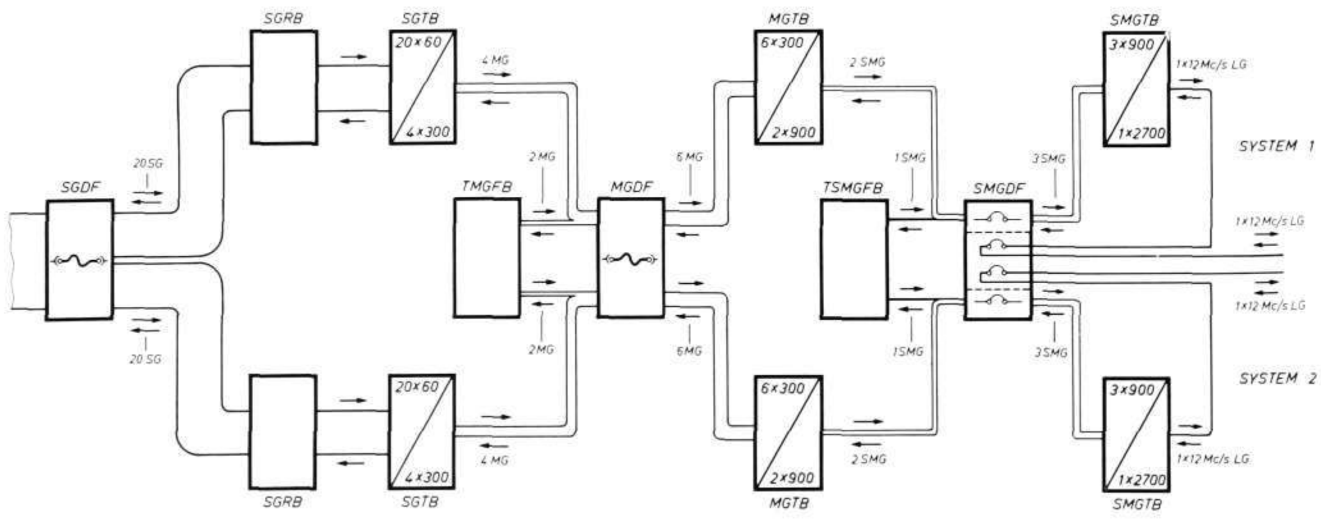
By using standardized groups, through connexion can be arranged between different types of system. All groups of the same type in a station are brought to a central distribution frame and can here be connected for termination or for through connexion. Through connexion can be arranged for basic groups, supergroups, mastergroups or supermastergroups.

For practical reasons the h.f. modulating equipment is not so selective that through connexion can be made without providing extra protection from filters. The through connected group must be passed through a filter to remove certain modulation products and remnants from neighbouring groups which would otherwise give excessive crosstalk between the two systems which are concerned in the through connexion.

The through connexion filter equipment is placed in special bays and is connected to the respective distribution frame of the station. Fig. 6 shows a bay layout diagram for a 12 Mc/s station with two systems where one supermastergroup and two mastergroups are through connected.

**Fig. 6** X 7876

**Bay arrangement fo a 12 Mc/s terminal station with two fully loaded systems. One supermastergroup and two mastergroups are through connected.**
**For abbreviations see next page.**



By employing refined calculating methods and the highest quality ferrite coils and capacitors, it has been possible to avoid using amplifiers in all through connexion filter equipment. This has resulted in a cheaper equipment which is more operationally reliable.

There is a special type of filter for the supermastergroups which permits direct through connexion in their respective positions in the line frequency band. The reduced flexibility which is thereby obtained is sufficient in many cases. The method has the advantage of not requiring any modulation and thus involves a slightly smaller noise contribution. An extra filter is not required for supermastergroup 1 as the supermastergroup translating equipment provides sufficient protection. The filters are placed in the same bay that is used for the normal through connexion filters.

For reasons of stability, the through connexion filters have been mounted in hermetically sealed boxes. All through connexion equipment has been designed so that the transmission of radio programs is possible without having to state restrictions on the position of the program channels in the frequency band.

Distribution frames also belong to the through connexion equipment. In these frames there are jacks for the modulation equipment and the through connexion filters. Connexions for termination or through connexion and the routing of traffic can easily and quickly be made in a clear manner by means of locking patch cords for the distribution frames for groups, supergroups and mastergroups and by U-links for the distribution frames for supermastergroups and 12 Mc/s line groups.

The reference pilot can be injected into possible spare group sections to permit their supervision.

## Bays

The equipment consists of modulators, filters and amplifiers which are designed as plug-in type electrical and mechanical units placed in the bays.

From the description of the through connecting equipment, it will be seen that all groups of the same type in a station are assembled at the central distribution frame for reasons of flexibility. A natural corollary of this is that each bay should only contain one type of modulation equipment. Thus one bay only contains equipment for modulation of supergroups to mastergroups, another bay only contains equipment for modulation of mastergroups to supermastergroups etc. In this way the bay and station layout is surveyable and easily managed by the operation and maintenance staff. This principle has produced the following types of bay.

| Designation | Abbreviation | Capacity |
|---|---|---|
| Channel translating bay | CTB | 5 basic groups |
| Group distribution frame | GDF | 360 jacks (90 groups) |
| Through group filter bay | TGFB | 16 pairs through connexion filters |
| Group translating bay | GTB | 6 basic supergroups |
| Supergroup distribution frame | SGDF | 360 coaxial jacks (90 groups) |
| Through supergroup filter bay | TSGFB | 26 pairs through connexion filters |
| Supergroup regulation bay | SGRB | 32 supergroups |
| Supergroup translating bay | SGTB | 4 mastergroups |
| Mastergroup distribution frame | MGDF | 360 coaxial jacks (90 groups) |
| Through mastergroup filter bay | TMGFB | 16 pairs through connexion filters |
| Mastergroup translating bay | MGTB | 2 supermastergroups |
| Supermastergroup and 12 Mc/s line group distribution frame | SMGDF | |
| Through supermastergroup filter bay | TSMGFB | 16 pairs through connexion filters |
| Supermastergroup translating bay | SMGTB | 1 line group |

It will be seen above that the 12 Mc/s line group distribution frame has been placed in the supermastergroup distribution frame as the number of 12 Mc/s line groups is as a rule low and does not warrant a special bay.

The group, supergroup and mastergroup distribution frames are identical in construction. The same design of through connexion filter bay is used for all types of through connexion filter.

Fig. 6 shows the arrangement of the different bays in a 12 Mc/s terminal.

## Flexibility

As the work of standardization by CCITT could progress with the development of the 12 Mc/s system, the equipment has been well defined and interworking with equipment of other manufacturers is made possible in most cases without extra measures being necessary. However, problems can arise regarding the levels of the group and basic supergroup. The levels at the distribution frames are for example not standardized and many different variants are in service today. L M Ericsson's channel, group and supergroup translating bays have therefore been designed so that matching of levels can easily be made.

On the supergroup side of the supergroup translating equipment the following levels can be accepted:

| | |
|---|---|
| Sending side, minimum | – 47 dbr |
| Receiving side, maximum | – 34 dbr |

The block schematic, fig. 2, shows the amplifier which in these cases replaces the maintenance test unit on the sending side.

Earlier group translating equipment often had no facility for injection of the supergroup reference pilot and it has therefore been considered suitable to be able to provide this facility in the supergroup translating equipment. Only one pilot distribution unit and a variant of the maintenance test unit is necessary at the supergroup input; see the block schematic, fig. 2.

As mentioned earlier under the heading "Through connexion filter equipment" a facility is provided for through routing the supermastergroups in their position in the line frequency band. To be able to realize this it is necessary to modify the supermastergroup translating equipment to function as shown in the block schematic, fig. 4b. The only thing that needs to be done is to make some rearrangement of U-link connexions in the bay. The modulators are disconnected from the signal path and in the pilot receiving equipment thereby avoiding variants of the pilot receivers which would otherwise need to be matched to the pilots in their modulated positions in the line frequency band.

A third operational case for the supermastergroup translating equipment is obtained if a restricted 4 Mc/s frequency band is used instead of the first

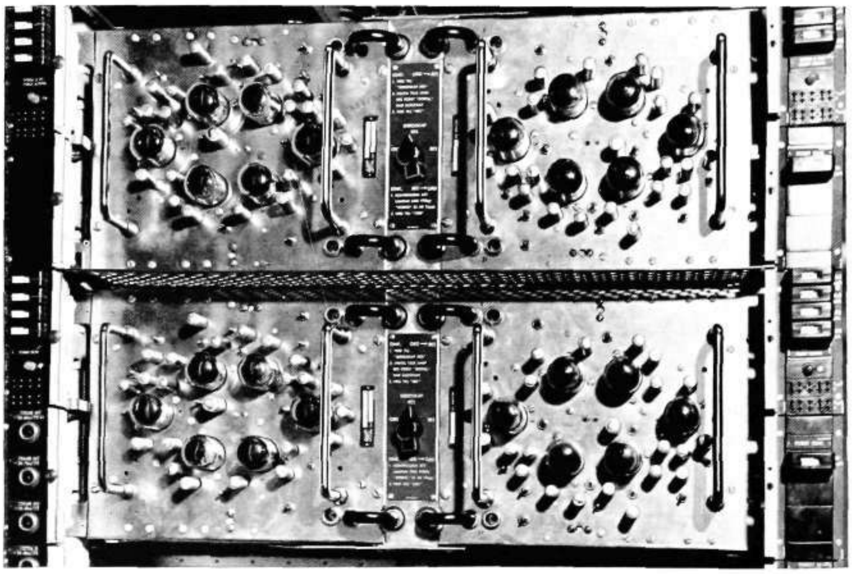


**Fig. 7** X 8402

**Detail from a supermastergroup translating bay**

Top, sending amplifier with standby; bottom, receiving amplifier with standby. Note the connexion of the amplifiers to the changeover unit in the middle.

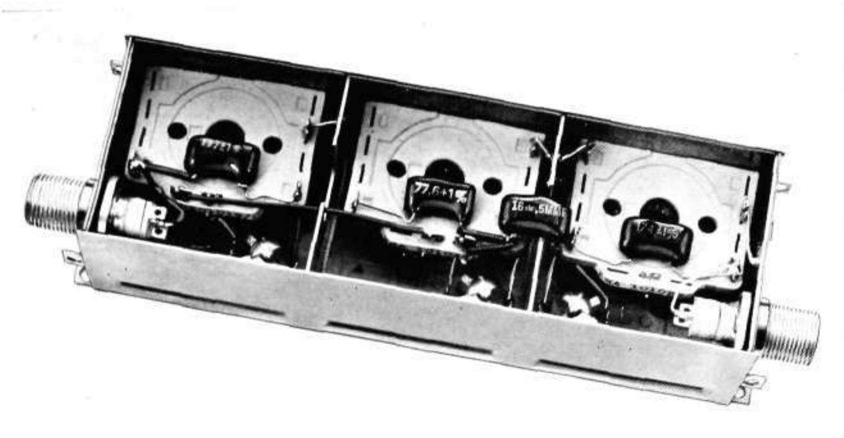


**Fig. 8** X 8403

**Part of a filter using the high frequency method of construction. Cover plate removed.**

supermastergroup (see the chapter entitled Modulation Plan). Rearrangements are also made here by means of U-links. If supervision is required for the 4 Mc/s band, this can be arranged by using the 1 552 kc/s pilot. CCITT has not made any recommendation regarding a pilot for a 4 Mc/s band, but 1 552 kc/s, which in this case is an intersupergroup pilot, can in most cases be used for this purpose without inconvenience.

When an Administration is faced with the problem of converting its 4 Mc/s coaxial network to 12 Mc/s, it can in certain cases be desirable to retain the existing terminal equipment for a further period. This is made possible by means of a special modulator equipment, designed by L M Ericsson, which modulates a restricted 4 Mc/s band consisting of supergroups 2–16 to the frequency band of a supermastergroup. Modulation is made using the carrier 12 648 kc/s and the lower sideband 8 620–12 336 kc/s is used. The bay contains equipment for two 4 Mc/s bands, sending and receiving.

## Mechanical Design

L M Ericsson's method of construction for the low frequency range, used for frequencies up to 600 kc/s, is described in Ericsson Review No. 4, 1960.

For higher frequencies the method of construction must be modified for natural reasons. Vacuum tube amplifiers are used in the region around 600 kc/s and above, and to provide cooling for the units with tubes, all units have been set back from the front so as to form a cooling chimney between the dust covers and the units in the bay. The amplifiers are built on vertical chassis with the tubes horizontal to obtain the most effective cooling, see fig. 7. It is very important to try to reduce the temperature rise of the units as this very much affects the length of life of components. For the same reason, the cooling chimney is brought out and a new air inlet is provided for the places in the bay containing modulators and filters.

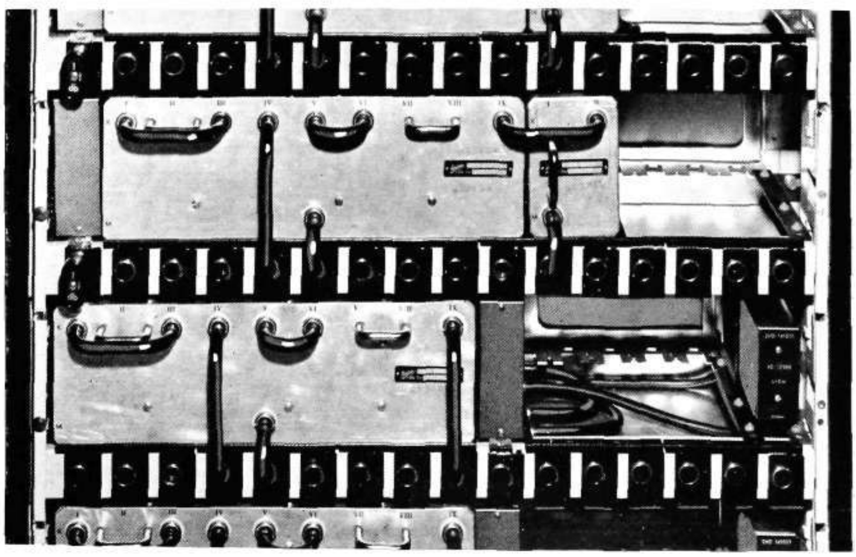


**Fig. 9** X 8404

**Part of supermastergroup translating bay showing the construction of the modulator filter units and their connexion (high frequency method of construction)**

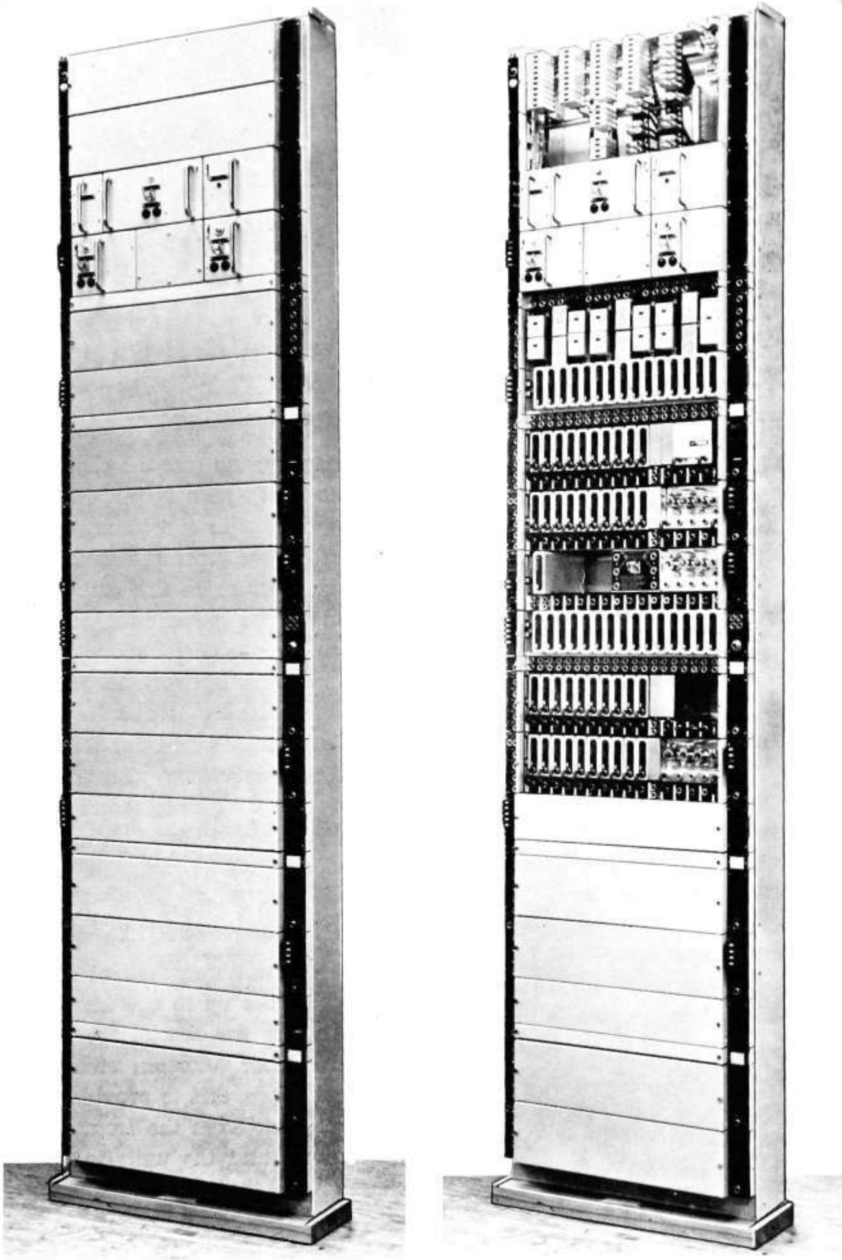


**Fig. 10** X 2682
X 2683

**Supergroup translating bay**

The right hand figure shows the bay with some of the dust covers removed.

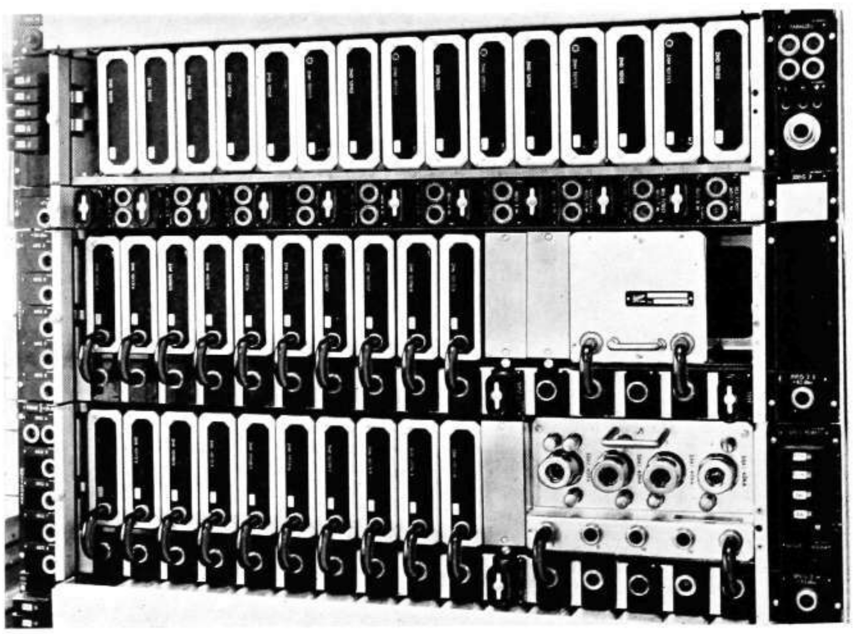


**Fig. 11** X 8405

**Detail of the supergroup translating bay. Equipment for one mastergroup.**

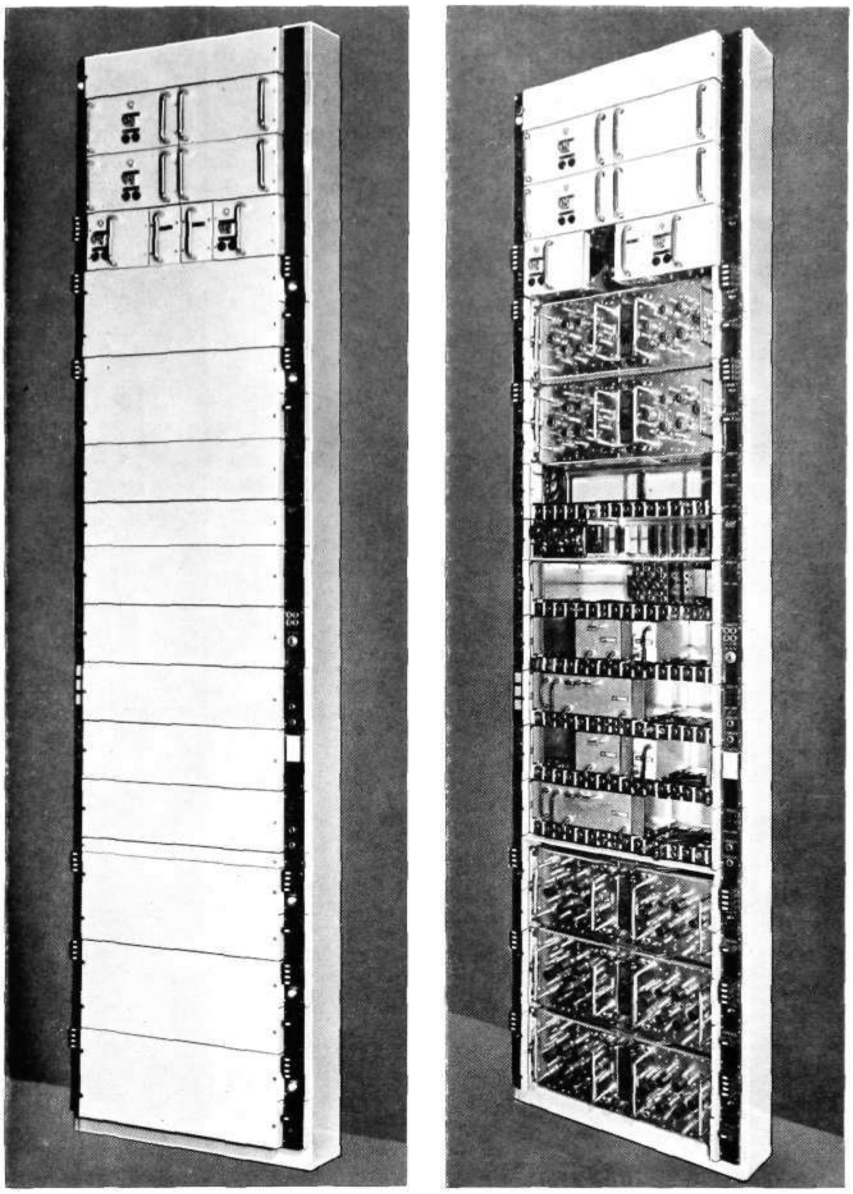


**Fig. 12**

X 2384
X 2685

**Supermastergroup translating bay**

**The right hand figure shows the bay with the dust covers removed.**

The units must be designed so that they are completely screened, and in certain cases it is also necessary to have separate screening between each filter circuit. These special requirements have resulted in a filter construction shown in figs. 8–9 and can be used in the h.f. range up to about 40 Mc/s. All units such as modulators, filters and amplifiers can be replaced directly and are plugged into the bay. All low frequency connexions are made automatically with plug and jack at the rear of the unit. All h.f. connexions are made at the front of the units by means of coaxial U-links to an associated underlying field which at the same time permits easy storage for the bulky coaxial cabling to the respective shelf (fig. 9). Exceptions to this are the supermastergroup and 12 Mc/s line group amplifiers which are connected to a change-over unit, fig. 7. The technique of using coaxial U-links also permits easy connexions in the h.f. path. An example of this is the connexion of the supermastergroup translating equipment for direct through connexion of a supermastergroup in the line frequency band.

Figs. 10 and 11 show the supergroup translating equipment, which is an example of bay for the intermediate frequency range. A number of units on the supergroup side which use the low frequency method of construction are included in the bay. The coaxial connexion of modulator filter units, mastergroup amplifiers and the natural way in which the two methods of construction is brought together are shown in the figures.

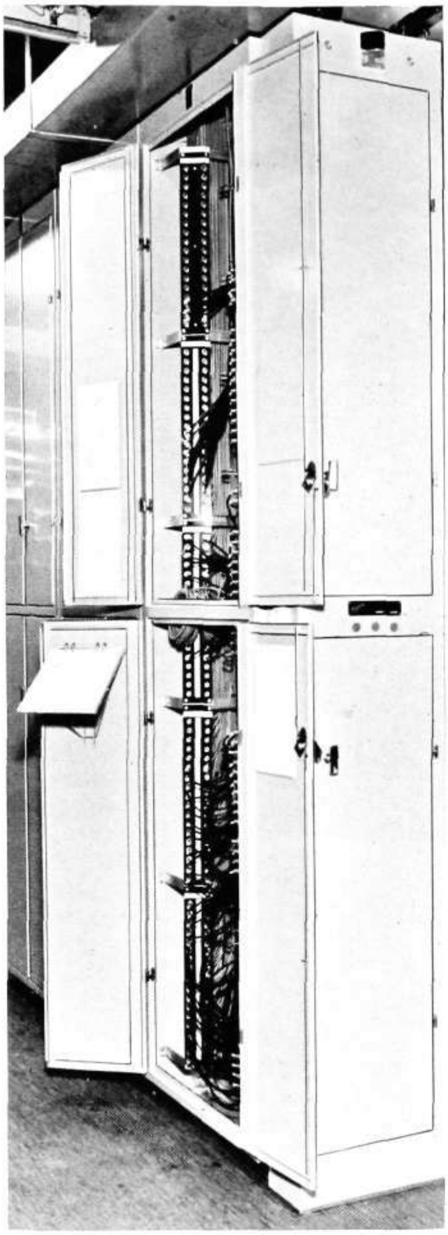


**Fig. 13**
**Distribution frame**

X 2386

Figs. 12, 7 and 9 show the supermastergroup translating equipment which are examples of a bay using pure h.f. method of construction. Note the coaxial U-links for the filters and amplifiers, the placing of the maintenance measuring points, fuses and the alarm lamps at the sides of the bay front. The mains supply unit and the bay connexion panel are seen at the top of the bay.

Fig. 13 shows the design of the group distribution frame.

## Technical Data

### *General*

*Power supply*, a.c.

*Nominal voltage* 110, 127 or 220 V ± 10 %

*Variation of nominal voltage* ± 2 %

*Frequency* 50 c/s ± 10 c/s

*Ambient temperature* max. 40° C

*Relative humidity* max. 90 % at 20° C
max. 70 % at 40° C

*Bay dimensions*

Height 2 743 mm

Width 670 mm

Depth 236 mm

(The group distribution frame has twice the above depth)

*Weight* per fully equipped bay approx. 300 kg

Other data are given in the following table.

| | Supergroup translating bay + regulating bay | Mastergroup translating bay | Supermaster-group translating bay |
|---|---|---|---|
| Variation of equivalent within the respective group relative to its reference pilot, sending or receiving, not greater than | ± 0.5 db relative to 411.92 kc/s | ± 0.5 db relative to 1 552 kc/s | ± 0.5 db relative to 11 096 kc/s |
| All combinations of near-end and far-end crosstalk, not less than | 85 db | 85 db | 85 db |
| Noise in a loaded system. Psophometrically weighted value measured at a point of zero relative level for the worst channel (sending + receiving), not greater than | 50 pW | 50 pW | 50 pW |
| Carrier leak on the sending side, not greater than | — 40 dbmO | — 40 dbmO | — 30 dbmO |
| Regulating range for the respective group receiving side | ± 6 db | ± 4 db | ± 2 db |

A typical graph of equivalent for the supergroup through connexion filter is shown in fig. 14.

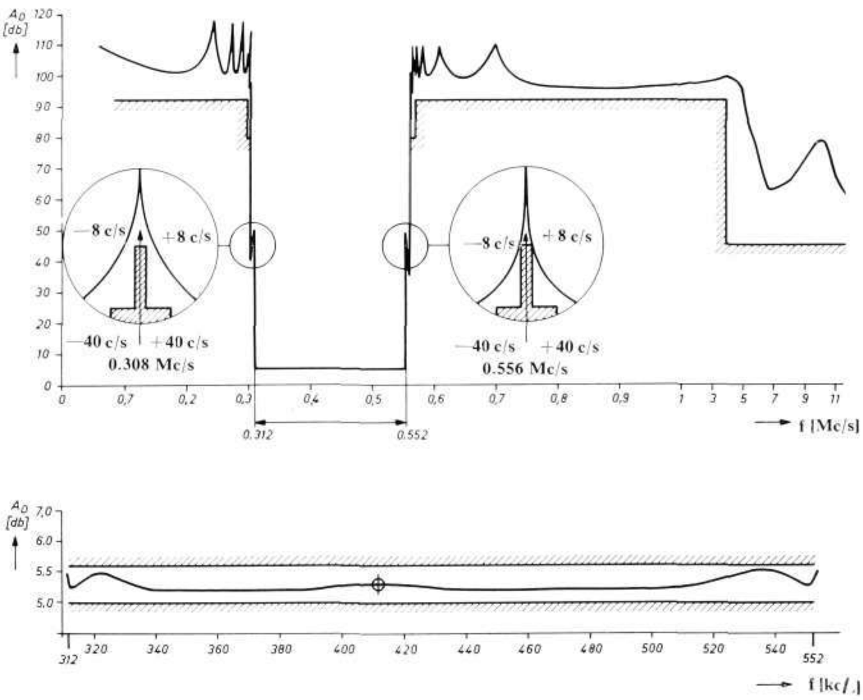



**Fig. 14** X 7861

**Typical graph of the equivalent for a supergroup through connexion filter**

# The New Telephone Exchanges in Tunis

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*The cut-over on November 30, 1962, of the new L M Ericsson crossbar exchanges in Tunis and its northern suburbs brought to an end the previously difficult, and sometimes dramatic, state of telecommunications in the country. The new exchanges, which represent the first step in the conversion of the entire Tunisian network to automatic operation, are described in this article.*

The importance of the new crossbar installations in Tunis will be best realized if I say a few words about the old equipment and about the development of the telephone traffic in general.

## The Public Telephone Network before 1957

Most of the older automatic exchanges and the trunk exchange in Tunis were installed in 1928. The former were chiefly Strowger and R-6 equipments. The R-6 system, developed by Thomson-Houston in France, was built up of decadically grouped 51-line rotary step-by-step switches under the control of marker devices. When the replacement of these old equipments was under consideration after the war, the authorities at that time decided to expand and successively replace the existing equipments by a new system called L43 which had only just then been developed in France by CIT. L43 was a register-controlled system, also with rotary step-by-step 51-line switches in decadic grouping. Some 5 000 lines of L43 equipment were installed in the three automatic exchanges in Tunis, viz.

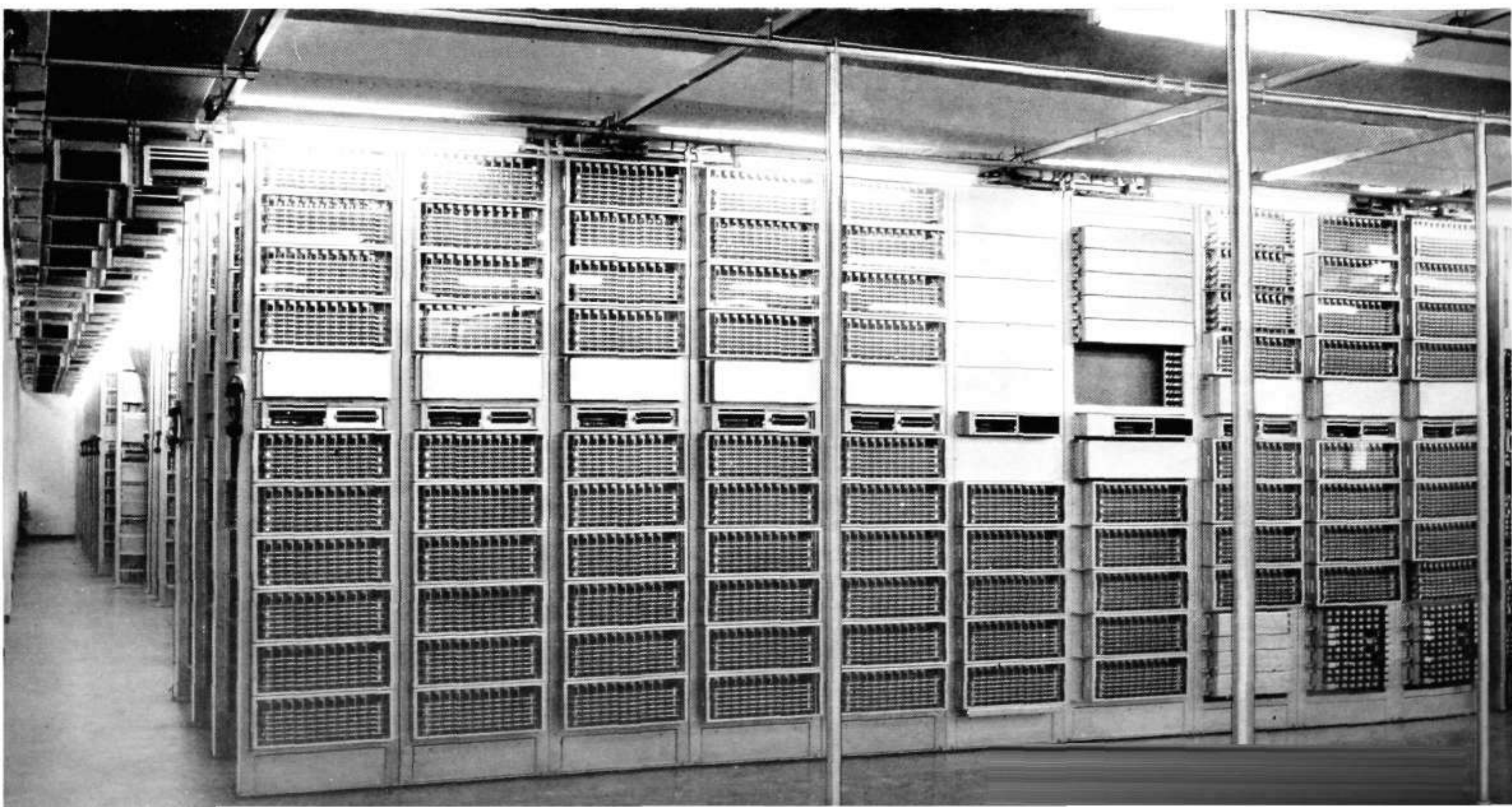
*Central Angleterre* (8 000 lines Strowger, 2 000 lines L43, and manual trunk equipment)

*Central Kasbah* (2 000 lines L43)

*Central Belvédère* (1 300 lines R-6, 1 000 lines L43, 500 lines manual Ericsson equipment)

**Fig. 1** X 7867

**The automatic switchroom in the Carthage exchange**



The suburbs were served by manual C.B. systems. The junctions from the suburban exchanges ran to the Angleterre trunk exchange, which handled outgoing inland traffic as well as the traffic to the Tunis suburbs.

The L43 system did not come up to expectations. The PTT thus had two main worries: in addition to the exacting maintenance of the Strowger equipment, the L43 equipment called for frequent adjustment, while the already high traffic continued to rise.

The reason for the large increase in traffic deserves special mention.

With the attainment of independence a number of services, which had earlier been supervised by the French administration, acquired a new importance. New foreign embassies, press and news agencies, economic, social and cultural organizations—all with a large need for telephones—brought an immediate and sharp increase in the already high telephone traffic, which thereby rose considerably above the capacity of the existing installations.

At certain exchanges the number of busy hour calls sometimes amounted to one-quarter or one-third of the total 24-hour rate, whereas normally it is not above one-sixth or one-seventh. At the same time the waiting list numbered several thousand would-be subscribers.

## The PTT Decision in 1957

In 1957 the PTT under President Habib Bourguiba's first government decided to adopt radical measures and to replace all telephone exchanges in the capital and its surroundings.

By introducing a fully modern system and building up the network on rational lines, it was desired to create the conditions necessary to meet the present and future needs of the country within so important a sector as telecommunications. This decision opened the way for future full automatization of the Tunisian telephone network.

Tenders were called for and submitted by nine manufacturers from different countries. After thorough study of the various proposals the PTT decided to accept L M Ericsson's crossbar system. The first contract was signed in 1959 and since then seven *ARF* exchanges totalling 26 000 lines have been put in service in Tunisia. *ARF* equipments for an additional 14 400 lines and *ARK* and *ARM* equipments for, respectively, 2 990 and 1 380 lines have been ordered.

## Interim Measures

While waiting for the first crossbar exchanges to be put in service, which was expected to take three and a half years, it was necessary to adopt various measures without delay, the most important being:

> Extension of the Belvédère exchange by manual positions.
>
> Installation of a switching point (Kasbah G) to handle the traffic of the government departments independently of the city network.

### *Extension of the Belvédère Exchange*

The Belvédère exchange serves the residential area, where the foreign embassies are also located. It was therefore necessary to find a quick and effective solution to the already fully utilized capacity of the exchange. A 500-line manual C.B. exchange with four positions was ordered from L M Ericsson and installed by the PTT in the Belvédère exchange building.

Connection of the manual equipment to the automatic network was effected on a group of a dozen circuits with PBX calling of the manual positions. The positions were equipped with automatic circuits for outgoing calls to the automatic exchange in Tunis. Trunk and international traffic was passed through direct junctions to the Tunis trunk exchange.

**Fig. 2** X 2396

**The Carthage exchange**

## *Kasbah G*

The administrative services in Tunis were affected more than other subscribers by the increasingly serious telephone situation. A quick solution had to be found at a reasonable cost, which would retain its value even after the new L M Ericsson equipment had been installed.

To find a quick remedy for the insufficient capacity of the public exchanges it seemed natural to combine all administrative service switchboards into a single unit. This solution would bring two advantages: satisfactory handling of the government telephone traffic, and so relief of the overloaded public network. It would not be too expensive, and it would require a limited cable network since the departments concerned are concentrated in the Kasbah area. To utilize this new switching point to the maximum, the intention was to connect to it various other subscribers such as official or semi-official organizations of vital importance to the country—public undertakings, banks, newspapers, schools, hospitals etc.

On June 22, 1961, therefore, a 2 000-line *ARF 101* system with high traffic capacity to serve the "government departments" was installed in the Kasbah exchange building under the name Kasbah G. The traffic with city subscribers is handled at 14 operators' positions.

The result was excellent. The government departments did not need to wait till the end of 1962 to have a telephone which works.

# The New Equipments in Tunis

## *Buildings*

Two of the three Tunis exchanges have been placed in new premises. For the two 10 000-line groups in the largest exchange, Angleterre, a new building has been erected at Avenue de Carthage for equipments with ultimate capacity of 40 000 lines. Another new building for 20 000-line ultimate capacity has been erected in Belvédère. In the Kasbah area the new crossbar equipments, the new trunk exchange (the old one was located in the Angleterre), and the Kasbah G have all been accommodated in the old building erected in 1952.

## *Capacity of the New Exchanges*

The number of already installed lines is at present 12 000 in Carthage, 5 000 lines in Belvédère, 4 000 in Kasbah, 1 000 in La Marsa, and 1 000 in Le Kram. The two latter exchanges are in the northern suburbs of Tunis.

## *Characteristics of the Crossbar System*

The large local exchanges have been equipped with the Ericsson crossbar system *ARF 10*. The system is well known, and this account will be restricted to a few of its prominent features, which are also characteristic of the other Ericsson systems for rural automatization (*ARK*) and transit exchanges (*ARM*).

The crossbar switch possesses excellent contact properties, which has been an important factor in the quality of transmission on long distance subscriber dialled calls, which often pass through many switching stages. Another characteristic of the crossbar switch is its very short switching time, which has been put to the best use through the design of the systems as register-controlled bypath systems with markers. Register control also permits great flexibility in the direction of traffic. These properties ensure the best utilization both of the exchange equipments and of the cable network. The structure of the system in the form of small plug-in units allows flexibility in adaptation to actual traffic requirements. The high reliability of the systems, moreover, results in low maintenance costs.

## *Trunk and International Traffic*

The 500-line trunk exchange contains 82 operators' positions divided into four independent groups for outgoing demand service, outgoing delay service, incoming and transit calls, and concentration positions.

Thirty-two demand positions, called on code 15, handle traffic to the majority of exchanges in the country. Thanks to the adequate supply of circuits between the capital and the various transit exchanges, calls are set up while the caller remains on the line. The operator starts automatic metering by pressing a button corresponding to the relevant unit tariff. All new installations are equipped for time-zone metering, based on conversation time and

**Fig. 3** X 7868

**The Kasbah trunk exchange**

distance between the subscribers: pulses are sent to the calling subscriber's meter at intervals inversely proportional to the distance.

Fourteen code 10 positions handle traffic to the southern suburbs, the number of circuits to which is insufficient to permit demand working. These operators can also take over calls from the demand positions when the latter cannot obtain access to a free circuit on a particular route.

Incoming and transit calls are handled at 20 positions at which all incoming circuits are multiplied and indicated by call lamps.

The trunk exchange also comprises 16 concentration positions equipped for handling all the aforementioned types of traffic. The number of operators can thus be reduced considerably during low traffic periods.

Then there are 16 international operators' positions, called on code 16. This traffic is handled on a call-back basis. All trunk circuits in Tunis are multiplied over these positions for the extension of incoming international calls.

## *Special Services*

Apart from the usual special services for fault reporting (code 11), complaints and claims (code 13), telephoning of telegrams (code 14), police (code 197), fire alarm (code 198), time announcements in Arabic (code 199), and in French (code 191), there are also information and interception services.

The information service is called by dialling 12. If the operator can give an immediate reply, the charge is recorded by a pulse on the subscriber's meter. If the information required takes time to procure or concerns questions of telegraphy or other services, the operator can automatically switch the subscriber to the proper special service.

The interception service on code 195 is centrally located in the Kasbah exchange and serves all subscribers in Tunis with suburbs. An intercepted subscriber's line is marked by the insertion of a plug. A subscriber whose subscription has been terminated or whose number has been changed can be marked in the same way. A subscriber whose line is intercepted can use his telephone for outgoing calls without hindrance. Incoming calls to his number are answered by an operator and put through to the subscriber if he so desires.

## New Exchanges in Tunis Suburbs

The southern and northern suburbs of Tunis extend over quite a wide area. We nevertheless considered it sufficient to provide two exchanges for the northern suburbs, La Marsa and Le Kram, and two for the southern, Hammam-Lif and Mégrine. So far only the La Marsa and Le Kram exchanges have been opened for service, at the same time as the Tunis exchanges on November 30, 1962. The Hammam-Lif and Mégrine exchanges are expected to be opened at the beginning of the summer of 1963.

The conversion of the north suburban network to automatic operation posed several problems in respect of the number of exchanges, their locations and their connection to the Tunis exchanges. In view of the distances and of the existence of a well developed underground cable network, we decided to combine the four existing small manual exchanges into two larger units of 1 000 lines each, one at La Marsa, the other at Le Kram.

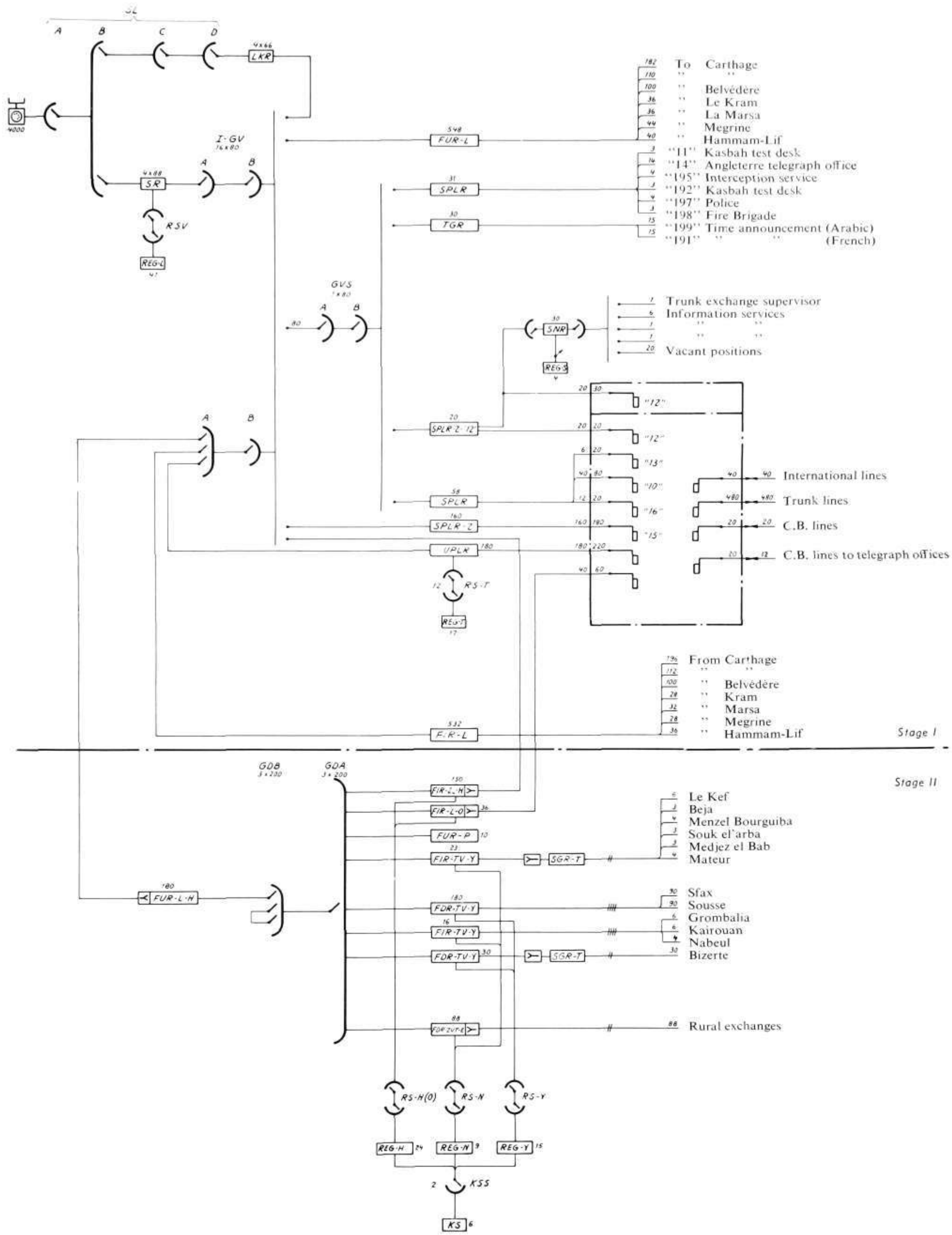



**Fig. 4** X 7871

**Trunking scheme of the Kasbah exchange**

After a comparative study of different signalling systems, a d.c. code system was chosen. Later, when the La Marsa and Le Kram exchanges have been extended, they can be connected to the *ARM 20* transit stages in Tunis, which are expected to be in service in 1964. At the present state of affairs it has proved most economical to deal with the suburbs in the same way as the Tunis exchanges. Thus La Marsa and Le Kram have been connected to the *I-GV* stage of the Kasbah exchange via *FUR* and *FIR* equipments of the same type as have been used for the junctions between the Tunis exchanges. The Kasbah exchange accordingly acts as a transit centre for all traffic between Tunis and its suburbs. Through the d.c. code signalling the subscribers in the northern suburbs have access to the trunk demand service by dialling 15 and thus have the same service as the Tunis subscribers.

## General Automatization of Tunisian Telephone Network

The opening of the Ericsson exchanges in Tunis with suburbs, and of the earlier exchange at Bizerte (November 1960), is the first step in a vast programme, the ultimate aim of which is the automatization of the entire Tunisian network.

The first stage of the project will embrace Sousse and Sfax in addition to Tunis and Bizerte. The local exchanges *(ARF 101)* at Sousse and Sfax, with manual trunk sections, are expected to be ready for service at the end of 1963. The conversion of these four areas to fully automatic operation within and between the areas should be completed in 1964.

This programme forms part of the government's three year plan 1961–1964 for the economic and social development of the country. The automatization of the Cap Bon area in the north-east, Le Kef in the west, and Gafsa, Gabès, Medenine in the south, will come in the latter part of a ten year plan (1961—1972).

### *Automatic Trunk Circuits*

Conversion of the entire network to automatic operation requires a large number of trunk circuits with very good transmission characteristics. Our Transmission Division under Chief Engineer Brahim Khouadja has worked out a plan adapted to the growth of the switching system. Thus a carrier link between Tunis and Sfax, with final capacity of 600 channels, is to be opened at the beginning of March 1963. The initial capacity will be 148 telephony and 2 radio channels. The frequency band will be 2 000 Mc/s, and the distance between the relay stations will vary between 45 and 70 kilometres. The radio system will have standby equipment and the power supply will come from the electricity undertakings. An extension of this link from Sfax to Tripoli within the next three years is at present being planned.

For automatization of the Sousse area (Sahel) a loaded cable will be laid within two years. Its capacity is expected to cover the requirements for the next 40—50 years. The cable will contain six carrier quads which will permit an increase of its capacity if required.

In the north-western area (Le Kef) the North African cable connecting Tunis, Constantine, Algiers, Oran, Fez and Rabat is to be deloaded to increase its capacity. This cable at present allows international 4-wire and local 2-wire connections.

Open wire carrier circuits are to be installed in the southern areas in March 1967, 6 channels for Gafsa—Gabès, 12 for Sfax—Gabès, and 12 for Sfax—Gafsa.

## *Underground Cable Networks in the Cities*

Simultaneously with the aforementioned projects the Lines Department under Chief Engineer Souhir Ben Lakhal has started an extensive programme of construction of underground cables in cities in which subscriber-dialling has been or is to be introduced. Thus, following on the major operation of transferring the Tunis subscribers from the old to the new exchanges, the Lines Department has already started to plan considerable extensions in the Sousse and Sfax areas.

These projects have been worked out in close cooperation with the planners of the general switching programme, and rational and modern solutions have been adopted. To take one example, the cables have been pressurized, which is expected to eliminate the disturbances that have occurred all too often as a result of rain.

## *Numbering Scheme*

The conversion of a telephone network to automatic operation necessitates a numbering scheme covering the entire country. There are several factors to be considered, the most important being the division of the country into zones, the extent of the traffic, and the numbers of subscribers within zones and group areas.

The Tunisian numbering scheme is based on the following seven considerations:

a. The country to be divided into seven zones.

b. Each zone to be divided into a number of group areas.

c. The switching points for zones and group areas to be located usually in the zone and group centres.

d. Linked numbering scheme within each zone, i.e. the zone code will not be used on calls between subscribers within the same zone.

e. Zone numbering schemes will vary between 4, 5 and 6 digit subscriber numbers. Tunis with northern and southern suburbs will have 6-digit subscriber numbers.

f. For interzone traffic digit 0 will be dialled followed by the code of the called zone.

g. The zone codes will be:

1 — Tunis city and suburbs

2 — Tunis—Bizerte—Cap Bon zone with zone centre in Tunis

3 — Sousse

4 — Sfax

5 — South with zone centre at Gabès

6 — Centre with zone centre at Kairouan

7 — North-west with zone centre at Kef

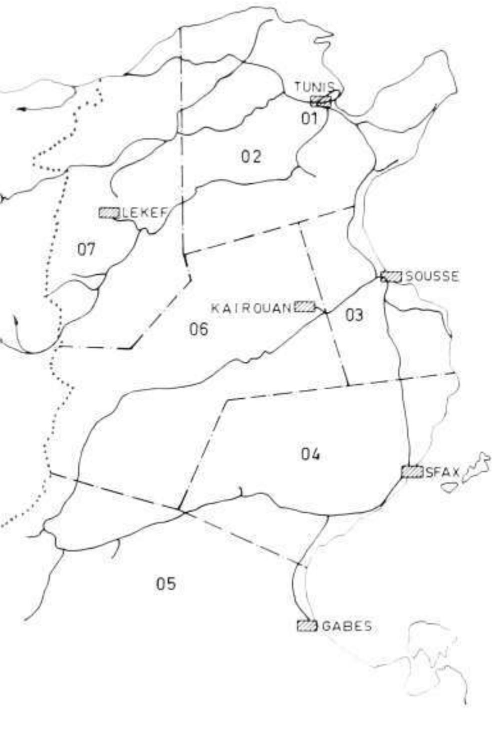
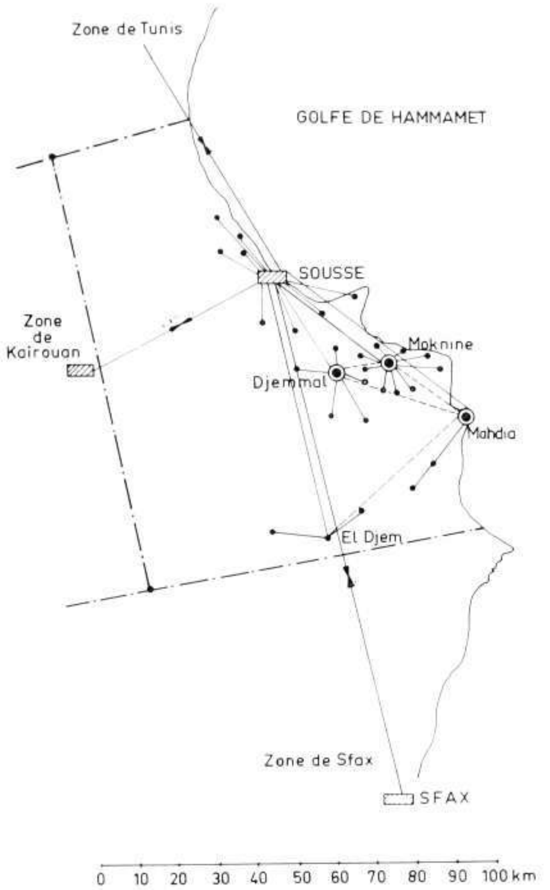



**Fig. 5**

**Map of the northern Tunisia with zone boundaries**

**Zone centre**

In some zones the subscriber density would not require 4-digit numbers. One might, therefore, consider increasing the geographical areas to be served by these zone centres. But such a course would involve an undue increase in the number and length of circuits in the zone which would not be justified by the traffic. On the other hand an increase in the number of zones with consequent reduction in the number of subscriber digits would not lead to a reduction in switching equipment. It was therefore considered best, from the start of automatization, to divide the country into zones adapted to the geography and to the communities of interest, and to determine the optimal number of subscriber digits accordingly. A 6-digit numbering scheme has




X 2698
X 9159

**Fig. 6**

**The Sahel zone with zone centre at Sousse**

**Zone centre**

**Group centre**

**Terminal exchange**

thus been introduced in the most populated parts of Tunis with suburbs, a 5-digit scheme for less densely populated areas, and a 4-digit scheme for the sparsely populated areas in the south where the group centres lie far apart. If, at some future point of time, the number of digits in a zone proves to be insufficient, the zone will be subdivided and an extra digit added to subscribers' numbers.

## *Zone Centre and Group Centre Equipments*

Zone centres will soon be equipped with Ericsson's *ARM* system—*ARM 20* in Tunis, Sousse and Sfax, and *ARM 503* in Bizerte. These systems are well-known and need no further presentation. An example of an *ARM* network is illustrated in fig. 6, showing the Sahel zone with zone centre at Sousse and its associated group centres and terminal exchanges.

## The Cut-over on November 30

This account would be incomplete without a few words about the small problems that arise in all large cut-overs, the present one not excluded.

The work preceding the opening of the new exchanges in Tunis and northern suburbs may be classed under two main headings, the large scale testing of the equipment and the transfer of the subscriber circuits to the new exchanges.

The testing of the switching equipment was done by a team from L M Ericsson assisted by a large number of technicians from the Tunisian PTT, who thereby gained the opportunity of becoming acquainted with the new equipments and at the same time helped to complete the tests in a shorter time. Local traffic was started in the five exchanges concerned and faults encountered were remedied. The junctions between the exchanges were tested in the same effective and methodical manner.

The Lines Branch at the same time put the finishing touch to the work on the underground cable network that had started 18 months earlier.

To check the connection of the altogether 18 000 subscribers to the new exchanges, a first series of tests was made on the M.D.F.'s, with systematic identification of the lines. This was followed by more comprehensive testing of the subscriber lines from test desks.

Finally, after some days of intense work, the line and switching specialists of the PTT and L M Ericsson completed their tests on time at 12 a.m. on November 30.

The actual cut-over could thus take place on schedule at 5 p.m. on the same day. The date of the cut-over was well chosen, for the next two days were public holidays and the work could be finished off without disturbance from too much traffic.

The cut-over comprised four main operations, viz:

Connection of the subscribers to the new equipments

Connection of the junctions between the Tunis exchanges

Connection of the trunks to the new trunk exchange

Connection of the junctions between Tunis and the suburban exchanges

To give an idea of how the problems were solved, we may follow the course of these four main operations.

The entire cut-over was led by a General Staff of engineers from the PTT Engineering Branch and from L M Ericsson. The Staff Headquarters was in the Kasbah exchange, where the main problems of different kinds were most likely to arise.

Twenty-eight teams were formed, 23 Tunisian and 5 Swedish, the leader of each team being directly responsible to the Staff.

The work was divided into six phases. Each team received precise instructions, and a new phase could be started only on the express order of the Staff. The progress of the entire operation could thus be followed from a central point.

The connecting-up of the subscribers had been prepared on the M.D.F.'s by 1 p.m. on November 30. Subscribers had been notified that a test was to be made between 5 and 9 p.m. and had been requested not to use their telephones during those hours. The old equipments were disconnected by removing the M.D.F. fuses. For the subscribers in Tunis and suburbs the telephone was thereafter silent for about one hour, and the old equipments closed down for ever.

Official subscribers and essential services could maintain telephone traffic through Kasbah G. The subscribers were thereafter connected to the new equipments by plugging-in the *LR/BR* relay sets in the racks. This work, which was done by Ericsson engineers, started at 6 p.m. and was carried through in steps to permit a check of faults and to avoid too heavy a rise in the traffic. It was completed at 8 p.m., by which time all subscribers had been connected to the new exchanges.

As regards the junctions between the Tunis exchanges, the spares in the existing underground cables had been sufficient for connection of all circuits on certain routes and for 85 per cent on other routes.

Trunks and junctions to the northern suburbs were established by prolonging the previous trunks between Kasbah and Angleterre.

The trunks from the Melassine repeater station had been branched both to the old Angleterre and to the new Kasbah trunk exchange. The isolation of the trunks at Angleterre started at 5 p.m. and the transfer to Kasbah was completed at 7.30 p.m.

Half of the routes between Tunis and the two north suburban exchanges had already been established. The connection of the remaining circuits between Kasbah and Le Kram required three teams and proceeded between 6.10 and 7 p.m. The subsequent connection of the circuits between Kasbah and La Marsa was completed by 8 p.m.

The work as a whole took 3 hours, and, after its completion, faults were found on only 120 of the 18 000 subscriber circuits involved. On about 4 per cent of the junction circuits to the northern suburbs, some additional adjustment was required on the *FIR* and *FUR* relay sets.

The cut-over of the crossbar exchanges had thereby been completed according to plan.

---

The cut-over of the new exchanges on November 30 came as a pleasant surprise to subscribers, since the official opening—synonymous with "cut-over" as far as the subscribers are concerned—had been announced in the

**Fig. 7** X 8422
**The Kasbah information service**

press for December 7. In this way the peak traffic which always follows on such occasions could be avoided.

The success of this operation exemplifies in a striking manner the excellent cooperation between the Tunisian PTT and L M Ericsson. A great deal of the initiative and action taken to provide the country with modern and efficient telecommunications is due primarily to the Bourguiba government and its Minister of Communications, Rachid Driss. The latter has shown a great interest in and personally supervised the work of installation and cut-over.

Mention should also be made of the very important contributions made by Chief Engineer Mohammed Mili, who has been responsible for all work on the exchanges, by the heads of the Transmission and Lines Branches, Chief Engineers Brahim Khouadja and Zouhir Ben Lakhal, and by all other members of the various telecommunications departments who have taken an active part in making the operation a success.

# L M Ericsson Exchanges Cut into Service 1962

## CITY EXCHANGES

*Public exchanges with 500-line selectors*

| Town | Exchange | | Number of lines |
|---|---|---|---|
| *Bolivia* | | | |
| La Paz | Centro | (extension) | 2000 |
| *Brazil* | | | |
| Curvêlo | | (extension) | 50 |
| Itabirito | | | 500 |
| Manhuacú | | | 500 |
| Sete Lagoas | | (extension) | 500 |
| Vitória | Central | (extension) | 500 |
| *Chile* | | | |
| Arica | | (extension) | 1000 |
| *Colombia* | | | |
| Bogotá DE | Centro | (extension) | 2000 |
| » | Ciudad Universitaria | (extension) | 3000 |
| » | Olaya | | 5000 |
| » | Ricaurte | (extension) | 2000 |
| » | San Fernando | (extension) | 3000 |
| Honda | | (extension) | 200 |
| Medellín area | América | (extension) | 2000 |
| » » | Bosque | (extension) | 1000 |
| » » | Buenos Aires | (extension) | 1000 |
| » » | Centro | (extension) | 500 |
| » » | Poblado | (extension) | 500 |
| *Ecuador* | | | |
| Guayaquil | Centro | (extension) | 500 |
| » | Sur | (extension) | 500 |
| *Ethiopia* | | | |
| Addis Ababa | Filwoha | (extension) | 1500 |
| *Finland* | | | |
| Karhula | | (extension) | 500 |
| Karjasilta | | (extension) | 500 |
| Mariehamn | | (extension) | 500 |
| Mikkeli/St. Michel | | (extension) | 500 |
| Pori/Björneborg | | (extension) | 500 |
| Rauma/Raumo | | (extension) | 500 |
| Ruosniemi | | | 500 |
| *Italy* | | | |
| *North Italy* | | | |
| Legnago | | (extension) | 200 |
| Mantova | | (extension) | 500 |
| Monselice | | (extension) | 100 |
| S. Bonifacio | | (extension) | 100 |
| Schio | | (extension) | 200 |
| Valdagno | | (extension) | 100 |
| Venezia/Venice | Lido | (extension) | 500 |

| Town | Exchange | | Number of lines |
|---|---|---|---|
| Verona | Borgo Trento | (extension) | 500 |
| » | Centro | (extension) | 500 |
| Vicenza | | (extension) | 1500 |
| *South Italy* | | | |
| Agrigento | | (extension) | 1000 |
| Barcellona | | (extension) | 100 |
| Bari | | (extension) | 3000 |
| Capri | | (extension) | 500 |
| Caserta | | (extension) | 500 |
| Milazzo | | (extension) | 100 |
| Napoli/Naples | Amedeo | (extension) | 1000 |
| » | Bagnoli | (extension) | 1000 |
| » | Museo | (extension) | 2000 |
| » | Posillipo | (extension) | 2000 |
| Palermo | Libertà | (extension) | 6000 |
| Piano di Sorrento | | (extension) | 100 |
| Reggio Calabria | | (extension) | 1500 |
| Sorrento | | (extension) | 100 |
| Taranto | | (extension) | 1500 |
| *Lebanon* | | | |
| Beyrouth | Furn-El-Chebak | (extension) | 1000 |
| *Mexico* | | | |
| México DF | Apartado | (extension) | 500 |
| » | Chapultepec | (extension) | 1500 |
| » | Churubusco | (extension) | 500 |
| » | Peralvillo | (extension) | 1500 |
| » | Piedad | (extension) | 2000 |
| » | San Angel | (extension) | 1000 |
| » | Saro | (extension) | 3000 |
| » | Tacuba | (extension) | 1000 |
| Villahermosa | | (extension) | 500 |
| *Netherlands' West Indies* | | | |
| Curaçao | Brievengat | (extension) | 200 |
| *Norway* | | | |
| Fiskå | | | 500 |
| Kristiansand S | | (extension) | 500 |
| Stavanger | | (extension) | 2000 |
| Svelgen | | | 360 |
| *Panama* | | | |
| Colón | | | 3000 |
| Panama City | Panama 5 | (extension) | 500 |
| *Peru* | | | |
| Arequipa | | (extension) | 500 |

| Town | Exchange | | Number of lines |
|---|---|---|---|
| *Sweden* | | | |
| Göteborg/Gothen-burg | | | |
| Suburban Area | Kortedala | (extension) | 1000 |
| Hagfors | | (extension) | 500 |
| Halmstad | | (extension) | 2500 |
| Hälsingborg | | (extension) | 500 |
| Kalmar | | (extension) | 2000 |
| Karlstad | | (extension) | 2000 |
| Katrineholm | | (extension) | 500 |
| Kiruna | | (extension) | 1500 |
| Köping | | (extension) | 500 |
| Linköping | | (extension) | 3000 |
| Ludvika | | (extension) | 1000 |
| Norrtälje | | (extension) | 500 |
| Skellefteå | | (extension) | 500 |
| Stockholm | | | |
| Centrum Area | Östermalm | (extension) | 500 |
| Suburban Area | Hanviken | (extension) | 500 |
| » | Lidingö-Brevik | (extension) | 1500 |
| » | Storängen | (extension) | 2000 |
| » | Vendelsö | (extension) | 1000 |

| Town | Exchange | Number of lines |
|---|---|---|
| Tumba | (extension) | 1000 |
| Ulricehamn | (extension) | 500 |
| Uppsala | (extension) | 2000 |
| Västervik | (extension) | 500 |
| Västerås | (extension) | 4000 |
| Åmål | (extension) | 500 |
| Örebro | (extension) | 3000 |
| *Turkey* | | |
| Adana | (extension) | 1000 |
| Antalya | (extension) | 500 |
| Kars | | 500 |
| Tarsus | | 1000 |
| Uşak | (extension) | 500 |
| *Venezuela* | | |
| San Carlos | | 500 |
| San Felipe | (extension) | 200 |
| | **Total** | **113110** |

## *Public exchanges with crossbar switches*

| Town | Exchange | | Number of lines |
|---|---|---|---|
| *Brazil* | | | |
| Brasilia | | (extension) | 5000 |
| Cubatão | | | 400 |
| Itajubá | | | 1200 |
| Leme | | | 600 |
| Recife area | Boa Viagem | | 1000 |
| » » | Boa Vista | | 7000 |
| » » | Santo Antonio | | 6000 |
| Santo André area | Mauá | (extension) | 200 |
| » » » | Ribeirão Pires | (extension) | 200 |
| » » » | Rudge Ramos | (extension) | 200 |
| » » » | Santo André | (extension) | 800 |
| » » » | São Bernardo | (extension) | 200 |
| » » » | São Caetano | (extension) | 400 |
| São José dos Campos | | | 2000 |
| Sorocaba area | Sorocaba | | 5000 |
| » » | Votorantim | | 120 |
| *Central-African Republic*[1] | | | |
| Bangui | | | 800 |
| *Chad*[1] | | | |
| Fort Lamy | | | 1000 |

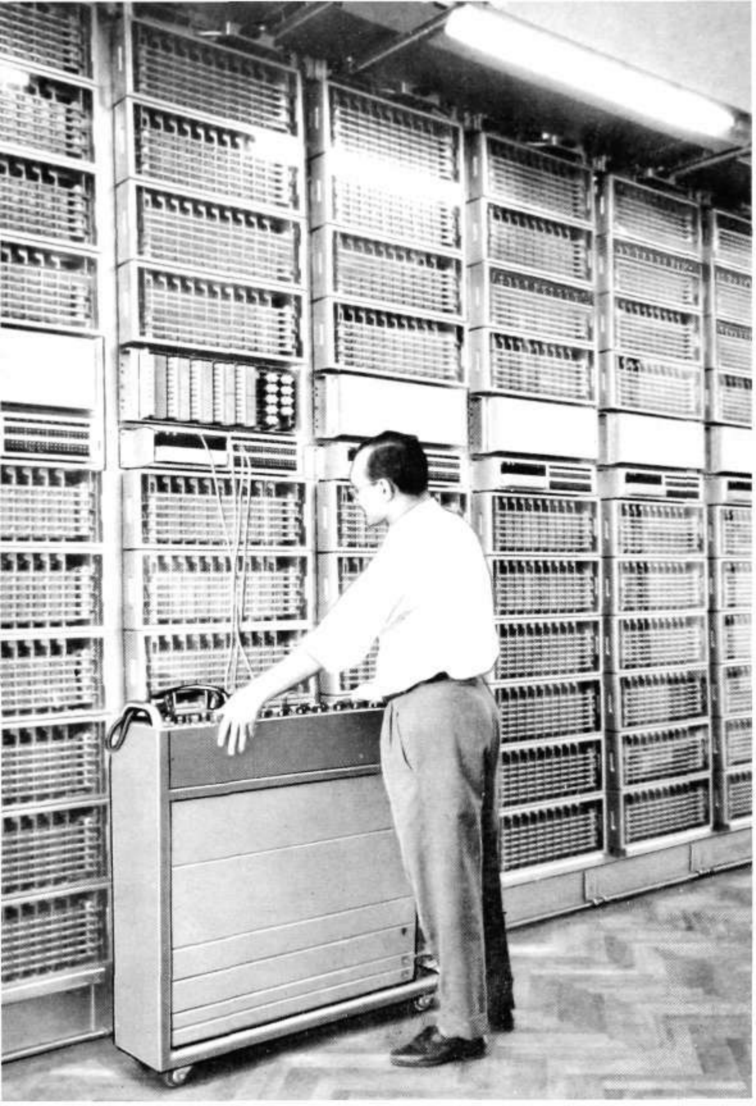
| Town | Exchange | | Number of lines |
|---|---|---|---|
| *Dahomey*[1] | | | |
| Cotonou | | | 2000 |
| Porto Novo | | | 800 |
| *Denmark* | | | |
| Aalborg | | (extension) | 2000 |
| Aarhus | Nord | | 2000 |
| » | Risskov | (extension) | 1000 |
| » | Skaade | (extension) | 1000 |
| Esbjerg | | (extension) | 8000 |
| Frederikshavn | | (extension) | 1000 |
| Grenaa | | (extension) | 200 |
| Helsingør/Elsinore | | (extension) | 1000 |
| Ikast | | (extension) | 400 |
| København/Copen-hagen | Bella | (extension) | 1000 |
| » | Birkerød | (extension) | 1000 |
| » | Brøndbyøster | (extension) | 1000 |
| » | Damsø | (extension) | 2000 |
| » | Glostrup | (extension) | 1000 |
| » | Herlev | (extension) | 3000 |
| » | Hvidovre | (extension) | 2000 |
| » | Kastrup | (extension) | 2000 |
| » | Lille Værløse | | 1800 |
| » | Nora | (extension) | 5000 |
| » | Rødovre | (extension) | 2000 |
| » | Sundbyøster | (extension) | 7000 |
| » | Trørød | | 1000 |

[1] These exchanges, system CP 400, were delivered by Société des Téléphones Ericsson, Colombes.

| Town | Exchange | Number of lines |
|---|---|---|
| København/Copen-hagen | Valby (extension) | 2000 |
| » | Vallensbæk (extension) | 1000 |
| Næstved | (extension) | 1000 |
| Struer | (extension) | 400 |
| Varde | | 1600 |
| *Finland* | | |
| Helsinki/Helsingfors | Gräsa | 1000 |
| » | Haaga/Haga (extension) | 1000 |
| » | Herttoniemi/Hertonäs (extension) | 400 |
| » | Kulosaari/Brändö (extension) | 400 |
| » | Laajasalo/Degerö | 1200 |
| » | Leppävaara/Alberga (extension) | 400 |
| » | Oulunkylä/Äggelby | 1600 |
| » | Pihlajamäki/ Rönnbacka | 1000 |
| » | Sörnäinen/Sörnäs (extension) | 2000 |
| Langinkoski | (extension) | 400 |
| Niirala | (extension) | 1000 |
| Porvoo/Borgå | (extension) | 500 |
| *France*[1] | | |
| Beauvais | (extension) | 400 |
| Blois | | 3200 |
| Haguenau | | 1600 |
| Saint Vallier | | 200 |
| *Gabon*[1] | | |
| Libreville | | 1000 |
| Port Gentil | | 600 |
| *Iceland* | | |
| Hafnarfjördur | | 2000 |
| *Ireland* | | |
| Dublin | Dundrum (extension) | 1000 |
| » | Palmerstone (extension) | 400 |
| Limerick | (extension) | 1000 |
| *Italy* | | |
| *North Italy* | | |
| Padova | (extension) | 4000 |
| Treviso | (extension) | 400 |
| Venezia/Venice | Mestre (extension) | 2200 |
| *South Italy* | | |
| Altamura | (extension) | 400 |
| Amalfi | | 600 |
| Augusta | (extension) | 200 |
| Avola | | 1000 |
| Benevento | | 4000 |

| Town | Exchange | Number of lines |
|---|---|---|
| Caltanissetta | | 6000 |
| Casalnuovo | | 400 |
| Casamicciola | | 800 |
| Castrovillari | | 800 |
| Corigliano | | 800 |
| Eboli | | 800 |
| Fondi | | 600 |
| Lentini | | 1000 |
| Marigliano | | 1000 |
| Napoli/Naples | Fuorigrotta | 10000 |
| Noto | | 1000 |
| Partinico | | 1000 |
| Paternò | | 1200 |
| Piazza Armerina | | 800 |
| Pomigliano | | 600 |
| Pozzuoli | | 1600 |
| Ragusa | | 4000 |
| S. Maria C.V. | | 1000 |
| Vico Equense | | 400 |
| *Nepal* | | |
| Kathmandu | | 1000 |
| *Netherlands* | | |
| Gouda | | 6000 |
| Maassluis | | 2000 |
| Ridderkerk | | 2400 |
| Rotterdam | Centrum IV | 5000 |
| » | Pernis | 4000 |
| *New Zealand* | | |
| Kensington | | 1600 |
| Onerahi | | 1000 |
| *Sweden* | | |
| Alingsås | (extension) | 300 |
| Motala | (extension) | 200 |
| Nyköping | (extension) | 300 |
| Skövde | (extension) | 700 |
| Visby | (extension) | 500 |
| Ystad | (extension) | 600 |
| *Thailand* | | |
| Cholburi | | 1000 |
| Yala | | 1000 |
| *Tunisia* | | |
| Tunis | Belvédère | 5000 |
| » | Carthage | 12000 |
| » | Kasbah | 4000 |
| » | La Marsa | 1000 |
| » | Le Kram | 1000 |
| *United Arab Republic* | | |
| Cairo | Abbassia | 10000 |
| Damanhour | | 2000 |
| Mansoura | | 4000 |

[1] These exchanges, system CP 400 were delivered by Société des Téléphones Ericsson, Colombes.



X 8418

**Interior from the new crossbar exchange at Mehalla-El-Kobra, Egypt, United Arab Republic.**

*Public exchanges with crossbar switches (cont.)*

| Town | Exchange | Number of lines |
|---|---|---|
| Mehalla-El-Kobra | | 3000 |
| Tanta | | 4000 |
| *USA*[1] | | |
| Chillicothe, Ohio | | 1000 |
| Elkin, North Carolina | (extension) | 200 |
| Export, Pennsylvania | (extension) | 850 |
| North Madison, Indiana | (extension) | 300 |
| Perry, Georgia | (extension) | 200 |
| Seymour, Indiana | (extension) | 500 |
| Winter Park, Florida | (extension) | 1000 |
| *Yugo-Slavia*[2] | | |
| Beograd | Akademija (extension) | 2000 |
| Niš | (extension) | 1000 |
| Priština | (extension) | 1000 |
| Sarajevo | (extension) | 3000 |
| Sisak | | 1000 |
| Sušak | | 1000 |
| Zagreb | Cernomerec | 2000 |
| » | Pešćenica (extension) | 1000 |
| » | Trešnjevka (extension) | 1000 |
| | **Total** | **246870** |

[1] These exchanges, system NX-1, were delivered by North Electric Co., Galion, Ohio.
[2] The equipment for these exchanges has been manufactured on L M Ericsson-license by the Yugo-Slavian factory Nikola Tesla, Zagreb.

## RURAL EXCHANGES

| | Number | Number of lines[3] |
|---|---|---|
| *Public rural exchanges with crossbar switches, system ARK, ART* | | |
| Brazil | 1 | 400 |
| Denmark | 3 | 1850 |
| Ethiopia | — | 60 |
| Finland | 52 | 7190 |
| Ireland | 5 | 1140 |
| Italy | 22 | 2640 |
| Lebanon | 1 | 200 |
| Netherlands | — | 1600 |
| Sweden | — | 1200 |
| USA[4] | 34 | 17610 |
| Yugo-Slavia[5] | 15 | 3700 |
| **Total** | **133** | **37590** |
| *Rural exchanges with 12-, 25- or 100-line selectors, system OL, XY* | | |
| Norway | **69** | **7190** |

## TRANSIT EXCHANGES

| | Number of junctions |
|---|---|
| *Transit exchanges with crossbar switches, system ARK, ARM* | |
| Colombia | 800 |
| Denmark | 2820 |
| Finland | 2340 |
| Italy | 2360 |
| Mexico | 700 |
| Netherlands | 2500 |
| **Total** | **11520** |

[3] The number of lines includes both new exchanges and extensions of existing exchanges.
[4] These exchanges, system NX-2, were delivered by North Electric Co., Galion, Ohio.
[5] The equipment for these exchanges has been manufactured on L M Ericsson-license by the Yugo-Slavian factory Nikola Tesla, Zagreb.

# Ericsson LM NEWS *from* *All Quarters of the World*

(Above) Mr. Rachid Driss, Minister of Communications, cuts the symbolical tape in the Tunisian national colours at the opening ceremony. On his right is Foreign Minister Mongi Slim, on his left president Sven T. Åberg and Ambassador Lennart Petri.

## L M Ericsson's New Automatic Exchanges Now in Service in Tunis

At President Bourguiba's reception: the President conversing with Messrs. Åberg and Petri.

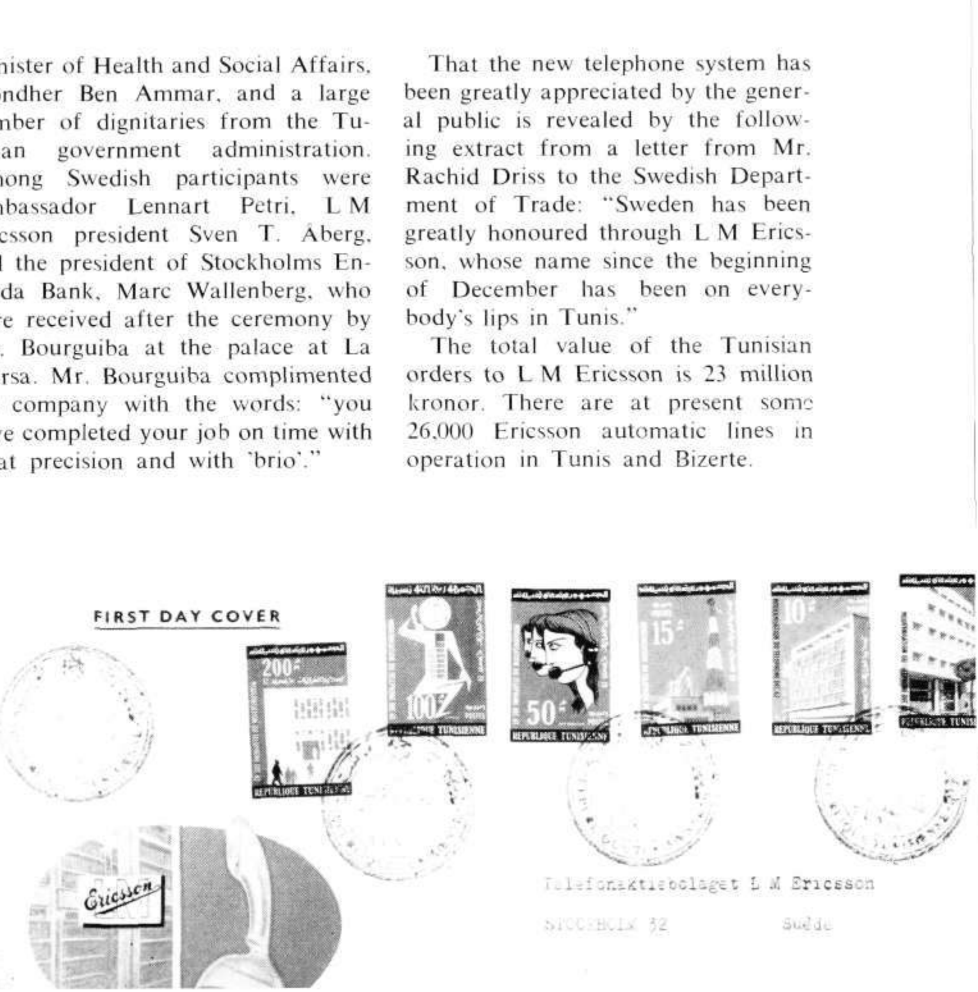
Minister Rachid Driss, Head of the Tunisian P.T.T., presided at the opening of L M Ericsson's automatic telephone exchanges in Tunis on December 7, 1962. The inauguration ceremony took place in the P.T.T. offices in Boulevard Farhat Hached in Tunis. These exchanges are a link in the re-equipping of the entire Tunisian network by L M Ericsson. The whole project is expected to be completed in 1964.

The ceremony was attended by the Foreign Minister, Mongi Slim, the Minister of Health and Social Affairs, Mondher Ben Ammar, and a large number of dignitaries from the Tunisian government administration. Among Swedish participants were Ambassador Lennart Petri, L M Ericsson president Sven T. Åberg, and the president of Stockholms Enskilda Bank, Marc Wallenberg, who were received after the ceremony by Mr. Bourguiba at the palace at La Marsa. Mr. Bourguiba complimented the company with the words: "you have completed your job on time with great precision and with 'brio'."

That the new telephone system has been greatly appreciated by the general public is revealed by the following extract from a letter from Mr. Rachid Driss to the Swedish Department of Trade: "Sweden has been greatly honoured through L M Ericsson, whose name since the beginning of December has been on everybody's lips in Tunis."

The total value of the Tunisian orders to L M Ericsson is 23 million kronor. There are at present some 26,000 Ericsson automatic lines in operation in Tunis and Bizerte.

The stamps on this First Day Cover were issued by the Tunisian P.T.T. in memory of the inauguration. The 200 millimes denomination depicts the Belvédère exchange, the 100 millimes a telephoning figure (the head is a dial and the trunk a crossbar switch), the 50 millimes three operators in profile, the 15 millimes the Sfax exchange and the Tunis-Sfax radio link, the 10 millimes the Carthage exchange, and the 5 millimes the Kasbah exchange.



# L M Ericsson Continues Expansion of C.T.C. in Scandinavia

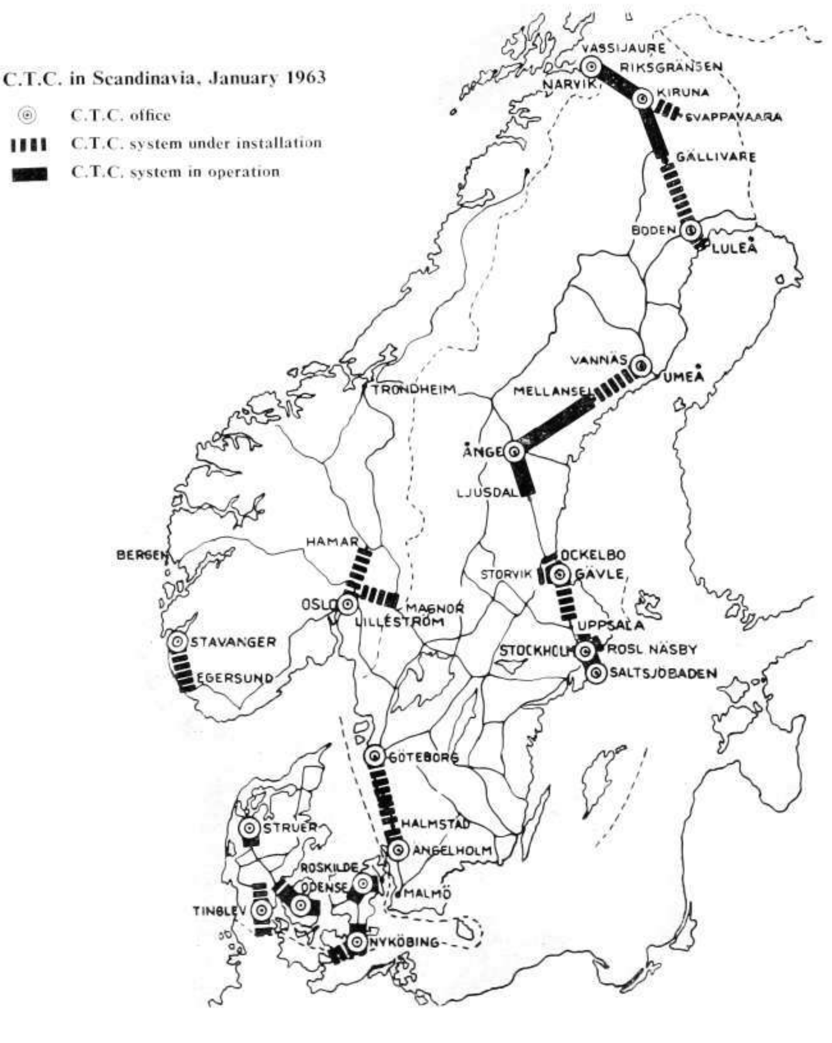
In the autumn of 1962 the Swedish State Railways ordered from L M Ericsson C.T.C. Code Control Equipment for 130 stations with five C.T.C. offices. The equipment suffices for a distance of 1,000 kilometres and is to be installed on the Gothenburg—Ängelholm, Uppsala—Gävle—Storvik—Ockelbo, Mellansel—Vännäs, Luleå—Boden—Gällivare and Kiruna—Svappavaara lines. The equipment is to be delivered in the years 1963—1965 and will be of the same kind as earlier installed at three C.T.C. offices and 71 field locations.

The Swedish Railways already have the longest continuous C.T.C. line in Europe, between Ljusdal and Mellansel, 357 km with 44 field locations. After the installation of the new equipment, Sweden will have a considerably greater length of railroad under centralized traffic control than any other country in Europe, altogether some 1,450 km.

As announced in Ericsson Review No. 1, 1962, the Norwegian State Railways are installing C.T.C. on two lines, between Narvik and Riksgränsen on the Swedish boundary in the north, and between Stavanger and Egersund in the south. The equipment is being supplied by L M Ericsson and A/S Norsk Signalindustri. The Norwegian Railways have since purchased equipment for the Lilleström—Hamar and Lilleström—Magnor lines, which will bring up the length of C.T.C. lines in Norway to 370 km with three C.T.C. offices and 61 field locations. The equipment is to be delivered during 1963.

The Danish State Railways are continuing to install C.T.C. on the main lines. According to present plans, before the end of 1963 C.T.C. will be in operation on 305 km of line with five C.T.C. offices and 42 field locations.

C.T.C. in Scandinavia, January 1963




# Sven Weber in Memoriam

Sven Weber died on January 15 in Helsinki.

At his death Sven Weber was chairman of the board of O/Y L M Ericsson A/B. Originally trained as a naval architect in Dresden and at Chalmers, Gothenburg, he entered the telephony field in 1930 when he accepted an appointment in the South Finnish Trunk Telephone Co. In 1934 he was appointed president of O/Y L M Ericsson A/B, a post to which he brought great ability and in which he remained until 1958 when he became chairman of the board.

During the many years in which Sven Weber presided over O/Y L M Ericsson A/B, telephony in Finland underwent a tremendous development. Under his leadership L M Ericsson established intimate cooperation with the Finnish telephone administrations, to the benefit of all parties. In his work and in his person Sven Weber was a man of stature. Dynamic, rich in initiative, a skilful engineer and businessman, he became in time the symbol of an indomitable spirit that acknowledged no difficulty. These qualities he combined with a kindness and a firmness of friendship, an optimism and infectious good humour which make his loss doubly great. Sven Weber was an important link in the relations between our two countries. In the memory of his colleagues and friends he remains a strong and bright light.

*Sven T. Åberg*

The work on the new telephone factory at Broadmeadows near Melbourne, Australia, has now started. The factory is being erected by L M Ericsson's Australian subsidiary, L M Ericsson Pty. Ltd. The first stage will comprise about 120,000 sq. ft. of factory and office space to step up the present production of telephone switching and other telecommunications equipment. President Sven T. Åberg is seen throwing up the first sod—or rather shovel-load—for the foundations of the new building.


The Ericofon has found its way far and wide around the globe. It has now reached these Colorado Indians, who have definitely abandoned smoke signals as means of communication. (Left)

Telefones Amazonas S/A has recently put in commission a telephone exchange equipped with one of L M Ericsson's manual C.B. switchboards type ADF for 120 lines. The exchange is situated at Itacoatiara 200 kilometres from the town of Manaus on the river Amazon. The exchange building, situated in one of the most rainy areas in the world, is shown in the photograph below.

The Nigerian Minister of Communications, Mr. Olu Akinfosile, has visited Stockholm and L M Ericsson at Midsommarkransen. (Left) Minister Akinfosile watches with interest the work in one of the Ericsson production shops.

Forty-one nations, including Sweden, were represented at the first international fair in tropical Africa—at Lagos, Nigeria—at the end of last year. The fair was a decided success and was visited by some 1,200,000 people in the three weeks that it was open. L M Ericsson telephones were among the well-known Swedish products in Africa that were exhibited. Nils Eriksson from L M Ericsson demonstrates some LME products to (from left) Tony Maxwell, IPTC, T. O. S. Benson, Nigerian Minister of Information, Governor General Nnamdi Azikiwe and Ambassador Love Kellberg.


# Carrier Equipment for Liberia

The telecommunication authorities of Liberia have been working for several years on a project covering the main towns of the country. As a result a contract with L M Ericsson was signed in 1961 for the supply and installation of telephone exchanges, pay stations, local cable plant etc.

Recently the Government of Liberia signed an additional contract with L M Ericsson covering the supply and installation of multiplex equipment for telephony and telegraphy. This equipment is of L M Ericsson's latest design and is fully transistorized.

The carrier telephony equipment will be installed at 22 stations, as shown on the map. The voice frequency telegraph equipment will constitute the initial installation for nine of the same stations. The order also includes training of maintenance personnel.

# Ericsson Technics No. 2, 1962

Ericsson Technics No. 2, 1962, has now appeared. In the first paper, "Planning of Exchange Locations and Boundaries in Multi-Exchange Networks" by Dr. Yngve Rapp, Telefonaktiebolaget L M Ericsson, methods are presented which are aimed at facilitating the preparation of a fundamental plan for multi-exchange networks, i.e. for determining the number of exchanges, their locations, and the boundaries between the exchange areas. This fundamental plan serves as starting point for the detailed planning of the subscribers' and junction networks. A summarized version of this paper was published in Ericsson Review No. 2, 1962, under the title "Planning of Multi-Exchange Networks with Aid of a Computer».

There follows a paper by Henry Scheftelowitz, Telefonaktiebolaget L M Ericsson, "Study of Sampling Noise, Especially in Reference to Systems for Transmission of Wide Band Signals on Identical Narrow Band Channels in Parallel Connection". In a time multiplex system the band width of the individual channel is determined by the pulse repetition frequency. If this frequency is, for example, 8 000 c/s, the upper cut-off frequency will be 4 000 c/s. For transmission of signals at higher frequencies several channels must be interconnected. Each individual channel may be regarded as a four-terminal network. A study is made of crosstalk as function of the characteristics of the four-terminal networks.

Finally, in "Calculations for the Design of Switching Devices in Automatic Telephone Systems", Karl Lundkvist, Telefonaktiebolaget L M Ericsson, describes a method of calculating the most suitable design of a switching device for automatic telephone exchanges consistent with the traffic per line, the production cost of the switch components, and the number of lines. For every telephone system there is an economic optimum for a given quantity of traffic. The size and arrangement of the corresponding switching group is sought having regard to the effect of different design measures on the price and traffic capacity of the telephone exchange.

# New Method for Jointing of Plastic Cables Developed by L M Ericsson

The use of plastic cables instead of paper-lead cables called for a jointing method which was acceptable both technically and economically. L M Ericsson has developed a method essentially fulfilling the requirements for satisfactory jointing of polythene-insulated and polythene-sheathed cables.

As far as the individual conductor splices are concerned, the method basically involves twisting of the conductors under heat without removal of the insulation, and welding of a plastic sleeve, which is sealed at one end, to the conductor insulation so as to insulate the splice.

As regards the sheath joint, the method implies a welding process by which the plastic material is heated in a hot gas stream via a heat resistant rubber band. To achieve a pressure-tight joint, sheath and jointing material must be of the same composition.

Far-reaching experiments and laboratory tests prove that the method evolved for plastic cables is as rapid as the jointing of paper-lead cables, and that conductivity and insulation of the joint are equivalent to those of the cable. The cost of the jointing material and the equipment appears to be acceptable.

The method has been utilized by L M Ericsson in the field and been found to be satisfactory.

A preliminary description of the method has been issued by the Network Department under reference N 2822.1—109 Us.

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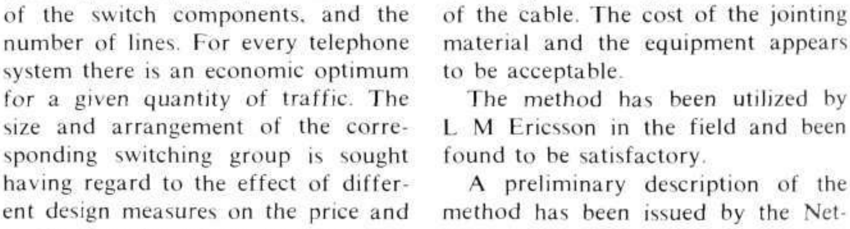
**In February L M Ericsson's new factory at Ronneby was opened—the fourth Ericsson factory in the province of Blekinge. It is expected to employ some 400 persons and will operate as a branch of the Karlskrona factory. The production will consist chiefly of the assembly and wiring of racks for automatic switching equipments.**



UDC 621.395.44
LME 8424

TRONSLIE, S: *Terminal Equipment for 2700-circuit Carrier System. I. Modulation Equipment.* Ericsson Rev. *40*(1963): 1, pp. 2—17.

The article deals with L M Ericsson's equipment for modulation from the basic supergroup to the line frequency band of the 12 Mc/s system. A brief description of the system is given and the most important technical data are presented.

The associated equipment for carrier frequency generation will be dealt with in an article to be published in a future number of Ericsson Review. The modulation equipment for the formation of the basic supergroup has been described in Ericsson Review, No. 1, 1961 and No. 2, 1962.

UDC 621.395.722
621.395.344.6
LME 8344

BEN CHEIKH, HABIB: *The New Telephone Exchanges in Tunis.* Ericsson Rev. *40*(1963): 1, pp. 18—28.

The cut-over on November 30, 1962, of the new L M Ericsson crossbar exchanges in Tunis and its northern suburbs brought to an end the previously serious state of telecommunications in the country. The new exchanges, which represent the first step in the conversion of the entire Tunisian network to automatic operation, are described in this article.

# The Ericsson Group

## Associated and co-operating enterprises

### • EUROPE •

**Denmark**
L M Ericsson A/S *København F*, Finsensvej 78, tel: Fa 6868, tgm: ericssons

Telefon Fabrik Automatic A/S *København K*, Amaliegade 7, tel: C 5188, tgm: automatic

Dansk Signal Industri A/S *København F*, Finsensvej 78, tel: Fa 6767, tgm: signaler

**Finland**
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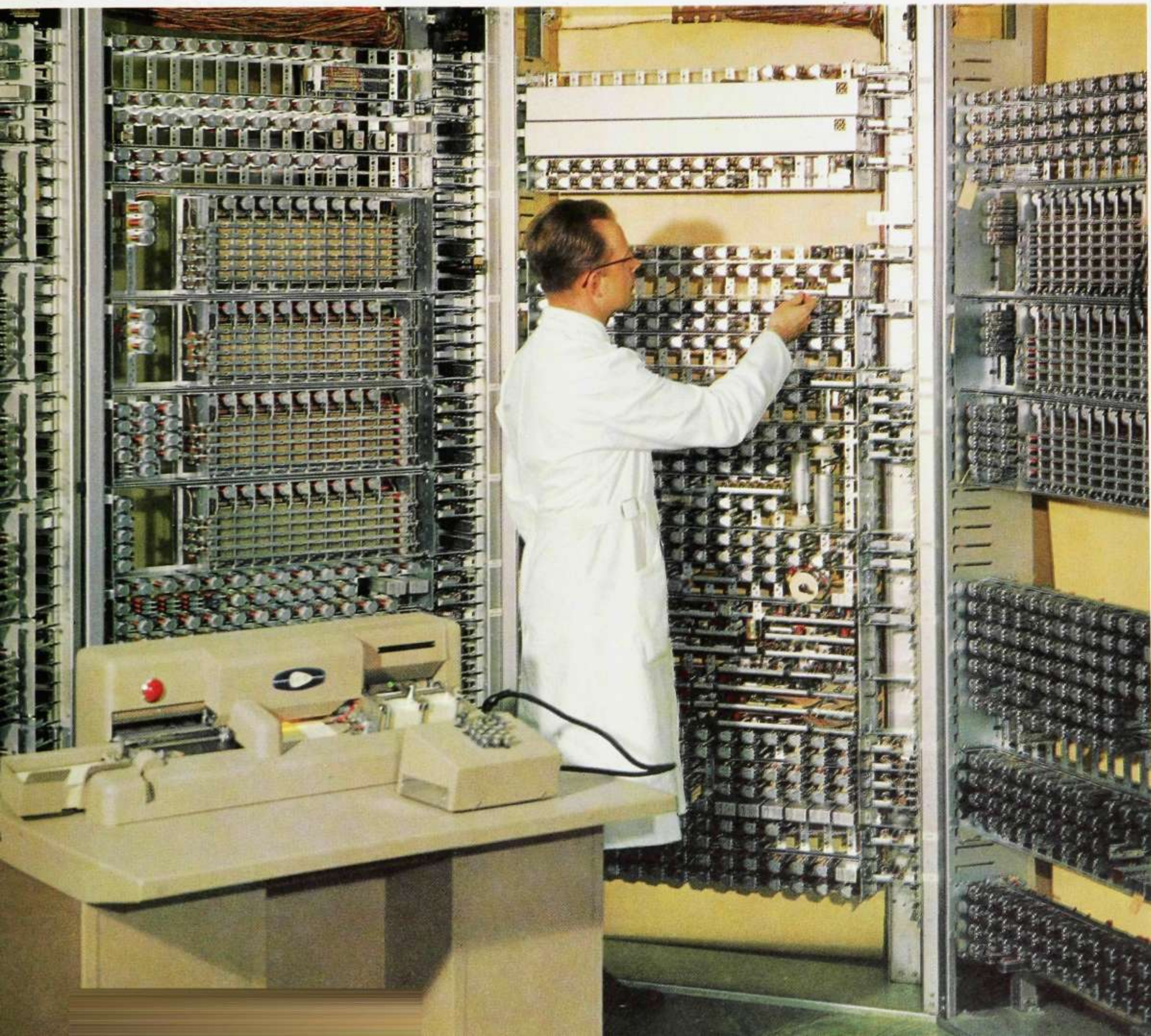

# ERICSSON REVIEW

Vol. XL No. 2 1963

RESPONSIBLE PUBLISHER: HUGO LINDBERG

EDITOR: SIGVARD EKLUND, DHS

EDITOR'S OFFICE: STOCKHOLM 32

SUBSCRIPTIONS: ONE YEAR $ 1.50; ONE COPY $ 0.50


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On cover: Laboratory Set-up of Automatic Transmission Measuring Equipment for Telephone Circuits. Foreground: Punched Card Reader for Control of the Measurements.

# European Subscriber Dialling

C JACOBÆUS, TELEFONAKTIEBOLAGET LM ERICSSON, STOCKHOLM

UDC 654.154.4
LME 808

*The first automatic international service was between the frontier areas in neighbouring countries. As the technique developed and the traffic demand grew, automatic service has extended to larger areas. C.C.I.T.T. has for a long time been studying means of introducing a fully automatic international service in Europe and has issued comprehensive recommendations covering the technical aspects and traffic considerations.*

*Various aspects of European subscriber dialling are presented in this article. The article is based on a paper read at "X convegno internazionale delle communicazioni" in Genua in October 1962. It is published with the kind permission of The Civic Committee of Columbus Celebrations.*

With the invention of the telephone 85 years ago there started a long period of technical development. The 19th century brought the telephone itself, the carbon granule transmitter and the main elements of manual switching. The first two decades of the 20th century saw the perfection of manual switching; at the same time automatic switching had now cast off its infant's clothing and produced basic solutions of problems which have since been accepted as standard methods. Gradings, registers, link systems and markers were all brought to birth in that period. In the following decades came the carrier systems and radio links, which permitted telephony over long distances. In the fifties followed the Atlantic cables and—an even more dramatic advance—in 1962 the first satellite communications, even though they are still used only for experimental purposes. The forties and fifties saw the breakthrough of crossbar switching, and we are now waiting for electronic switching to become a serious proposition.

We have, in fact, now a technical arsenal which permits us to solve any problem involved in the provision of communication between two subscribers wherever they may be situated.

In our days we accept subscriber dialling of local and long distance calls as a matter of course, the justification for which need no longer be discussed. But that has not always been the case. A well organized manual service has its advantages, in that it does most of the subscriber's work for him. But for various reasons manual service has become impossible, especially for local calls. Operators' salaries have risen, while automatic exchanges now cost hardly more than manual exchanges. In areas with high traffic intensity, moreover, it would be impossible to recruit the number of operators required without resorting to compulsion. Furthermore, when calls have to pass several exchanges, even the best manual service would be cumbersome and the risk of wrong connections would be much greater. Subscribers have come to appreciate that automatic service is to their advantage.

For long distance calls there has been considerable doubt as to whether subscriber dialling would be the correct procedure. Up to the '50's the trunk circuits in most countries were so limited in number that delay working was inevitable. A queuing arrangement for automatic calls was hardly conceivable, and it was therefore necessary to have operators to handle the queue. Another argument in favour of operators was the need for efficient utilization of the expensive long distance circuits. The system of advance preparation was, of course, often employed, i.e. the calling and called subscribers were connected up locally before a trunk circuit became free so that the new call might start as soon as the circuit was released. Another reason for employing operators was the accounting problem. There were no suitable means of automatic charging, and it was also thought that subscribers would require a specification of charges for long distance calls.

Owing to the method of delay working and the fact that charges were usually based on a 3-minute period, the system of person-to-person calls was widespread. For a very slight extra charge the caller could be connected direct to the wanted person. If the latter was unobtainable at the first attempt, he was requested to notify the exchange on his return. Connection was then established.

Since World War II, coaxial cable carrier systems and radio links have made long distance communication cheaper. At the same time operators' salaries have risen. This led to semi-automatic service, in which connections were established with the aid of one operator. She had a dial or keyset to set up the connection to the called subscriber. This system was very much cheaper for administrations and generally provided better service for subscribers. The operator still wrote a ticket for each call. This led to the development of automatic trunk exchanges. Tandem traffic required a plentiful supply of circuits to keep congestion at a low level. After the war, as a result of the satisfactory experience within their individual countries, the administrations took up the question in C.C.I.F. of arranging for inter-state semi-automatic traffic within Europe. After several years of work certain specifications were agreed upon, and for some years now the majority of the international traffic in Europe has been handled in this way.

Within the national field the fifties have also seen the breakthrough of subscriber-dialled long distance calls. This has been made possible by the abundance of circuits. The saving of operators has reduced costs, so that tariffs could be lowered as well. With lower tariffs and the quick rise in the standard of living, it has been possible to dispense with detailed particulars of calls. The principle of multi-fee metering is employed, involving successive operations of the subscriber's meter, so that the 3-minute period as basis for charging could be abandoned. Short calls can now be made at a correspondingly lower price. The need for person-to-person calls has practically disappeared. The initial fears that subscribers would not be able to manage the troublesome dialling procedure or that technical difficulties would arise have proved entirely unfounded. On the contrary, subscriber long distance dialling has led to a great increase in traffic, which is the best proof of its usefulness. The main reason is the immediate access, but an important contributory factor is the absence of friction of a human kind in the setting up of calls. For administrations it has become a good source of income.

The logical next step is direct subscriber dialling of international calls. The same advantages may be expected in the form of simplified and quick connection, lower tariffs and simpler accounting. The general tendency in international relations, moreover, is to demolish the barriers between peoples. When customs duties are being done away with and frontiers are being opened for the exchange of goods, telephone traffic should not be subject to special regulations when it passes a national frontier. The telephone is in itself a tool for trade and, as such, should be simple to use on a universal basis.

This article will deal with some of the problems encountered in international subscriber-dialling, with especial reference to the conditions in Europe.

## General

The automatization of international traffic naturally imposes many problems on telephone technicians. Subscriber-dialled international traffic represents in a nutshell the entire problem of world telephony. It is a problem with technical, economic and operating aspects, while at the same time human factors are involved in almost every detail.

The problems of technique and of the human factor in telephony are in several respects intimately related. One may say that the entire transmission technique has essential parameters determined by the human speaking organs and faculties of hearing. Numbering schemes, signal tones, accounting and maintenance are other problems which have both technical and human aspects. In international traffic the human factor is the more accentuated because of differences of language and of national practice.

The world telephone system is a unit which places definite demands on its sub-systems if it is to function as a whole. C.C.I.T.T., in principle, should be concerned solely with the conditions of international traffic, but in fact has had to make definite stipulations as to how national telephone systems shall function in many detailed respects.

The C.C.I.T.T. recommendations for international automatic traffic were laid down at the Plenary Assembly at New Delhi in December 1960 and are published in "RED BOOK" Volume VI and Volume II bis. But developments are proceeding rapidly and an intense study is being devoted to several sectors to cater for the new technical facilities. We may therefore expect a number of new or amended recommendations at the next Plenary Assembly.

An automatic international connection may be divided into three parts, one in the outgoing country, one the international chain, and one in the incoming country. The national chain in the outgoing and incoming countries consists of the subscriber's telephone, local network and trunk chain. The latter is made up of up to three, in exceptional cases four, 4-wire circuits. The international chain consists of one, two or, sometimes, three 4-wire circuits, at least within the boundaries of Europe.

The switching system for international calls is naturally a register system. At every international exchange a register is seized for directing the connection within the exchange and, in some cases also, for routing it onward. Alternative routing is employed whenever the network structure so permits. For purposes of statistics and to ensure a fair settlement of accounts between countries, the register at the international sending exchange must be given an indication of the route on which the connection has been set up.

## Determination of the Required Numbers of International Circuits

C.C.I.T.T. is studying the question of how to estimate the quantities of circuits needed for the international network. There is admittedly a recommendation now in force to the effect that the congestion to be allowed on international circuits shall be 1 %. But this must be regarded as a provisional arrangement. C.C.I.T.T. is now considering the entire problem from a more global point of view, and there is no doubt that different levels of congestion will be established for different sections of the network: one for intercontinental circuits, one for the main continental routes, one for secondary routes, etc. The recommendations will be influenced by the availability of alternative routing and by the fact that the busy hour occurs at different times at different places. C.C.I.T.T. is also studying methods of measurement and the quantities to be measured.

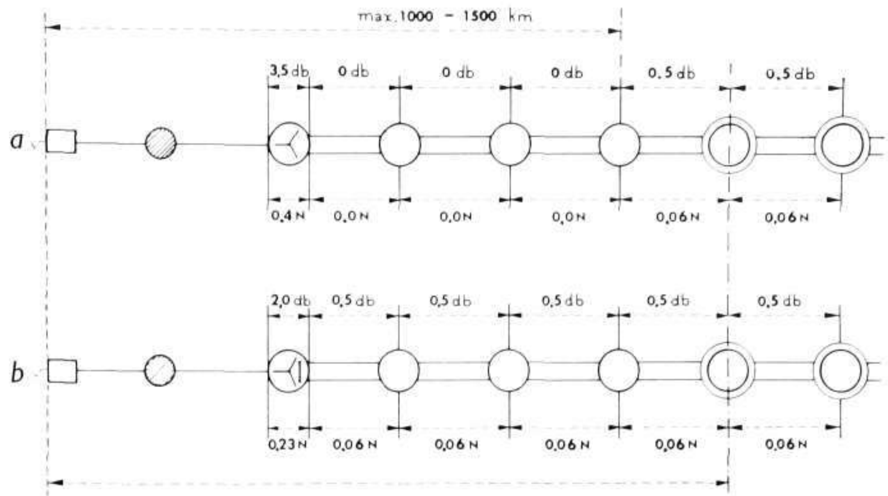


**Fig. 1** X 8400

***a* and *b* represent different alternatives for the distribution of overall loss in the national network of a large country**

After the conditions in the international network have been regulated, certain demands will probably be placed also on the grade of service of national networks. The congestion in a receiving country must not be too high if the automatic traffic is to be able to function. There is a parallel here to the circumstance that C.C.I.T.T. must recommend a certain quality of transmission in national networks.

## Transmission Questions

C.C.I.T.T. has drawn up various alternatives for the distribution of overall loss in the national and international sections of the 4-wire network. These are shown in fig. 1 and 2. The international network employs a nominal attenuation of 0.5 db per circuit. In national networks the attenuation on the 4-wire chain of circuits between the 2-wire termination and the international exchange must be at least $2.0 + 0.5\ n$ db, where $n$ is the number of national circuits in tandem employed on a given connection. Thus 3.5 db suffices for all connections in countries where the number of circuits in tandem does not exceed three: in large countries, i.e. with up to four circuits from the 2-wire termination to the international exchange, this figure will be 4.0 db, but a corresponding increase is allowed in the reference equivalent. The standard deviation may be up to 1 db per circuit. In extreme cases and with many circuits in tandem, this standard deviation may result in a large difference in attenuation from case to case. With nine circuits in tandem, the attenuation

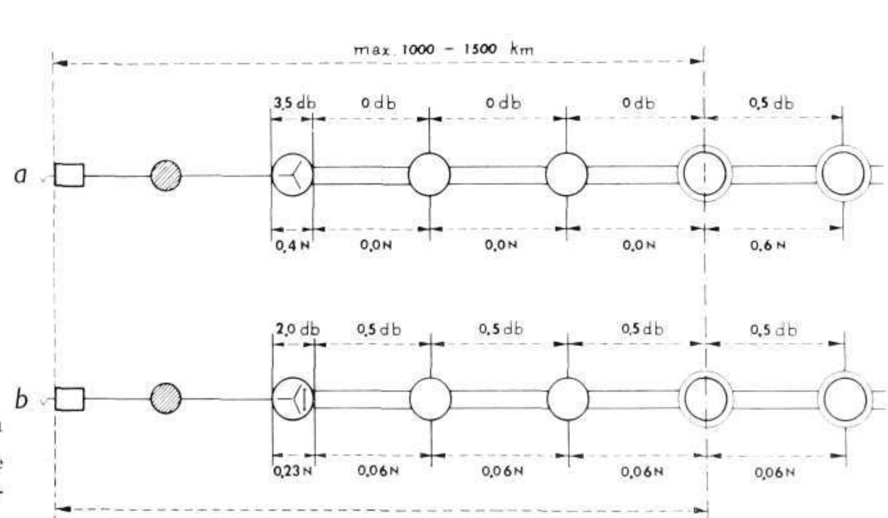


**Fig. 2** X 8401

***a* and *b* represent different alternatives for the distribution of overall loss in the national network of a medium-sized country**

may with 1 % probability exceed the nominal by 6.9 db. In the same way there may be a positive gain on the 4-wire section which under conditions of mismatch on the 2-wire sides will result in instability. With manual service the operator can decide whether the transmission is acceptable or whether another circuit must be chosen. With automatic service the subscribers themselves must decide whether the circuit is satisfactory. They must become accustomed to making a new attempt in the same way as is now done on national calls if no connection is obtained.

The transmission conditions should have no particular consequences for automatic traffic in other respects. The signalling problems, however, are intimately associated with the transmission technique.

## Signalling System

C.C.I.T.T. has standardized two different signalling systems for automatic traffic, one operating with a single frequency, "the one-frequency system", the other with two frequencies, "the two-frequency system". Both systems may be used for terminal traffic, whereas the two-frequency system is standardized for tandem traffic. For terminal traffic the sending country decides which signalling system shall be employed. This recommendation is obviously possible if the lines are one-way, which at present is the case. In the future, however, we shall probably have two-way circuits as well. For this case a new recommendation is necessary.

A distinction is made in both systems between line signals (supervisory signals) and numerical signals.

### *The One-frequency System*

This system operates with a single frequency of 2,280 ± 6 c/s. The signal level is − 6 ± 1 dbm. To avoid disturbance on national networks the system must be designed for a splitting time of at most 35 ms, i.e. no fraction of a signal exceeding 35 ms may pass out of the international circuit.

The line signals are shown in Table 1.

**Table 1. 1 V.F. System signal code.**

Line signals

| List No. | Name of signal | 1 V.F. System |
|---|---|---|
| | FORWARD SIGNALS | |
| 1 | a) Terminal seizing signal | X |
| | b) Transit seizing signal | XX |
| 3 | Numerical signals | Arhythmic code |
| 4 | End-of-pulsing signal | Arhythmic code |
| 9 | Clear-forward signal | XXSXX |
| 12 | Forward-transfer signal | XSX |
| | BACKWARD SIGNALS | |
| 2 | Proceed-to-send signal | X |
| 5 | Number-received signal | X |
| 6 | Busy-flash signal | XX |
| 7 | Answer signal | XSX |
| 8 | Clear-back signal | XX |
| 10 | Release-guard signal | XXSXX |
| 11 | Blocking signal* | Continuous |

*The maintenance instructions given to the maintenance staff stipulate that a circuit may only be blocked for a limited period.

The elements of each of the voice-frequency line signals shown in Table 1 have a duration of:

X $150 \pm 30$ ms
XX $600 \pm 120$ ms
S $100 \pm 20$ ms

The numerical signal code is shown in Table 2. This code is a binary code of four elements, each element being constituted by either the presence or the absence of the line-signal. These elements must follow each other within a fixed period; this period is marked by a start element (frequency present) and a stop element (frequency absent) between which the 4 characteristic elements of the numerical signals are sent.

The code is in all ways similar to the arhythmic code used for telegraph transmission and differs from it only by its lower modulation rate and by the fact that it consists of only 4 elements instead of the 5 used in telegraphy.

**Table 2. Arhythmic code signals of the 1 V.F. system.**

| Arithmetic value of the marking relays energised | | 8 | 4 | 2 | 1 | |
|---|---|---|---|---|---|---|
| Figure | Start | Moments | | | | Stop |
| | | 1 | 2 | 3 | 4 | |
| 1 ..... | — | | | | — | |
| 2 ..... | — | | | — | | |
| 3 ..... | — | | | — | — | |
| 4 ..... | — | | — | | | |
| 5 ..... | — | | — | | — | |
| 6 ..... | — | | — | — | | |
| 7 ..... | — | | — | — | — | |
| 8 ..... | — | — | | | | |
| 9 ..... | — | — | | | — | |
| Digit 0 (10) ..... | — | — | | — | | |
| 0 | 50 | 100 | 150 | 200 | 250 | 300 |
| | | | | | | Milliseconds |

*Note.* The relation between the transmitted digits and the different combinations of the arhythmic code is arrived at by giving the value of 8, 4, 2 or 1 to the presence of a positive signal element depending on the moment No. 1, 2, 3 or 4 of the signal in which it occurs.

## *The Two-frequency System*

The signal frequencies in this system are

$2{,}040 \pm 6$ c/s (the x-frequency)
$2{,}400 \pm 6$ c/s (the y-frequency)

these frequencies being applied separately or in combination. Each frequency has a level of $-9 \pm 1$ dbm. When they are sent in combination they must not differ in level by more than 0.5 db.

The splitting time may be at most 55 ms.

The line signals are shown in Table 3.

**Table 3. 2 V.F. system signal code.**

Line signals

| List No. | Name of signal | 2 V.F. System |
|---|---|---|
| | FORWARD SIGNALS | |
| 1 | a) Terminal seizing signal .................... | PX |
| | b) Transit seizing signal ...................... | PY |
| 3 | Numerical signals ............................ | Binary code |
| 4 | End-of-pulsing signal ........................ | Binary code |
| 9 | Clear-forward signal .......................... | PXX |
| 12 | Forward-transfer signal ...................... | PYY |
| | BACKWARD SIGNALS | |
| 2 | Proceed-to-send a) Terminal .................. | X |
| | b) International transit......... | Y |
| 5 | Number-received signal ...................... | P |
| 6 | Busy-flash signal.............................. | PX |
| 7 | Answer signal ................................ | PY |
| 8 | Clear-back signal ............................ | PX |
| 10 | Release-guard signal .......................... | PYY |
| 11 | Blocking signal* .............................. | PX |
| — | (Unblocking) = use of signal 10 .............. | PYY |

*In addition to the blocking which is provoked by the reception of a blocking signal at the outgoing end of a circuit, the outgoing equipment should be such that a temporary condition of "circuit busied" should result at the outgoing end on receiving, on a free circuit, one or other of the frequencies X or Y or both these frequencies. This condition should be maintained for as long as the frequency or frequencies are received. The maintenance instructions given to the maintenance staff stipulate that such an occupation of a circuit should be of short duration.

The elements of each of the voice-frequency line signals shown in Table 3 have a duration of:

| | |
|---|---|
| P | 150 ± 30 ms |
| X and Y | 100 ± 20 ms |
| XX and YY | 350 ± 70 ms |

The numerical code is given in Table 4.

**Table 4. Binary code of the 2 V.F. system.**

| Figure | Combinations | | | |
|---|---|---|---|---|
| | Elements | | | |
| | 1 | 2 | 3 | 4 |
| 1 ........... | y | y | y | x |
| 2 ........... | y | y | x | y |
| 3 ........... | y | y | x | x |
| 4 ........... | y | x | y | y |
| 5 ........... | y | x | y | x |
| 6 ........... | y | x | x | y |
| 7 ........... | y | x | x | x |
| 8 ........... | x | y | y | y |
| 9 ........... | x | y | y | x |
| Digit 0 (10) ........... | x | y | x | y |

The relation between the transmitted digits and the different combinations of the binary code is arrived at by giving the value 8, 4, 2 or 1 to the presence of an element X depending on whether this element X constitutes the 1st, 2nd, 3rd or 4th element of the numerical code.

The symbols used in Table 4 have the following significance:

x short element of the single frequency x
y short element of the single frequency y
s short element of silence

The sending duration of the interval of silence $s$ between signal elements of the same digit shall have the value of 35 ± 7 ms.

The code is a binary code of four elements each separated from the next by an interval of silence; each element consists of the sending of one or the other of the signalling frequencies.

The two-frequency system also includes acknowledgement signals which are sent back from incoming international and transit exchanges. They are sent immediately after reception of the fourth element in the numerical signal, in the form of an $x$-signal from an incoming international exchange and a $y$-signal from an international transit exchange.

In Europe the intention is to use end-to-end signalling, i.e. signalling from a register in the sending international exchange to registers in the transit exchanges and on to the international exchange in the receiving country without repetition at intermediate points. This applies likewise to the supervisory signals. It may be expected that connections across Europe, using three international circuits, may very occasionally lead to rather too difficult conditions for the signal receivers at the ends of the international chain. In these rare cases, the intention is that the subscriber shall re-dial as he does on other connections when a technical fault is encountered.

The one- and two-frequency systems both represent fairly conservative solutions of the signalling problem. The receivers for the supervisory signals, which are associated with the junction circuits, serve at the same time as receivers for the numerical signals. In more modern systems use is often made of multi-frequency receivers for the numerical signals, associated with a register or marker. On the initiative of the Dutch P.T.T. the introduction of a system of this kind has been discussed outside the C.C.I.T.T. Several administrations, especially within the Community of Six, have shown an interest in such a system, and systems of this kind are used to some extent for terminal traffic between neighbouring countries.

Any two administrations are, of course, free to agree on any signalling system for the terminal traffic between their countries. This is particularly common in the cases of traffic between neighbouring areas on the two sides of a frontier. As a matter of fact the bulk of the international traffic is handled on a simplified signalling system, i.e. with one-frequency signalling and dial type pulses (see Green Book Vol. V, pages 39–40).

## Dialling and Numbering Schemes

The question of dialling and numbering schemes is one which involves technical as well as human factors. It is therefore related both to the equipment and to the subscriber.

The basis of the numbering scheme is, of course, the subscriber's national number. The subscriber's number is usually composed of two parts, a local number which is dialled within the local area and a trunk code signifying the local area in which the subscriber has his telephone. There is also a trunk prefix which is used when the subscriber wishes to ring a subscriber within another local area. Take, for example, the national number of a subscriber in Düsseldorf:

Trunk prefix
Trunk code
Local number
0 211 123456

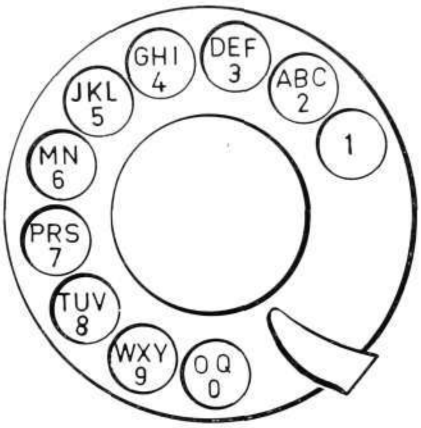


**Fig. 3** X 2681

**Dial for European operators on semi-automatic international service**

The European countries are furthermore allotted individual two-digit numbers as follows:

20 Poland
21 Algeria
22 Belgium
23 Austria
24 –
25 Finland
26 Arabia
27 Cyprus
28 Bulgaria
29 Gibraltar
30 Greece
31 Egypt (United Arab Republic)
32 –
33 France
34 Israel
35 Hungary
36 Turkey
37 Lebanon
38 Norway
39 Italy
40 Libya
41 Jordan
42 Portugal
43 Malta
44 Great Britain
45 –
46 Sweden
47 Rumania
48 Morocco
49 Germany
50 Spain
51 –
52 Ireland
53 –
54 Syria
55 the Netherlands
56 –
57 Czechoslovakia
58 –
59 Albania
60 Luxemburg
61 Denmark
62 Tunisia
63 Yugoslavia
64 Iceland
65 –
66 Switzerland
67 –
68 and 69, 70 to 79 } U.S.S.R. (European Republics)
80 to 89 { Spare codes (in addition to codes 24, 32, 45, 51, 53, 56, 58, 65, 67)
90 to 99 Intercontinental traffic

In the same way as for national trunk traffic, a complete number requires also an international prefix indicating that the call is to a subscriber in another country. The complete number of the Düsseldorf subscriber when called from Italy, for example, will be

00 49 0211 123456

in which 00 is the international prefix and 49 the code number for Germany. To call from the Netherlands to a subscriber in Stockholm, the number will be

09 46 08 707189

09 being the international prefix in the Netherlands and 46 the code number for Sweden.

In the examples chosen, which are typical, the subscribers have to dial 13–14 digits. This is quite a large number—but unavoidable—and naturally leads to more dialling errors than with the shorter national numbers. The numbering scheme is logically constructed, but even so it is difficult for a subscriber to remember how far he has got in the long series of digits he has to dial. The introduction of a dial tone after the national code, for example, would possibly be a help to the subscriber.

It may seem unnecessary to include the trunk prefix in the numbering scheme. But for the receiving country the trunk prefix indicates that the call is subscriber-dialled. If any other digit comes, one knows that the call emanates from an operator and the digit indicates the language spoken by the operator, so that in case of necessity she can be connected to an operator speaking the same language. It would, of course, be possible to let the equipment in the sending country generate the extra digit automatically, since the equipment knows that the call comes from a subscriber. But business organizations are likely to indicate on their letter headings the entire national number including the trunk prefix. Telephone directories likewise indicate the area code and trunk prefix on each page.

At a meeting of C.C.I.T.T. study groups in Montreal in the summer of 1962, the question of numbering schemes was discussed with reference to the need which may soon arise for intercontinental automatic traffic. The international numbering schemes will be altered to permit intercontinental traffic. Countries or groups of countries will have one-, two- or three-digit national codes. To save digits, the trunk prefix will be eliminated from the international number, which will be "all numeral". Subscribers will be requested to print their international number as well as national number in letter headings etc. The international number will comprise the national code, trunk code and local number and will be a closed number consisting of max. 11 (exceptionally 12) digits. Letters, where employed, will be translated into the corresponding digits. Subscribers will naturally dial the international prefix before the international number.

An especial difficulty is presented by trunk codes and exchange codes in letter form as used in some countries, e.g. Britain and France. Instead of having the entire number in digit form, they employ letters for the codes, representing an abbreviation of some geographical name associated with the area in question. From investigations made in the United States, these letter codes have no advantage even for the national subscribers. The number is not easier to remember, and dialling errors are no fewer. For a subscriber in a foreign country who has no letters on his dial, the procedure is naturally troublesome. It is to be hoped, therefore, that letter codes will be successively abolished. At all events the corresponding digits should be indicated at the same time.

In order that letter codes shall not render international automatic traffic impossible, there must be a definite relationship between letters and digits. For semi-automatic international operators in Europe, C.C.I.T.T. recommends a dial as shown in fig. 3. No recommendation has yet been made for subscribers' dials.

## Signal Tones to the Subscriber

When a subscriber rings a subscriber in a foreign country, he should receive information of the condition of the called subscriber's line by means of tones in the same way as on a call within his own country. The tones in question are ringing tone, busy tone and special information tone. On the basis of practice in Europe, C.C.I.T.T. has agreed on a recommendation as follows:

*Ringing tone* is a slow period tone in which the tone period is shorter than the silent period. The recommended limits for the tone period are from 0.67 to 1.5 seconds, for the silent period 3 to 5 seconds. The frequency for ringing tone should be between 400 and 450 c/s.

*Busy tone* is a quick period tone in which the tone period is roughly equal to the silent period. The total duration of a cycle (tone period + silent period) should be between 300 and 1,100 ms. The ratio of the tone period to the silent period should be between 0.67 and 1.5.

The frequency for busy tone should be between 400 and 450 c/s. The fairly wide limits for the busy tone permit the use of two busy tones, one for subscriber busy and one, if required, to indicate trunk busy.

*Special information tone* is a standardized international tone universally comprehensible and designed to invite the calling subscriber to get in touch with an operator in his country to obtain assistance when abnormal conditions are encountered which caused the tone to be given. The tone period consists of three successive tone signals, each lasting for $330 \pm 70$ ms. These are followed by a silent period of $1{,}000 \pm 250$ ms. The frequencies used for the three tone signals are $950 \pm 50$ c/s, $1{,}400 \pm 50$ c/s, $1{,}800 \pm 50$ c/s.

All tones shall have a level of $-10$ dbm at a zero relative level point.

## Accounting

As already mentioned, there has been much discussion of the question of accounting for international calls. The aim has been to establish the same method of accounting as for national long distance calls. In most cases international calls are not made over longer distances than national trunk calls. Since the method of operation is the same in both cases, it should be possible to adopt the same tariffs, i.e. based on distance and duration of individual calls.

Automatic accounting requires agreement between the countries concerned on the tariffs to be adopted. This may obviously cause problems for countries with very different levels of trunk tariffs. The tariffs should not differ too much from those for trunk calls over comparable distances in the respective countries. Nor should a country charge different tariffs for calls to different countries at comparable distances. Clearly the international subscriber-dialled traffic in Europe will indirectly have an equalizing effect on national tariffs. At the same time any taxation of trunk calls would become more difficult.

A special difficulty has been that countries have different accounting systems. The predominant method is to use subscriber's meters. But there are two main types of metering, one based on one pulse at a time, the pulse frequency being proportional to the distance, and the other based on a given number of pulses proportional to the distance at the beginning of every 3-minute period. The former type is preferable, of course, since the subscriber pays more exactly according to the duration of the call. It is to be feared, therefore, that traffic between two countries with these different systems will be distorted, with a preponderance of outgoing traffic from the country which employs the former method of charging. C.C.I.T.T. has been aware of this possibility and has therefore adopted a recommendation to the effect that charging shall be either per minute or by means of periodic singular pulses.

A minority of countries have equipment for automatic printing of tickets for long distance calls. There is, of course, nothing to prevent their use on international calls, even if the majority of receiving countries employ subscribers' meters.

For the very long connections across Europe the tariffs will be so high, at least for some years to come, that it is doubtful whether they can be satisfactorily charged on subscriber's meters. The pulse frequency may be so high that calls are disturbed by the pulses if transmitted on the speaking circuits. Another difficulty is that subscribers may wish for a cost specification for these expensive calls.

## Maintenance Questions

In an automatic network the subscribers' instruments, lines and exchanges together form a system of extraordinary complexity. All parts need not operate to perfection in order for the system to fulfil its function—this would, moreover, place altogether unreasonable demands on their reliability. When a fault occurs in a switching unit, there is always the possibility of using another unit with the same function. This is true in respect of circuits as well as of switching equipment. (The subscriber's telephone and line alone are generally not redundant.) But a subscriber cannot himself influence the selection of equipment for the call he initiates. If he cannot get through, or if the transmission is unsatisfactory, he must make a new call. In such case he usually finds another path to the called number, using other switches or circuits. The job of the maintenance services is to maintain telephones, lines and exchanges in such condition that subscribers obtain satisfactory connections except on very few occasions. How far one should go in this respect is dependent on many factors and is a problem of service versus cost. From the point of view of the national economy, an increased cost of maintenance is paid for by the better service given to subscribers. The subscriber's time must be evaluated in terms of the time lost on unsuccessful calls and of the irritation to which he is exposed. The latter at least is difficult to estimate. In some cases the subscriber's loss of time is very noticeable, i.e. when the transmission is so poor that he has constantly to ask for a message to be repeated, which also involves having to pay for a longer call. In their own interest, and in the interest of the administration as well, subscribers should be trained to place new calls in such cases.

*International subscriber-dialled traffic* introduces certain factors which may be expected to affect the public.

1. International connections may perhaps not be longer than many national ones, but the international connection will probably contain, on an average, a greater number of circuits. This increases the risk of poor transmission.

2. The subscriber will be more sensitive to bad transmission when using a foreign language.

3. At least in the next few years international calls will be used, on an average, for more important communication requirements than national calls.

4. International calls will, to start with, be more expensive than national calls over the same distance.

On the other hand subscribers may have some understanding for the fact that, on an international call, they are making use of larger parts of a complicated machine and that the defects of the machine are therefore more likely to be felt.

To summarize, one may justifiably say that international subscriber-dialled traffic will place greater demands on the quality of service than national traffic. But since the bulk of the equipment employed on international calls belongs to the national networks, we shall have to bring national networks up to the standard required for international traffic.

An analysis of trunk traffic conditions shows that the switching equipments can be designed for an adequate quality of service. Administrations which devote thought and care to their maintenance have generally no difficulty in ensuring that their switching equipments are operating efficiently. Maintenance technique has been systematically studied and has reached a high level. The situation is not quite so satisfactory, however, on the transmission side.

A large number of trunk circuits have been in operation for a long time and suffer from manifest defects. They exhibit a wide spread in their transmission data. Sudden variations of attenuation and interruptions of up to half a second are not uncommon. These defects have been rectified in the more recent carrier systems, but for many years to come there will be a large number of circuits in national networks which are not fully satisfactory. Likewise the maintenance technique is not so fully developed in respect of trunk circuits.

In the manual and semi-automatic services some assistance is obtainable from the operator, who can make sure that a call has arrived at its proper destination and can also check the transmission. If the conditions are unsatisfactory the operator can hold the connection and report the fault to the maintenance service. With subscriber-dialled traffic, compiaints from subscribers are of little value, not only because they are seldom notified and are usually vague, but particularly because the faulty connection is cleared when the subscriber replaces his handset.

C.C.I.T.T. has devoted and is still devoting considerable attention to questions of maintenance. Recommendations have been issued concerning organization and procedure. But much still remains to be done. The following points in particular should be borne in mind.

Equipment for rapid automatic through-testing of entire routes or individual circuits will be necessary. Automatic identification and blocking of unsatisfactory circuits is desirable. Certain organizational changes in maintenance work, based on the fact that automatic international circuits terminate on and are maintained from the multiple field in the switching terminals, are likely to be necessary. Methods and equipment for continuous observation of the *entire* switching and transmission system will undoubtedly be introduced. *Integrated* maintenance, based on uniform principles for the entire telecommunications technique, is gradually evolving. The consequence will be the establishment of special maintenance centres in the international network, from which the traffic conditions can be supervised and controlled.

The proper coordination of international maintenance, however, demands a large measure of teamwork on the part both of individuals and administrations. It will be particularly necessary that the different categories of maintenance personnel have an understanding and knowledge of the other sections of the communications network.

To summarize these remarks on maintenance questions and their solution, it may be foreseen that the automatization of the European network will require

1. A large measure of automatic supervision of routes carrying international traffic, both inside and outside the national networks.

2. A successive automatic quality control of international traffic.

3. A concentration of the necessary supervisory technique to appropriate geographical points from the traffic point of view.

4. A maintenance service organization suited to the foregoing considerations.

## Modification of National Networks for International Automatic Traffic

National transmission equipments will not be affected by the introduction of automatic international traffic; the only changes needed will be in automatic switching equipment.

As already mentioned, an international number will consist of more digits than a national number. The registers in the national systems must therefore be adapted for the reception of all these digits. The alternative is to arrange that special registers with an adequate digital capacity are switched in between two digits. These changes may often be very costly. Administrations may therefore be forced to compromise by introducing a second dial tone after the national code to allow time to switch in an appropriate register.

Another field in which a compromise may be needed is accounting. In some cases the tariff-determining devices cannot accommodate the extra functions required for international calls. At exchanges where international traffic is likely to be small, the administration may decide not to introduce automatic international service. This will probably be the case especially at rural exchanges without any pronounced community of interest with foreign countries.

## Subscribers' Reactions

What is likely to be the reaction of subscribers to the new service offered by the administrations? The main users of this service will be those who have contacts of a lasting character in the foreign country. Business organizations will ring to suppliers and customers in this way, foreign companies will dial calls to their subsidiaries, newspaper correspondents will ring their papers etc. Travellers abroad, on the other hand, will not often use this form of service, owing to their lack of familiarity with the telephone system of the foreign country. Furthermore, it must be supposed that a traveller must pay for his call immediately, which requires the cooperation of an operator. Calls must also be placed with an operator when one does not know the wanted party's number. Language difficulties are not likely to be of any major significance since people who make foreign calls can expect that, even if they do not themselves understand the language of the receiving country, there is somebody at the other end who knows their language. There is always the possibility of calling for an operator's assistance in the event of difficulty.

Introduction of automatic traffic is likely to lead to an increased volume of traffic. This will help in lowering tariffs since there will be no operators, who are especially expensive for this service.

## What has the Future in Store?

European automatic traffic has perhaps been regarded with some scepticism in certain circles. It has been thought that the investments needed in the national systems would hardly be justified. With the growth of integration in Europe, this view will undoubtedly prove to be over-cautious, especially in the highly industrialized countries. The less outward-looking countries may perhaps do right in introducing this service on a more gradual basis, starting with the capital and other large cities in order to gain experience especially of the volume of traffic to be catered for.

The automatization of international traffic will accentuate the tendency towards greater uniformity of telephoning within Europe. The standardized dial has been mentioned. Will there not be coin boxes of roughly the same type in different countries? The arrangement of directories is another field in which uniformity could be introduced.

European subscriber-dialling may also lead to an equalization of national tariffs. Countries with high tariffs will probably have to moderate them in due course.

Automatic telephone traffic in Europe is, of course, a step on the road to the greater goal of automatic traffic throughout the world. As more cables are laid under the oceans and efficient satellite communications become available, there will obviously be a sufficient number of channels to permit on-demand traffic. The technical problems, however, will be acute. Devices such as TASI and echo suppressors place new demands on the signalling systems. Transmission questions likewise will be more difficult when there are more 4-wire links in tandem. Under adverse conditions the overall loss on the chain of 4-wire circuits in the national and international networks will be fairly high owing to the fact that the loss on several of the circuits may be near the tolerable maximum. Maintenance questions as well will, of course, be more difficult. It is also doubtful whether tariffs can be reduced to the point at which subscribers' meters can be used within the foreseeable future.

Still further in the future lies the possibility of obtaining access to a person on his personal number wherever he may be. Everyone would carry with him a small telephone set connected via radio to a telephone exchange. How such a service would be arranged is, of course, not known. Further inventions in the memory and data processing techniques will undoubtedly be necessary, as also in radio technique. One wonders whether this is not a matter of technique for its own sake. People should be entitled to a private life, where they are free from the telephone if they so desire. Whoever must and wishes to be available for telephone calls can indicate his whereabouts through a manual information service or, at a later stage, by automatic re-direction to another telephone.

# Video Amplifying Equipment for Television Program Transmission

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UDC 621.375: 621.397.6
LME 752, 8547

*The spread of television has given rise to the need for transmission facilities capable of handling the very wide band of frequencies of the picture signal. This article describes video amplifying equipment developed by L M Ericsson for cable transmission, intended for local distribution of television pictures.*

*The equipment has been designed for and delivered to the Swedish Board of Telecommunications. The broad lines of the specification have been arrived at by the joint efforts of the Board and of L M Ericsson.*

## Distribution Network

The point of origin of a program where it is fed into the television system is a studio or, for an outside telecast, a sports arena etc. The distribution network conveys the program to the transmitters, which in turn broadcast it to the TV receivers. The distribution network for a television system has a wide scope, since the point of origin and the transmitter may be located anywhere in a country. Links to networks in other countries may make the distribution world-wide.

For distribution of television programs, both radio links and cables are used for transmission. For long-distance cable transmission, carrier systems are used, while for shorter paths (e.g. within an urban network) transmission at video frequencies is advantageous. The equipment described here provides for this latter type of distribution.

The video-frequency local network links up TV transmitters, studios, switching centres etc., to the repeater stations of the long-distance network. Both the long-distance and local networks are usually bidirectional, i.e. programs can be sent in both directions simultaneously. By making circuits reversible a greater flexibility is obtained, making it simpler to meet traffic requirements for the different directions.

The sound channel associated with a TV program is normally transmitted on the distribution network for sound programs: this will not be further described here (see Ericsson Review No 3, 1959).

## Cables

The cables normally used with L M Ericsson's video amplifying equipment contain screened video pairs having a nominal characteristic impedance of 125 ohms (e.g. Sieverts types *EUM 1.2 mm* or *EUM 1.8 mm*). These screened pairs consist of a symmetric pair of copper conductors with cellular polythene insulation, twisted together with two polythene filler cords and enclosed in a double copper screen. The inner screen is made with a straight folded seam: the outer screen is wound spirally over it. Outside this, normal cable protection is provided: the video pairs can be included in larger cables containing for instance coaxial tubes, telephony pairs, music pairs etc. Fig. 1 shows a cable containing four video pairs with 1.2 mm conductor diameter, and fig. 2 shows the characteristic impedance of the same cable as a function of frequency.

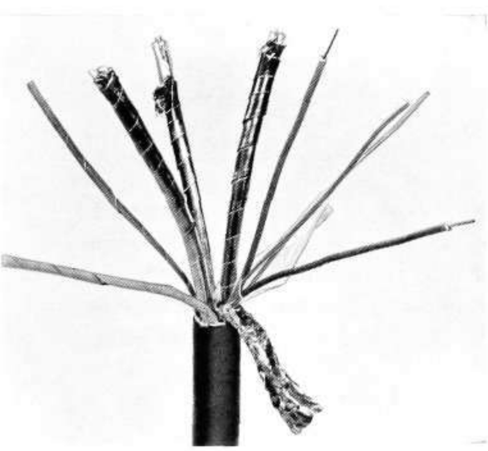


**Fig. 1** X 2687
**Cable with four video pairs**

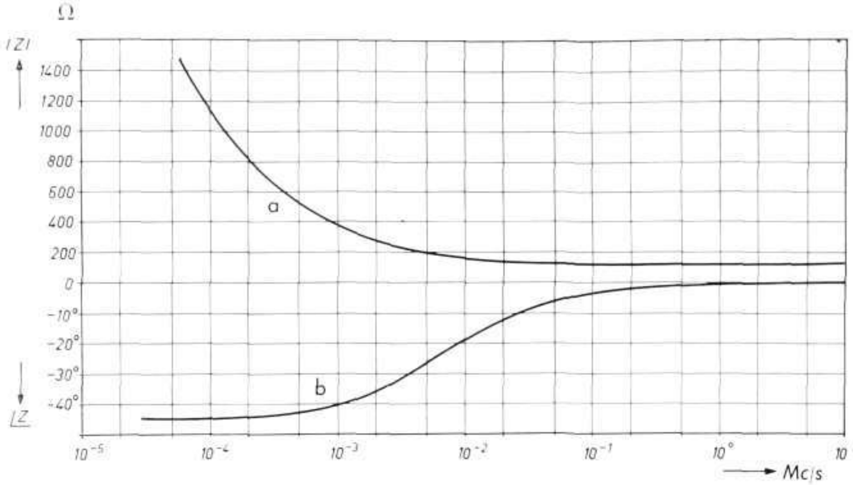



**Fig. 2** X 8406

**Characteristic impedance of a 125-ohm video cable with conductor diameter 1.2 mm**

a. Magnitude
b. Phase angle

The attenuation of these cables at a frequency of 5 Mc/s is about 13.6 db/km for *EUM 1.2 mm* and about 9.1 db/km for *EUM 1.8 mm* at + 20° C. It is also possible to use coaxial cable, e.g. the 2.6/9.5 type recommended by C.C.I.T.T., and this is in fact imperative if the repeater spacing exceeds some 6.5 km, because it can give lower attenuation per kilometer than the pair cables previously mentioned. The best results as regards interference are in this case obtained by using the inner conductors of two tubes as a symmetrical line with an impedance of 2 × 75 ohms. A single tube can be used but usually gives more interference.

## Transmission Requirements

When television picture signals are transmitted, the picture quality must not be appreciably degraded. With this as objective the C.C.I.T.T. (International Telegraph and Telephone Consultative Committee) have established recommendations for television program transmission over a hypothetical circuit of 2 500 km length: this has been chosen as an example of a long-distance international connexion. The C.C.I.T.T. has not set up any recommendations for local networks. Seeing that the recommendations referred to apply to a 2 500 km long international circuit, we can hardly allow the same tolerances to be applied to a circuit for local distribution. As design objective for L M Ericsson's video amplifier equipment, 1/6 of C.C.I.T.T's recommended values have been taken, these limits to be met for up to ten repeater sections in tandem. It would be unrealistic to require 1/10 × 1/6 of C.C.I.T.T's recommended values for each individual repeater section because of the cost involved; nor is it necessary since the deviations of individual sections add statistically. This has been taken account of when setting up the design objectives for the video amplifier equipment.

## Transmission Principles

(Simplified block schematic in fig. 3)

The television signal enters the sending side of the equipment in the standardized form for interconnexion in repeater stations, i.e. impedance 75 ohms unbalanced. It is converted to 125 ohms balanced for matching to the impedance of the video cable, this cable being directly connected to the sending amplifier. At low frequencies the cable screen is not effective against inter-

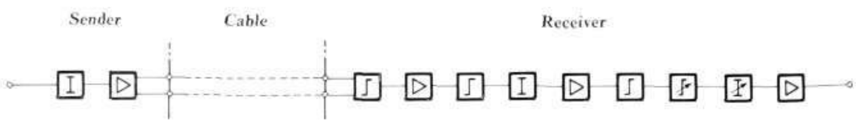



**Fig. 3** X 8407 X 9156

**Simplified block schematic of video amplifier equipment**

Amplifier
Pad
Adjustable pad
Equalizer
Variable equalizer

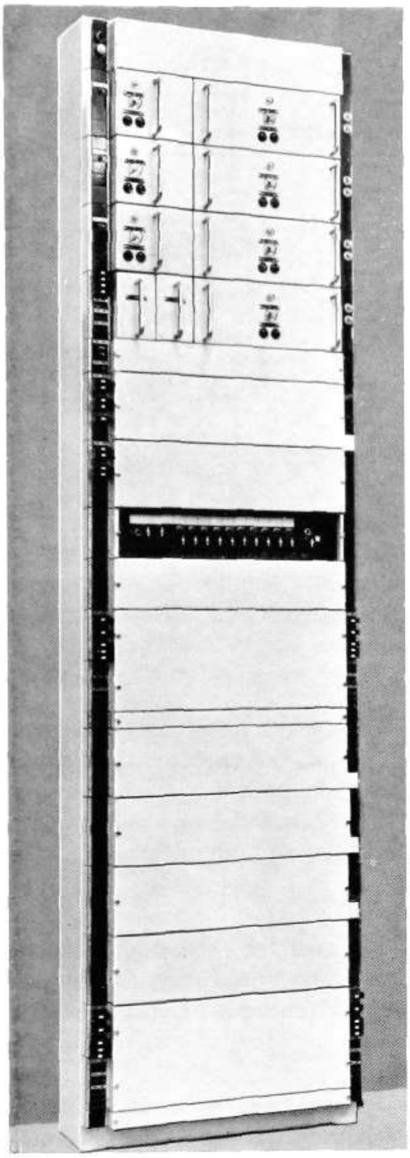


Fig. 4 X 2688
Video amplifier equipment bay

ference from the surroundings (e.g. mains hum) but on the balanced cable the interference is of longitudinal type which is sufficiently suppressed in the input amplifier unit of the receiving equipment.

The receiving equipment which follows the cable comprises a fixed equalizer and thereafter an *input amplifier* with balanced input which provides some gain and also converts the impedance from the 125 ohms balanced of the cable to the 75 ohms unbalanced of the repeater station. The input amplifier is followed by further equalizing networks, pads and amplifiers as shown in fig. 3.

The maximum cable loss which can be compensated by the video amplifier equipment without pre-emphasis is 60 db (cable loss at 5 Mc/s). By appropriate choice between various fixed equalizers, any cable loss between 0 and 60 db can be equalized. For lower values of cable loss it is possible to dispense with one of the amplifiers. By the use of pre-emphasis, up to 66 db cable loss can be compensated.

To permit distribution to several sending video amplifiers, the equipment is provided with a distribution panel which can feed up to nine further bays.

For program monitoring, monitoring amplifiers are built into both sending and receiving sides.

The equipment can be provided with a reversal device for reversing the direction of program transmission.

## Construction

The video amplifier equipment is mounted in a bay as shown in fig. 4. The bays carry units on one side only, so that if so desired they can be placed back to back or directly against a wall. A bay can contain one set each of sending and receiving equipment, but may of course be partially equipped with, for instance, receiving equipment only.

All units are connected to the bay cabling by plug-in connexions. Special coaxial U-links are used for connecting the units to the high frequency cables.

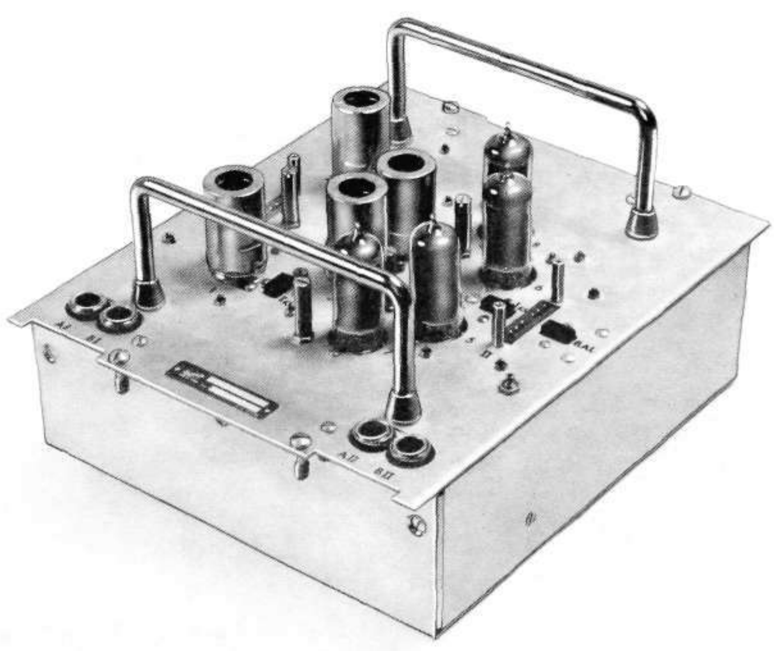


Fig. 5 X 8408
Video amplifier

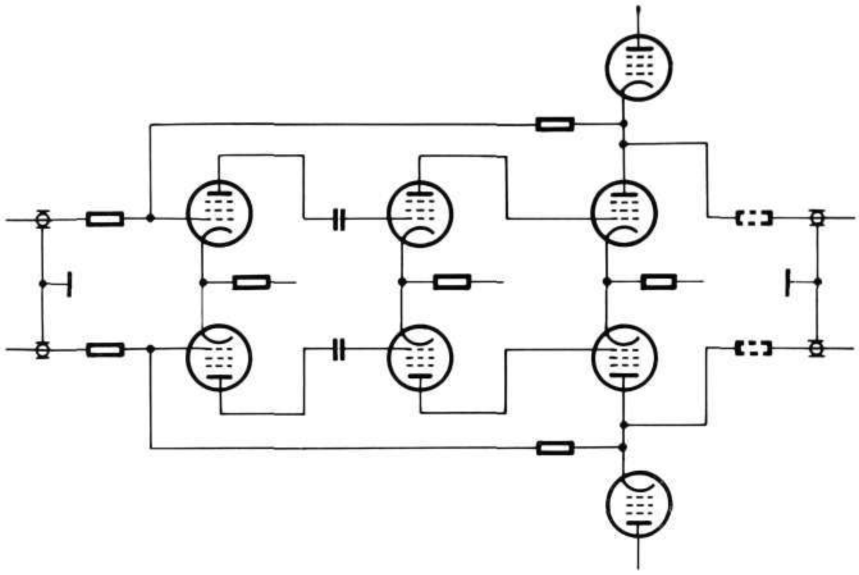


Fig. 6 X 8416
Block schematic of video amplifier

## Video Amplifiers

The video amplifiers are of two types, one having unbalanced input and output, and the other having either balanced input and unbalanced output or vice versa. Changeover between the latter two alternatives is made at a connector strip above the amplifier chassis. The electrical and mechanical design of the amplifiers is identical apart from the input and output networks. The mechanical construction can be seen in fig. 5.

Electrically, the amplifier is built as a balanced three-stage amplifier (as shown in fig. 6) with considerable feedback, thereby ensuring that its gain is not significantly affected by changes in tube conductance or power supplies, and that its distortion is very small.

Tube currents and output d.c. balance are measured at small measuring jacks on the amplifier chassis itself. For balancing the output d.c., a potentiometer is included in the grid circuits of the second stage. As indicated, the input and output leads are made with coaxial connexions; and to ensure that the two halves of the amplifier shall be similar as far as possible, great care has been taken to make all connexions symmetrical about the geometrical centre line.

The performance data of the video amplifier are as follows:

| | unbal/unbal | bal/unbal | unbal/bal |
|---|---|---|---|
| Input impedance | 75 ohms | 125/150 ohms | 75 ohms |
| Output impedance | 75 | 75 | 125/150 |
| Gain (flat) | 24 db | 33 db | 25 db |
| Relative suppression of longitudinal signals, at least | | 40 db | |
| Frequency range | | 0.1 c/s—5 Mc/s | |
| Response over the above frequency range, within | | ± 0.1 db | |
| Output level, nominal | | 1 V peak-to-peak | |
| Tubes used | | type *404 A*, quantity 4 | |
| | | type *6761*, quantity 4 | |

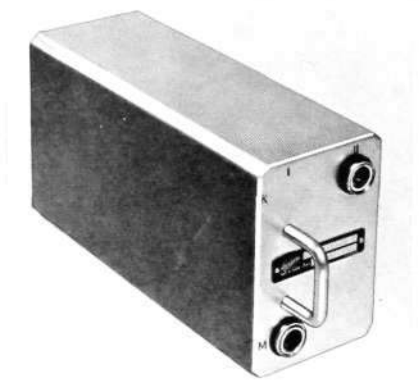


Fig. 7 X 2690
Cable equalizer

The tubes used are long-life types with a guaranteed life of more than 30 000 hours and an expected average life of at least 50 000 hours.

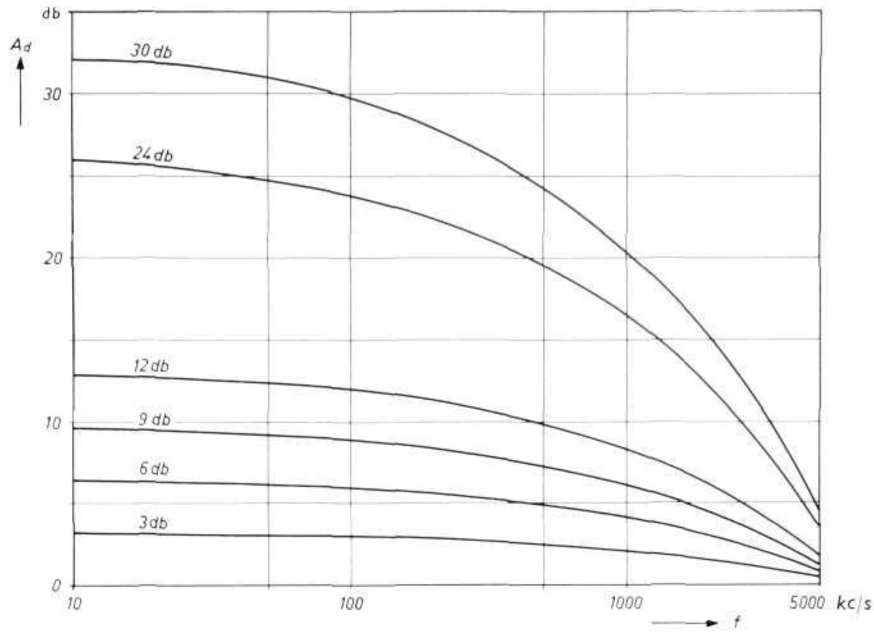



**Fig. 8** X 8409
**Attennation of the fixed cable equalizers**

## Equalizers

For cable equalization, a number of fixed and variable equalizers have been developed: their general external appearance can be seen from fig. 7.

The fixed equalizers are designed in the form of bridged T-networks for equalizing cable losses of 30, 24, 12, 9, 6 and 3 db respectively (cable loss at 5 Mc/s). By selecting combinations of from 1 to 3 of these networks, cable losses between 3 and 60 db can be equalized to within a theoretical accuracy of ± 1.5 db. The 30 db equalizer is made with an impedance of 125 (or 150) ohms balanced, for placing at the receiver input, while the others are made for an impedance of 75 ohms unbalanced. The network attenuation curves and circuit diagram are given in figs. 8 and 9 respectively.

In order to make a still closer equalization of the cable loss, there is an adjustable equalizer, of variable Bode network form, which can theoretically permit equalization to within ± 0.2 db.

The temperature variations which the cable undergoes can affect the frequency response in such a way that the tolerances mentioned would not be met. In order to correct the changes involved by this variation, a manually adjustable temperature equalizer has been provided which can compensate changes in response corresponding to temperature changes up to about ± 15° C. This network is of Bode form: its attenuation is shown in fig. 10.

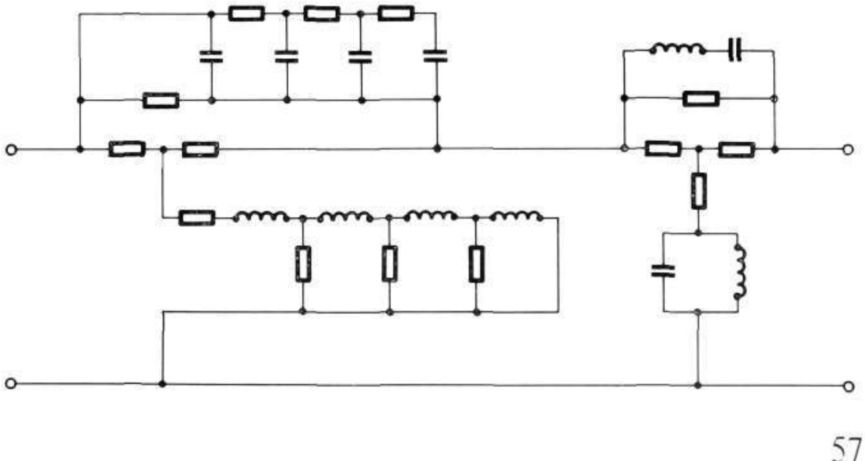


**Fig. 9** X 8417
**Circuit diagram of a cable equalizer**

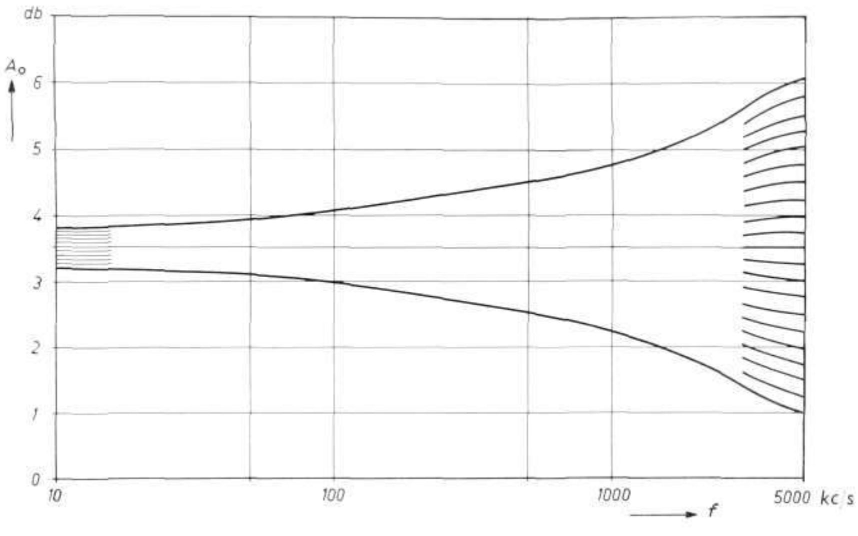



**Fig. 10** X 8410
**Attenuation of the variable equalizer network for compensation of temperature changes**

The fixed cable equalizers are intended to be used with the video pair cable but can also be used with coaxial cable, since this has a similar behaviour as a function of frequency. Any difference in attenuation can be taken into account in the residual equalization for the complete circuit. Even video pair cable may need some residual equalization due to differences between different batches of cable. The networks for this residual equalization form a separate unit.

Adjustment of the receiver output level to its nominal value is effected with the necessary accuracy by means of a plug-in coaxial pad; these pads are available in steps of 0.2 db.

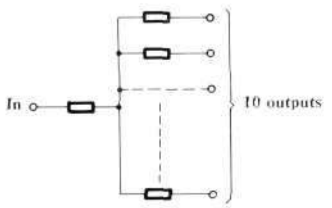



**Fig. 11** X 2692
**Principle of distribution panel**

## Distribution Panel

In order to permit distribution of program to several video sending amplifiers, the bay is provided with a distribution panel. This uses the resistor arrangement shown in fig. 11, which gives a very good return loss. Should it happen that one of the outputs is left unterminated or is short-circuited, the program level in other branches is not affected by more than about 1 db.

## Program Reversal

The transmission direction can be changed by means of a reversing device using mercury-wetted relays; these can be remotely controlled via a control pair included in the video cable. The circuit diagram for reversing is shown in fig. 12.

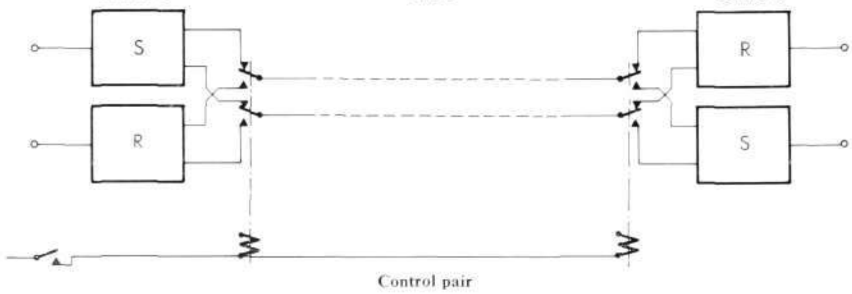



**Fig. 12** X 8426
**Circuit diagram for reversal of direction of program transmission**

S Sender
R Receiver

## Auxiliary Units

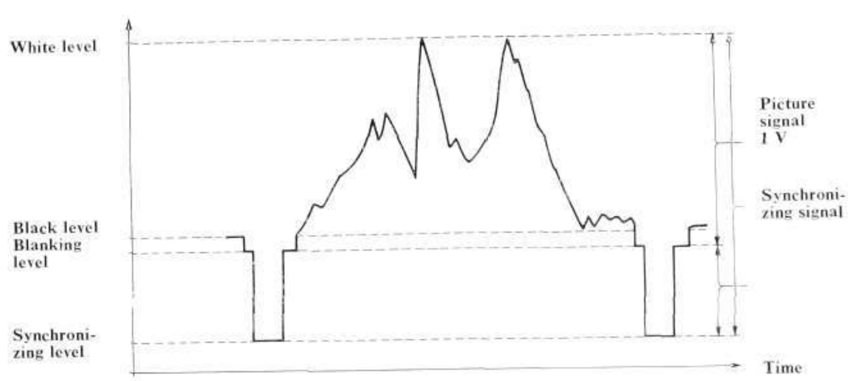
To allow connexion of program monitors, two single stage video amplifiers with high input impedance are provided in the bay, one for the sender and one for the receiver. The nominal output level from these is 1 V peak-to-peak. Level supervision in the bay is provided by checking the amplitude of the line synchronizing pulses, and alarm is given if these are weak or disappear entirely. If a program is received in one bay and sent out in another, the level alarms in the two bays can be interconnected so as to give an automatic indication of whether a fault is already present in the incoming program or has occurred within the repeater station concerned.

A fully equipped bay contains seven mains supply units; four of these supply one amplifier each with anode and heater voltages. The other three supply the remaining units with anode, heater and relay voltages. Alarm units are provided for supervising supply voltages, fuses and signal levels; these indicate two types of alarm, namely urgent alarm if the fault is of a type which can affect program transmission, and non-urgent alarm for other types of fault. These alarms can be extended to a central supervision point.

## Technical Data

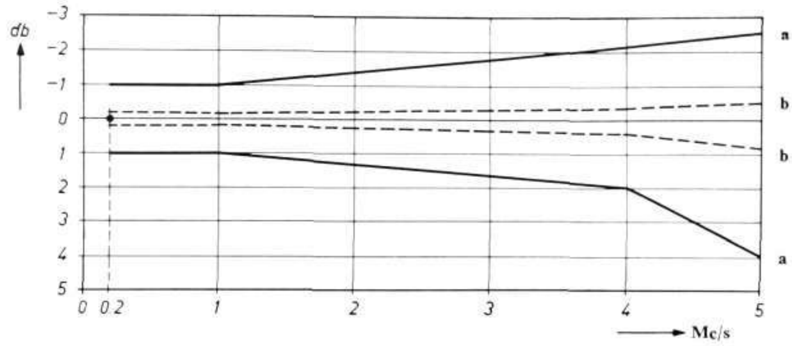
Below is a summary of the more important technical performance data for L M Ericsson's video amplifier equipment, and for comparison C.C.I.T.T. recommendations for an international circuit. The values quoted refer to television circuits for 625 lines with 5 Mc/s bandwidth, as given in Volume III of the Red Book (New Delhi, 1960), Part 3, Section 6.

| *C.C.I.T.T.* | *L M Ericsson* |
|---|---|
| *Impedance* | |
| Input and output impedances in the video-frequency interconnexion points to be 75 ohms unbalanced. | Drop-side — 75 ohms unbalanced<br>Line side —<br>alt. 1 125 ohms balanced<br>alt. 2 2 × 75 ohms unbalanced<br>alt. 3 75 ohms unbalanced |
| *Polarity* | |
| The signal polarity is to be positive, i.e. transition from black to white is in the positive direction (cf. fig. 13). | Drop side — positive<br>Line side — positive |
| *Signal amplitude* | |
| 1 V peak-to-peak at the interconnexion points | 1 V peak-to-peak on drop side |




X 8412

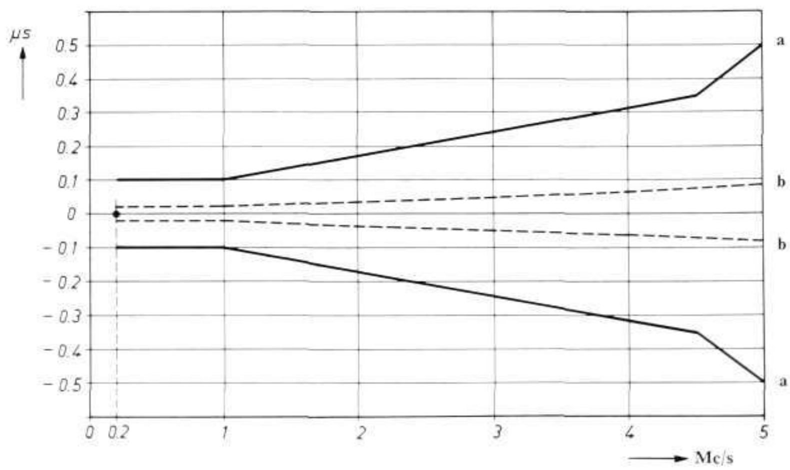
**Fig. 13**
**Characteristics of a television signal**




X 8413

**Fig. 14**
**Attenuation tolerances**
a. C.C.I.T.T.
b. L M Ericsson

| *C.C.I.T.T.* | *L M Ericsson* |
|---|---|
| *Insertion gain variations* | |
| Short-period (1 second) $\leq \pm 0.3$ db | $\leq \pm 0.1$ db |
| Medium-period (1 hour) $\leq \pm 1.0$ db | $\leq \pm 0.2$ db |
| *Noise* | |
| For *continuous random noise:* ratio of peak signal to r.m.s. weighted noise, $\geq 52$ db<br>(Weighting in accordance with C.C.I.T.T. weighting network) | Weighted thermal noise —<br>— for 60 db cable loss, 59 db<br>— for 50 " " " 65 db<br>— for 40 " " " $> 70$ db |
| For *periodic noise*<br>Signal/noise ratio for power-supply hum (fundamental and lower harmonics) $\geq 30$ db | Hum modulation + direct hum after 10 repeater sections $\geq 55$ db |
| *Non-linearity distortion* | |
| Measured for high frequencies using C.C.I.T.T. test signal No. 3 | After 10 repeater sections |
| $\frac{m_a}{M_a} \geq 0.8 \qquad \frac{m_b}{M_b} \geq 0.8$ | $\frac{m_a}{M_a} \geq 0.96 \qquad \frac{m_b}{M_b} \geq 0.96$ |
| where *a* and *b* refer to signals with black and white picture content respectively. | |




X 8414

**Fig. 15**
**Group delay distortion tolerances**
a. C.C.I.T.T.
b. L M Ericsson

| *C.C.I.T.T.* | *L M Ericsson* |
|---|---|
| *Attenuation/frequency characteristic* | |
| The response curve must lie within the limits shown in fig. 14 | Relative to 200 kc/s reference frequency, tolerances are:<br>200 kc/s — 1 Mc/s ± 0.2 db<br>at 4 Mc/s ≤ ± 0.4 db<br>at 5 Mc/s + 0.8 db, ≤ − 0.48 db<br>(see fig. 14) |
| *Envelope-delay/frequency characteristic* | |
| Delay relative to that at 200 kc/s reference frequency must lie within the limits given in fig. 15 | Delay limits relative to 200 kc/s:<br>200 kc/s — 1 Mc/s ± 0.02 μs<br>at 4.5 Mc/s ≤ ± 0.06 μs<br>at 5 Mc/s ≤ ± 0.08 μs<br>(see fig. 15) |

*Power supply*

| | |
|---|---|
| Mains voltage | 220, 110 or 127 volts ± 2 % |
| Mains frequency | 45 — 65 c/s |

*Bay dimensions*

| | | |
|---|---|---|
| Height | 2 451 mm | (8′ 1/2″) |
| Width | 670 mm | (2′ 2 3/8″) |
| Depth | 236 mm | (9 1/4″) |

# Automatic Transmission Measuring Equipment for Telephone Circuits
## 1. Equipment Description

P CARLSTRÖM, TELEFONAKTIEBOLAGET LM ERICSSON, STOCKHOLM

UDC 621.317.74: 621.395.73
LME 7121

*An equipment developed by Telefonaktiebolaget L M Ericsson for measuring the transmission characteristics of automatic telephone circuits is described. The equipment permits the control of measurements within a network from a central point. For automatic measurements punched cards are used both for control of the measurements and for recording the results. Manual measurements are controlled from a keyset and the results are displayed on a lamp panel. The article is based on a paper presented at the Meeting of Norwegian Telephone Engineers at Lillehammer on May 27, 1962.*

The introduction of direct distance dialling involves new methods for the use of long distance circuits.

With manual working, direct trunks are employed as far as possible. Direct distance dialling, with rapid signalling methods and rapid switching systems, increases the use of transit switching. Under alternative routing arrangements, calls between two exchanges may pass through entirely different kinds of transmission system. In order that differences in the quality of transmission shall not be too noticeable to subscribers, the overall loss of the circuits must be the lowest possible consistent with echo and stability requirements. Such highly qualified utilization of the circuits increases the need for circuit supervision and for control of circuit characteristics by measurements.

The greater volume of work created by the increasing number of trunks, and by the more comprehensive series of measurements required, calls for mechanization of the measuring operations. With the present methods of manual testing, the circuits must be taken out of service for a fairly long time and personnel must be employed simultaneously at the two terminals, which causes many organizational problems, at the same time as part of the traffic capacity of the network is lost. With a mechanical procedure the work can well be done at nighttime when there is little traffic. Normally it is only noise which must be checked during heavy traffic periods. If the normal switching equipment is used for the test connections, the risk of introducing circuit faults by taking circuits out of service for testing is eliminated; the circuit is in the same condition after as before testing.

Since one wishes to know the characteristics not only of the individual circuit but also of a group of circuits (the mean equivalent and its standard deviation), the test programme should be readily variable and the results should be presented in a form adapted for statistical analysis.

The equipment described below is used for automatic measurement of the transmission characteristics of telephone circuits.

A telephone circuit is to be tested between exchanges *A* and *B* (fig. 1). The measuring equipment consists of units *A* and *B*, which allow measurement of the equivalent at 800, 400 and 2 800 c/s, as well as the measurement of noise.

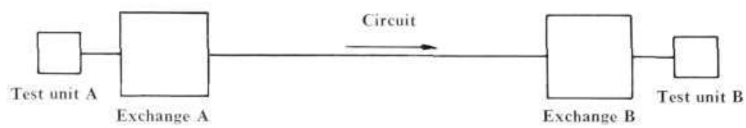



**Fig. 1** X 8398

**Test units A and B check the transmission characteristics of the circuit between exchanges A and B.**

The measurements is controlled from test unit *A*. For connection of the individual trunks to be tested, use is made either of the normal switching equipment of the exchange or of special test selectors. Use of the normal switching equipment is to be preferred since the line signalling equipments, circuits for signalling over the speech paths within the exchange, pads, hybrid units etc. associated with the trunk and affecting its transmission characteristics, are then included in the test.

The trunk is connected to the controlled equipment, unit *B*, via the normal switching paths in exchange *B*. For setting up and taking down this connection, use is made of the normal line and register signals for the circuit. One thus obtains a functional test of the circuit at the same time as it is set up for measurement of transmission.

## Procedure

The measurements are carried out on a 2-wire basis. For measurement of the equivalent, one end of the circuit is fed for 3 seconds from one of three generators supplying zero level and having the frequencies 800, 400 and 2 800 c/s. The signal level reaching the other end of the circuit is measured and gives a direct indication of the circuit equivalent. The signal indicator relay of the level measuring set operates when the level of the incoming signal exceeds — 2.99 N at the reference point (fig. 2). For lower levels the relay releases. During the measurement the incoming test tone is attenuated by the successive switching-in of pads until the level at the reference point is — 2.99 N. The level of the incoming test tone is then the inserted loss less 2.99 N.

The switching-in of pads is controlled from the signal indicator relay in the level measuring set; the process is shown in fig. 3. The switching is effected in 14 steps. The loss inserted in any given step is dependent on whether the signal indicator relay is operated or released. The first step in the measure-

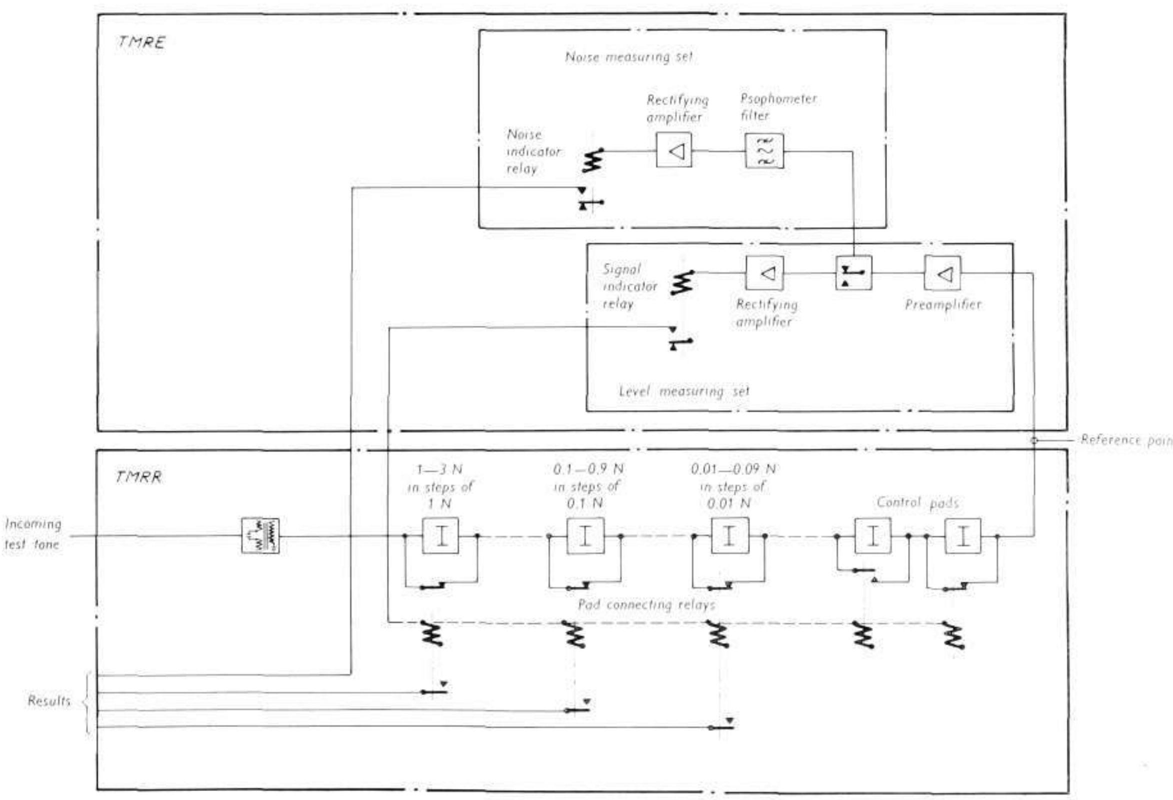



**Fig. 2** X 7862

**The equipment measures the circuit equivalent and circuit noise.**

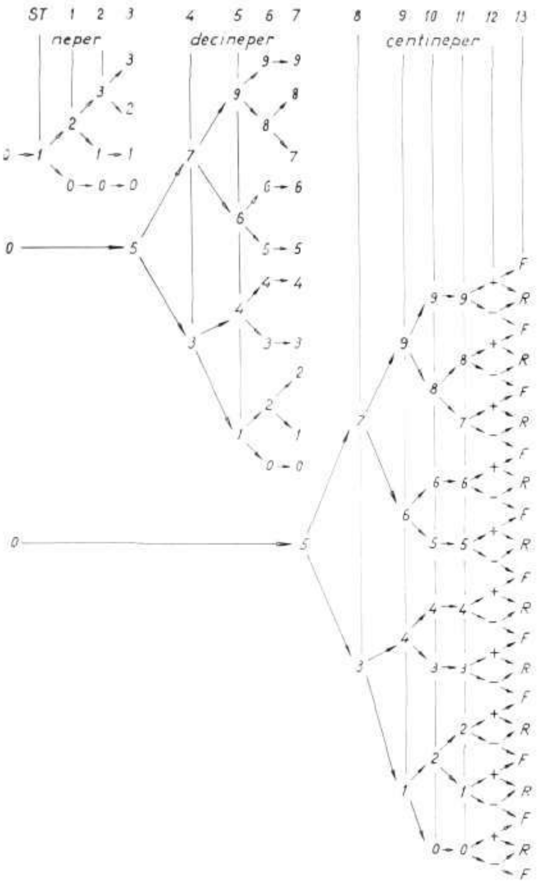



**Fig. 3** X 2378

**The equivalent is evaluated by the successive switching-in of pads**

The figures at the top indicate the relays in the chain. The arrows point to the loss inserted in the next step. Their slope indicates the condition of the signal indicator.

↗ Signal indicator operated
↘ " " released

\+ and — A loss introduced (+) or eliminated (—) to decide whether the input level is stable

R Input level stable
F " " unstable

ment is to determine the figure in the neper range, which is done by switching-in a 1 N pad in the *ST* (Start) step. If the signal indicator relay is thereafter still operated (arrow upward), a 2 N pad is switched-in in step *1*. If the relay then releases (arrow downward), the 1 N pad is switched-in again in step *2* and the equipment advances to step *3* for setting of the decineper range, *and so on*.

In step *12* a control pad is switched-in (+) or out (—) to determine whether the level of the test tone is stable or not. In step *11* so great a loss has been inserted that the level at the reference point lies within $-2.99 \pm 0.01$ N. If the signal indicator relay is then operated, the level is rather higher than $-2.99$ N. The switching-in of the 0.06 N control pad in step *12* then brings the level at the reference point well below $-2.99$ N, causing the signal indicator relay to release, *R* in step *13*. If the signal indicator relay is released in step *11*, the level at the reference point is rather below $-2.99$ N. The switching-out of the 0.06 N pad in step *12* then brings the level at the reference point above $-2.99$ N and the signal indicator relay operates, *R* in step *13*. If the relay does not change condition on the switching in or out of the control pad as related above, the level at the reference point in step *11* will be outside $-2.99 \pm 0.06$ N and the input level will have been unstable during the measurement, *F* in step *13*.

The range of the equipment is from $-2.99$ N to $+0.99$ N with accuracy of setting in steps of 1 cN. The accuracy of the generator is better than $\pm 1$ cN. The accuracy of the level measuring set is better than $\pm 2$ cN at 800 c/s and better than $\pm 4$ cN at 400 and 2 800 c/s.

The object of the noise measurement is to determine whether the noise exceeds a preset threshold value or not. The noise is evaluated as the root mean square value of the psophometrically weighted noise voltage during a period of 5 seconds. If the noise exceeds the threshold value, the noise indicator relay operates to indicate that the noise on the circuit is too high. The noise threshold can be strapped to —4 N, —5 N or —6 N referred to 0.775 V and cannot be made dependent on the nominal or measured equivalent of the circuit.

For noise measurement the circuit is terminated with 600 ohms.

## Control and Recording of Results

The circuit to be measured is connected between the selector stages in exchanges *A* and *B*, which are assumed to be marker-controlled crossbar exchanges in a register-controlled network (fig. 4).

The controlling test set *A* is terminated on an inlet in the switching network at exchange *A* via which it can be switched to every outgoing (and two-way) circuit. For connection to a circuit, use is made of an individual number specific to the circuit.

The controlled test set *B* is terminated on an outlet in the switching network at exchange *B* via which it can be reached from every incoming (and two-way) circuit. One of the special service codes of the exchange is used for connection to the test set.

The tests can be controlled manually or automatically. The programme is fed into the control unit of test set *A*, which controls the setting up of the connection at exchange *A* to the circuit to be tested, the register signals between exchanges *A* and *B* for connecting to test set *B*, the signalling equipment for signalling of the programme to the control unit in test set *B*, the effectuation of the test and the recording of the results.

The measurements in exchange *B* and the signalling of the results to test set *A* are controlled in the same way by the control unit in test set *B*.

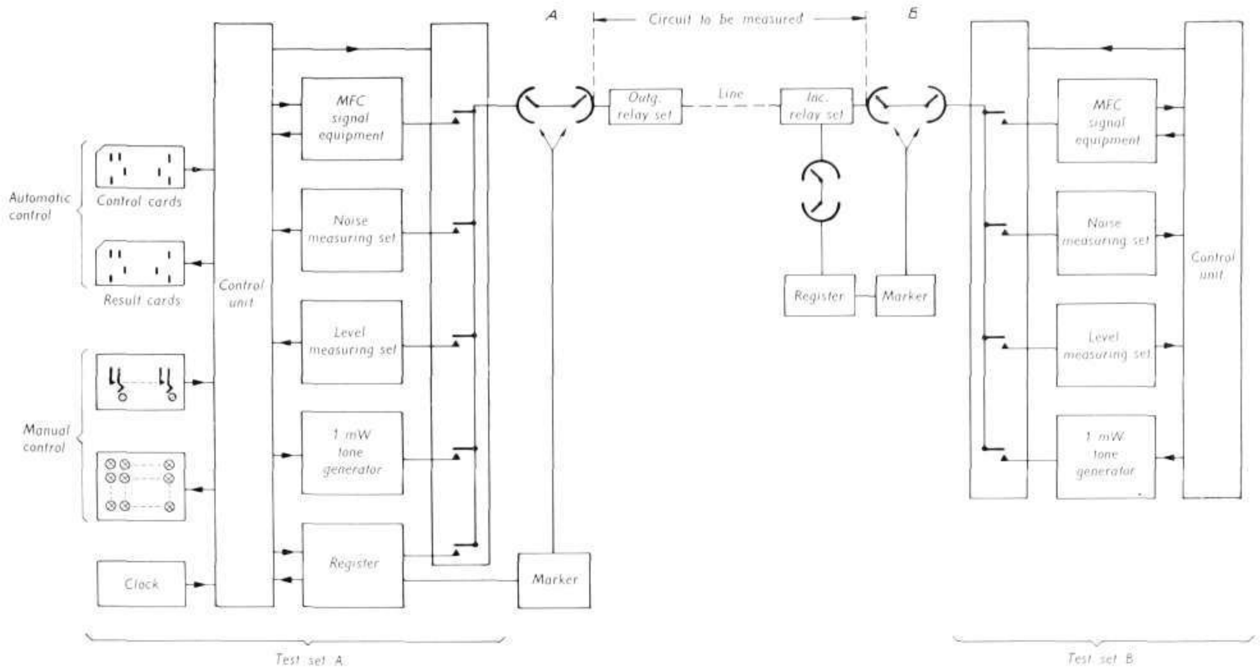



**Fig. 4** X 7863

**For automatic control punched cards are used for programming and recording of the results; for manual control a keyset and lamp panel**

For automatic control there is a punched card for every circuit to be measured. This control card contains the necessary information for setting up the test connection, carrying out the measurements, and analysing, evaluating and recording the results. The recording is effected by the punching of a card for every circuit measured. The result card contains information of the identity of the circuit and of the measured values.

Test set *A* is fed with a pack of control cards for the circuits to be included in a series of measurements. The control unit reads one control card at a time, makes the measurements and punches a result card for each circuit. From the control card, readings are made of the individual number at exchange *A* of the circuit to be measured, the code of exchange *B* at which the circuit terminates, and the special service code of test set *B* at that exchange. The individual number is used by the marker at exchange *A* for setting up the connection between the switching inlet for test set *A* and the circuit. From the outgoing junction relay set for that circuit a seizure signal is sent to the incoming end of the circuit at exchange *B* and seizes an incoming register. The numerical information required for connecting the circuit to test set *B* is transmitted from the register in test set *A* to the incoming register in exchange *B*. When the connection has been established, exchange *B* sends an answer signal to exchange *A*.

All signalling for the setting up of the test connection is done with the line and register signalling equipments normally used between exchanges *A* and *B*.

MFC signalling is used between test sets *A* and *B* for control of the measurements and transmission of the results. Different combinations of two out of six of the frequencies 1 380, 1 500, 1 620, 1 740, 1 860 and 1 980 c/s are used for signals and digits in the direction *A* to *B*, and of frequencies 1 140, 1 020, 900, 780, 660 and 540 c/s in the direction *B* to *A*.

Measurements of the equivalent can be made in both directions at frequencies of 800, 400 and 2 800 c/s, and also of the circuit noise.

What measurements shall be made on any given occasion depends on the type of circuit (cf. C.C.I.T.T. Red Book, Vol. IV, Recommendation M 64).

On one occasion the equivalent may need to be measured for all circuits at 800 c/s, for certain circuits also at 400 and 2 800 c/s, while certain circuits shall be checked for noise. The control unit in test set *A* decides which measurements shall be made for a given circuit by combining the periodicity class of the measurement (e.g. weekly, monthly, half-yearly), indicated by the throwing of a key, with the class of circuit, indicated by the punching of the control card. Thus the measurements to be made are determined individually for each circuit. The equipment provides 20 circuit class indications and 6 periodicity classes.

For the measurement of the equivalent, test set *A* signals an order to test set *B* stating at which of the three frequencies the measurement shall be made. Thereafter test set *A* connects test tone of zero level to the circuit for about 3 seconds. Test set *B* measures the level of the received tone, so providing a direct measurement of the equivalent in the *A*—*B* direction, and signals the result back to test set *A*. Test set *B* then sends a test tone of zero level for about 3 seconds to test set *A*, which measures the level of the received tone, indicating the equivalent from *B* to *A*. If other measurements are to be made, test set *A* signals a new order to test set *B*, e.g. measurement of equivalent at one of the other two frequencies, or measurement of noise. For measurement of noise both test sets connect their noise measuring sets to the circuit simultaneously for 5 seconds. The result of the measurement at *B* is signalled to *A* as acceptable or unacceptable noise.

When the programme for a circuit has been completed, test set *A* orders test set *B* to transmit a clear-back signal. On reception of the same, test set *A* breaks the connection through exchange *A*. The circuit is cleared in the normal way and a clear-forward signal is sent to exchange *B*. The connection to test set *B* is broken and the test set is released.

In test set *A* there is now stored information from the control card for the measured circuit and the results of the measurements. Before the next control card is read, the results are analysed and a result card is punched, viz. the identity number of the circuit, read from the control card, and the values of equivalent and noise. From the control card the test set has received particulars of the nominal equivalent of the circuit and now calculates and punches the deviation from the nominal value at the various frequencies for both directions of transmission. The control card has also indicated the maximum permissible deviations upwards and downwards. The test set investigates whether the deviations lie within the prescribed limits. For a circuit tha' is passed in respect of equivalent and noise, a "pass" is punched on the result card, and also the date and time of the measurement.

On the control card the nominal equivalent is indicated in centinepers, the maximum permissible deviations in whole decinepers. The measured values and the calculated deviations are punched on the result card in centinepers.

If a circuit is engaged when a test connection is set up, test set *A* waits for the circuit to become free. The time of waiting can be set as desired. If the circuit does not become free within that time, a copy of the circuit control card is punched as result card. Since the control card is unpunched in the position for completed measurement on the result cards, it can be sorted out manually from the pack of result cards. The control cards reproduced in this way are used for the control of new test connections on circuits which did not become free at the first attempt. The waiting time for an engaged circuit set on test set *A* should be such that the number of circuits not tested at the first attempt is kept within reasonable limits.

The pack of result cards contains the deviation from nominal equivalent of each circuit. Statistical analysis, including determination of the standard and mean deviation, can be done by sorting the result cards in accordance with normal punched card routine.

Manual measurements are controlled from a keyset on test set *A* and the results are displayed on a lamp panel. The equipment does not analyse the results. A separate order is given for each individual measurement. Every possible measurement can be repeated any number of times on the same test connection.

## Organization of a Transmission Measurement Network

The described equipment can be used both for direct and for remote-controlled measurements (fig. 5). A direct measurement is a measurement of an outgoing circuit from the exchange in which the controlling test set (*A*) is located. The switching and measuring processes have been described above.

A remote-controlled measurement is a measurement of a circuit from another exchange equipped with a test set (*C*) with simplified controlling functions. The controlling equipment is test set *A*, which reads the control card for the circuit to be tested. Every control card carries the area code of the exchange from which the circuit proceeds. If test set *A* finds that the circuit proceeds from an exchange *C*, it directs a connection to a test set *C* at that exchange. The number of test set *C* in the numbering scheme of exchange *C* is punched on the control card. Any of the circuits between exchanges *A* and *C* can be used as control circuit.

Switching and control information for the measurement is signalled over the telephone circuit between test set *A* and test set *C*.

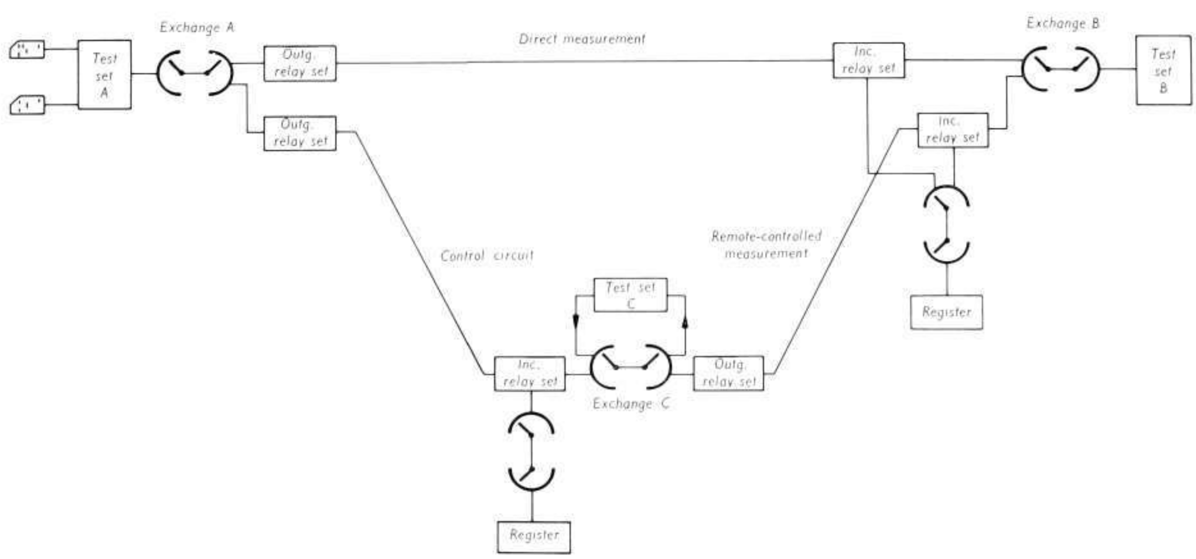
Test set *A* signals to test set *C* in MFC the number in exchange *C* of the circuit to be measured and the number of test set *B* in the exchange to which the circuit runs. When the test connection has been set up between test sets *C* and *B*, test set *A* directs the measurements by signalling orders for each measurement to test set *C*.

Test set *C* signals the result of each measurement back to test set *A*. On completion of the programme, test set *A* analyses the results and punches a result card as for a direct measurement. Test set *C* receives an order to release the test connection.

If the next circuit to be measured runs from the same exchange *C*, the already established connection to test set *C* is used for the measurement.

**Fig. 5** X 7870

**The equipment makes direct measurements of outgoing circuits from the home exchange as well as remote-controlled measurements of outgoing circuits from another exchange**



It is thus possible to concentrate to a central point in the network the operations of automatic control of the measurements and of recording of the results. From every test set *A* and *C*, furthermore, manually controlled measurements can be made—direct and remote-controlled measurements from test set *A*, and direct measurements only from test set *C*.

A single automatic direct measurement on a circuit (measurement of equivalent at one frequency, or measurement of noise) takes about 20 seconds, a single remote-controlled measurement about 30 seconds. Each additional measurement takes about 10 seconds. A test set *A* can thus control the measurements on about 100 circuits per hour or 1 000 circuits per night.

## Conclusion

Automatization of the routine measurements in a telephone network facilitates their planning and organization. They can be performed speedily and at low-traffic periods, so improving the traffic capacity of the network. Especially for measurements of international circuits great care is required in planning and organization, since different administrations are responsible for the two ends of a circuit. C.C.I.T.T. (Question 11/IV 1961—1964) is studying how routine maintenance measurements can be facilitated by the use of automatic equipment. Field trials are to be made with such equipment in Europe. The specifications for the field trial equipment are given in C.C.I.T.T. document COM IV No. 3 of July 14, 1961. The data for our measuring equipment comply in all essential respects with the specifications. For the transmission and recording of the results C.C.I.T.T. specifies the use of telegraph signalling and teleprinters. This is a natural course for an international trial network since international specifications for such equipment already exist. In the international measurements the results are registered at both ends of the circuit.

# NEWS *from All Quarters of the World*

# L M Ericsson Signs Contracts in Ecuador for 35 million Kronor

L M Ericsson has signed two contracts with the government of Ecuador for telephone installations for the capital city of Quito, the port of Guayaquil, and their rural areas. The equipments, worth 35 million Kronor, are to be delivered over a period of five years and will consist partly of extensions of earlier Ericsson exchanges and partly of new exchanges and trunk installations in the provinces of Pichincha and Guayas.

L M Ericsson has had interests in Ecuador for many years. The first contract was signed in 1945, and the two abovementioned cities have today a total of 36,000 lines in service, all of system AGF.

Automatic equipment ARM for the trunk traffic between Quito and Guayaquil is to be put into service this summer. New exchanges will be built with crossbar switches.

**(Right) The signing of the contract in Quito. (From left) Dr. Francisco Acosta Yépez, Minister of Communications, Messrs. Sven Wenhammar and Bengt Looström of L M Ericsson, and Col. Jorge Echeverria, head of the Quito Telephone Administration.**

**(Below) The signing of the contract for Guayaquil. Seated (from left) Mr. Sven Wenhammar, L M Ericsson, Mr. Enrique Alarcón, head of the Guayaquil Telephone Administration, Dr. Francisco Acosta Yépez, Minister of Communications, the Notary Public, and Mr. Paladines, Governor of the Province of Guayas.**

## Large Colombian Order for Telephone Equipment

L M Ericsson has received orders worth about 25 million Kronor for automatic telephone exchange equipment from the telephone operating companies of Bogotá, capital of Colombia, and Medellín, one of the largest industrial cities in Colombia.

The main part of the equipment will be of Ericsson crossbar system and will be used both for extensions of earlier Ericsson exchanges and for new exchanges.

Colombia is an old Ericsson market and one of the best telephone-equipped countries in South and Central America.

# Canada New Market for Ericsson Crossbar

L M Ericsson's first public automatic exchanges in Canada were cut over on February 17. Situated at L'Annonciation and Labelle in the province of Quebec these exchanges are of Ericsson crossbar system ARK 523, each with 600-line capacity.

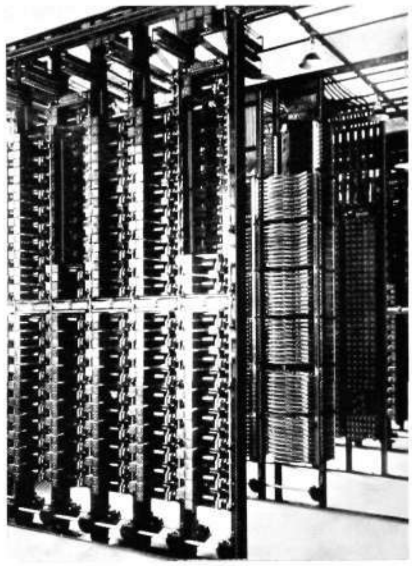
Three exchanges of the same capacity have been ordered by The Bell Telephone Company of Canada, and three also by The Maritime Telegraph & Telephone Company. These exchanges are expected to be ready this autumn.

**(Above) The opening of the L'Annonciation exchange. (From left) Mr. Rolland Pelletier, Mayor, Mr. Rolland Lachapelle, Bell Telephone Co. of Canada, Rev. Simon L'Allier, Pastor of L'Annonciation, Mr. H. E. Leonard, Bell Telephone Co. of Canada, and Mr. Eric Carnell, L M Ericsson Ltd., Montreal.**

**(Below) Dr. Carlos Julio Arosemena, President of Ecuador, declares the link open for traffic in a telephone call to the Mayor of Salinas. (Standing, from left) Mr. Enrique Alarcón, head of the Guayaquil telephone administration, Major Manuel Chicaiza, Chief Adjutant of the Air Force, and Mr. Miguel Salem Dibo, Minister of Public Works and Communications.**

## 40-year-old Telephone Exchange in Rotterdam

Roughly 2000 million register operations have so far been performed by the Ericsson 500-line selector exchange, West I, in Rotterdam, Holland, which had its 40th anniversary on May 10, 1963, and which is still doing its job very satisfactorily. The exchange (photo below) was originally equipped for 5000 lines, but now has 10,000 lines.



## Opening of Long Distance Connections in Ecuador

On April 11 a radio link was opened between the port of Guayaquil and the seaside resorts Playas and Salinas on the peninsula of Santa Elena in Ecuador. The inauguration ceremony was attended by the President of Ecuador, Dr. Carlos Julio Arosemena.

The new connection, which forms part of the expansion plans for which L M Ericsson has been granted a contract by the Ecuador government, consists of an Elektrisk Bureau radio link 3RL10 with a base band width of max. 24 circuits. The carrier terminals are of type ZAR 12.

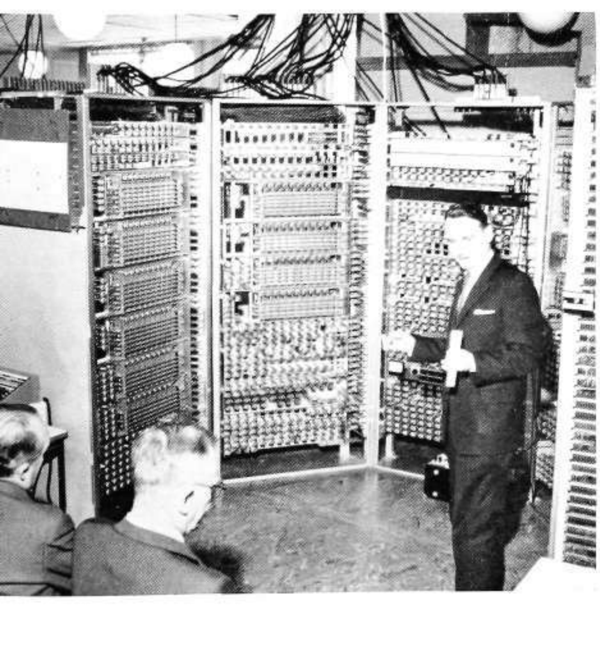
Calls will for the time being be handled manually, but automatic operation will be introduced in conjunction with the opening later this year of the ARM stages ordered for Quito and Guayaquil, when the traffic between the two latter cities will also be on an automatic basis.

A Communication Gallery was opened at the Birla Industrial and Technological Museum in Calcutta, India, on March 16. After only four years of life the Museum has already aroused a lively interest on the part both of students and of the general public. The Communication Gallery has been assisted by grants from a number of large Indian and foreign companies and institutions. Telephone equipment was presented by L M Ericsson. The inauguration ceremony was presided over by Professor Humayun Kabir, Minister of Scientific Research and Cultural Affairs, who is here seen inspecting a working model of L M Ericsson's crossbar system. On Professor Kabir's right is Mr. A. Bose, B.I.T. Museum, and on his left Mr. A. B. Bhattacharya, head of Ericsson Telephone Sales Corporation AB, Calcutta.

A "Telecommunications Week" was arranged in Lisbon in the last week of March. An interesting selection of telecommunications equipment was shown at the exhibition by Sociedade Ericsson de Portugal Lda. In the photograph (left) Mr. J. Bento Miguel of S.E.P. is demonstrating Ericsson products to the President of Portugal, Admiral Américo Tomaz. To the right of Mr. Miguel is seen Mr. Gonçalves de Proença, Minister of Labour.

The Swedish Board of Telecommunications, headed by Director General Hakan Sterky and Technical Directors B. Bjurel and E. Esping, has visited the Ericsson headquarters for information about and demonstration of automatic transmission equipment. (Below, left) Mr. Nils-Göran Themnér demonstrating the equipment.

A delegation from Turkey has been on a visit to Midsommarkransen. (Below, from left): Chief Engineer Ömer Duru, Ambassador Veysel Versan, Chief Engineer Fadil Sarioğlu, Technical Director Zeki Günsoy, and L M Ericsson's representative, Haldun Yaşaroğlu, in the Permanent Exhibition Room.



# 8.3 Million Increase in World Telephones 1961

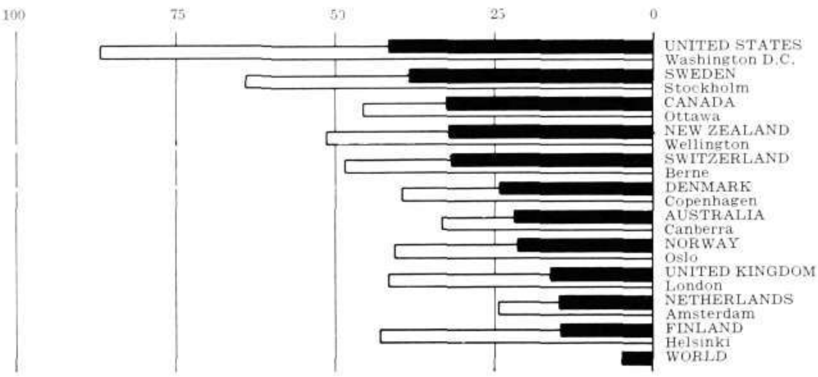
Sweden retains second place after the U.S.A. in telephone density according to the statistics published in "The World's Telephones 1962" by American Telephone and Telegraph Company.

The number of telephones in the world increased in 1961 by 8.3 million, 63 per cent of this figure being in countries outside the U.S.A. There are now 150 million telephones in the world, 136 million of which are connected to automatic systems. Sweden is rapidly approaching the 3 million mark. The world telephone density rose from 4.7 to 4.9 per 100 inhabitants. Great differences exist between different parts of the world. North America had 41.0 telephones per hundred inhabitants, Oceania 20.2, Europe 7.7, South America 2.3, Central America 1.6, Africa 0.8, and Asia 0.6. U.S.A. leads the world with 41.78 telephones per hundred inhabitants. Thereafter come Sweden with 38.51, Canada 32.66, New Zealand 32.37, Switzerland 31.90. Last are Brazil and India with 1.42 and 0.12 telephones, respectively, per hundred inhabitants.

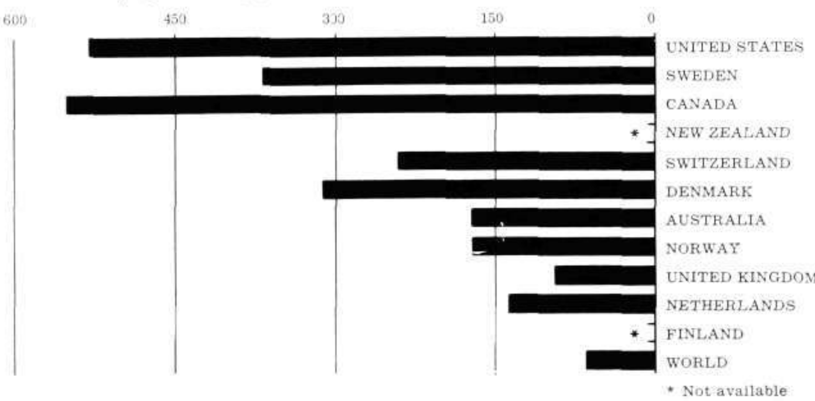
Among the major telephone countries Switzerland alone has 100 per cent automatic telephones. Thereafter follow the Netherlands with 99.9 per cent, U.S.A. 97.2, Sweden 91.9. At the end of 1961 more than 90 per cent of the world's telephones were automatic.

**Countries with at least 500,000 telephones and 15 per 100 population**

**Telephones per 100 population**




**Conversations per person during year**




# 55,450 Kronor in Annual LME Grants

The Telefonaktiebolaget L M Ericsson Foundation for the Promotion of Electrotechnical Research has made 13 awards this year, amounting to 24,950 kronor. The company's Foundation for Travel and Other Educational Grants has awarded 30,500 Kronor to 21 employees of the Ericsson Group and to 6 employees of the Swedish Telecommunications Administration.

# Sigfrid Häggberg In Memoriam

Sigfrid Häggberg has passed away. A remarkable life came to an end through an accident on March 1, 1963, fifty years to the day after the start of his career in the service of Swedish telephony. In 1913, at the age of 25, he had joined the Stockholm Telephone Company. In 1918 he went over to the L M Ericsson Cable Works and in 1922 started the career in Poland which was to last for the rest of his life. As Technical Director in the telephone company operated jointly by the Polish government and L M Ericsson, he was the mainstay of Ericsson's activities in Poland for forty years. During this long period in his second homeland he fought through vicissitudes of the most varying kinds, was imprisoned by the Nazis and remained under the shadow of a death sentence from 1942 to 1944, yet returned to life with unbroken mental powers.

L M Ericsson counts Sigge Häggberg among the few great Vikings who have led the company through its diverse international fortunes. He was fearless, self-sacrificing, buoyant in spirit and, above all, wise in the broadest sense of the word. His achievements won recognition in many ways, one being the award of the rarely conferred Gold Medal of the General Export Association of Sweden.

The L M Ericsson management and his colleagues pay tribute to Sigge Häggberg's memory and to his great achievements. An innumerable host of other friends in Sweden and Poland share in the sorrow at his death.

*Sven T Åberg*

UDC 654.154.4
LME 808

JACOBAEUS, C: *European Subscriber Dialling*. Ericsson Rev. *40*(1963):2, pp. 38—52.

The first automatic international service was between the frontier areas in neighbouring countries. As the technique developed and the traffic demand grew, automatic service has extended to larger areas. C.C.I.T.T. has for a long time been studying means of introducing a fully automatic international service in Europe and has issued comprehensive recommendations covering the technical aspects and traffic considerations.

Various aspects of European subscriber dialling are presented in this article. The article is based on a paper read at "X convegno internazionale delle communicazioni" in Genua in October 1962. It is published with the kind permission of The Civic Committee of Columbus Celebrations.

UDC 621.375: 621.397.6
LME 752, 8547

MYHRMAN, Å: *Video Amplifying Equipment for Television Program Transmission*. Ericsson Rev. *40*(1963):2, pp. 53—61.

The spread of television has given rise to the need for transmission facilities capable of handling the very wide band of frequencies of the picture signal. This article describes video amplifying equipment developed by L M Ericsson for cable transmission, intended for local distribution of television pictures.

The equipment has been designed for and delivered to the Swedish Board of Telecommunications. The broad lines of the specification have been arrived at by the joint efforts of the Board and of L M Ericsson.

UDC 621.317.74
621.395.73
LME 7131

CARLSTRÖM, P: *Automatic Transmission Measuring Equipment for Telephone Circuits. 1. Equipment Description*. Ericsson Rev. *40*(1963):2, pp. 62—68.

An equipment developed by Telefonaktiebolaget L M Ericsson for measuring the transmission characteristics of automatic telephone circuits is described. The equipment permits the control of measurements within a network from a central point. For automatic measurements punched cards are used both for control of the measurements and for recording the results. Manual measurements are controlled from a keyset and the results are displayed on a lamp panel. The article is based on a paper presented at the Meeting of Norwegian Telephone Engineers at Lillehammer on May 27, 1962.

# The Ericsson Group

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Dansk Signal Industri A/S *København F*, Finsensvej 78, tel: Fa 6767, tgm: signaler

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A/S Norsk Kabelfabrik *Drammen*, P. B. 205, tel: 1285, tgm: kabel

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AB Rifa *Bromma 11*, tel: 26 26 10, tgm: elrifa-stockholm

AB Svenska Elektronrör *Stockholm 20*, tel: 44 03 05, tgm: electronics

L M Ericssons Driftkontrollaktiebolag *Solna*, tel: 27 27 25, tgm: powers-stockholm

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*Istanbul*, Istanbul Bürosu, Liman Han, Kat 5, No. 75, Bahçekapi, tel: 22 81 02, tgm: ellemist

• A[illegible]

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North Electric Co. *Galion, Ohio*, P. O. B. 417, tel: Howard 8-2420, tgm: northphone-galionohio, telex: 470-U

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Teléfonos Ericsson C. A. *Caracas*, Apartado 3548, tel: 543121, tgm: tevela

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*North Sydney (NSW)*, 182 Blue's Point Road, tel: 92—1147, tgm: ericsyd

Teleric Pty. Ltd. *Melbourne C 1 (Victoria)*, 20 Collins Street, tel: 635646, tgm: teleric

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**Greece**
"ETEP" S. A. Commerciale & Technique *Athens 143*, 57, Akadimias Street, tel: 629.971, tgm: aeter-athinai

**Iceland**
Johan Rönning H/F *Reykjavik*, P. O. B. 45, tel: 14320, tgm: rönning

**Ireland**
Communication Systems Ltd. *Dublin 4*, 138 Pembroke Road, Ballsbridge, tel: 680787 tgm: crossbar

**Yugoslavia**
Merkantile Inozemna Zastupstva *Zagreb*, Pošt pretinač 23, tel: 36941, tgm: merkantile, telex: 02-139

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# ERICSSON Review

3
1963

# ERICSSON REVIEW

Vol. XL No. 3 1963

RESPONSIBLE PUBLISHER: HUGO LINDBERG

EDITOR: SIGVARD EKLUND, DHS

EDITOR'S OFFICE: STOCKHOLM 32

SUBSCRIPTIONS: ONE YEAR $ 1.50; ONE COPY $ 0.50

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On cover: Main Plant of Telefonaktiebolaget L M Ericsson, Stockholm, with New Office Block on the Left.

 PRINTED IN SWEDEN, ESSELTE AB, STOCKHOLM 1963

# 40th Anniversary of Ericsson 500-Line Selector Exchange in Rotterdam

G H WIENEKE, FORMERLY HEAD OF THE ROTTERDAM TELEPHONE ADMINISTRATION

UDC 621.395.343
LME 8342

*On May 10 this year L M Ericsson's oldest 500-selector exchange in the world, at Rotterdam–Delfshaven, Holland, completed 40 years of service. It was in the early days of automatic telephony that L M Ericsson developed its 500-selector system, and for many years this remained the most widespread and successful of the company's switching systems. It was Rotterdam, too, that provided the first valuable experience of automatic operation, which proved the advanced design and efficiency of the 500 system. It may therefore be of interest to give a resumé of the events which led up to the decision to install this exchange, and of its performance during these 40 years.*

## Choice of System

During the years following the first world war Rotterdam suffered from a serious shortage of lines. The Botersloot manual exchange had been extended to 14,400 lines, but this was no longer sufficient, and in the early twenties there were 3,000 subscribers on the waiting list. It was therefore necessary to open new satellite exchanges. The first of them was to be built in Delfshaven in west Rotterdam, and it was thought that automatic equipment could be installed for 10,000 lines. The choice lay between a Strowger step-by-step system, the American Rotary system—which was already operating at the Hague and was made in Antwerp—and the recently introduced Swedish 500-selector system. Mr. Boom, head of the Rotterdam Municipal Telephone Administration, was faced with a difficult choice. But he was convinced of the advantages of a system based on switches with a large line capacity, and

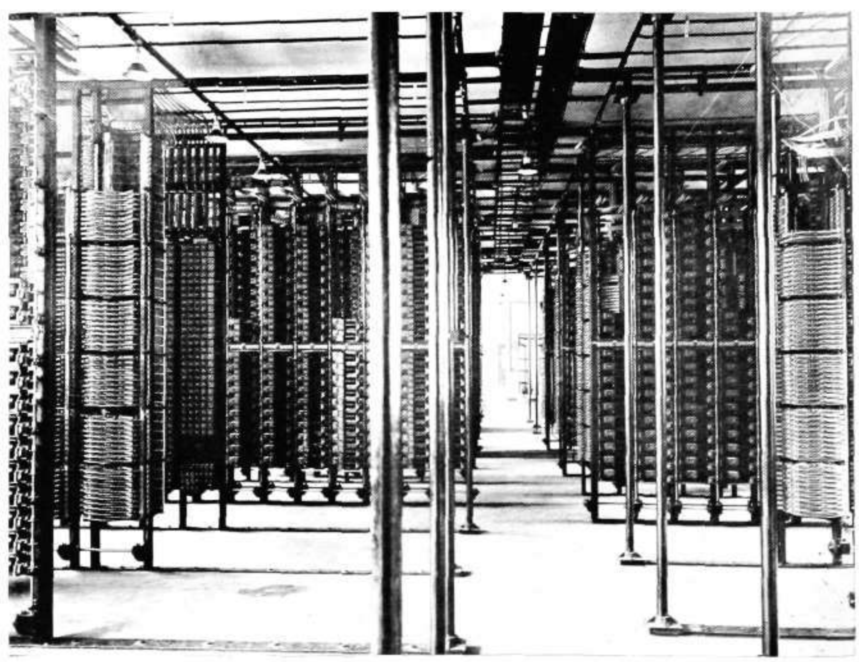
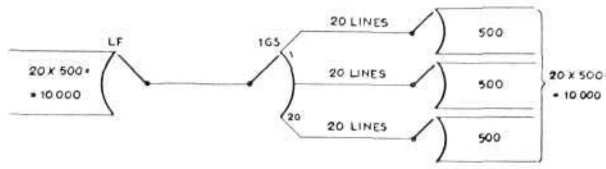


**Fig. 1** X 8435
**View through the length of the switchroom**

Fig. 2 X 8434
**Schematic of a 10,000 line system**
**Line finder**




the 500-line groups in the Swedish system allowed better utilization of the switches and much simpler operating conditions. He considered it an advantage that the switching apparatus in the 500 system was of plug-in type and could therefore be easily adapted to variations in traffic intensity. Another advantage was that a Swedish 10,000 line group required very much less floor space than comparable equipment of other systems. Great value was attached also to the flexibility of junction traffic with the manual exchange provided by the Swedish system, since it was thought that it might take several years before the manual exchange could be converted to automatic operation.

The Swedish system had admittedly not yet been tried out in practice. But Mr. Boom possessed such confidence in L M Ericsson's engineering ability and in the robustness of the system that he advised the Rotterdam municipality to adopt this system for the new exchange. This they did, and it may be said that the administration has not had cause to regret their decision.

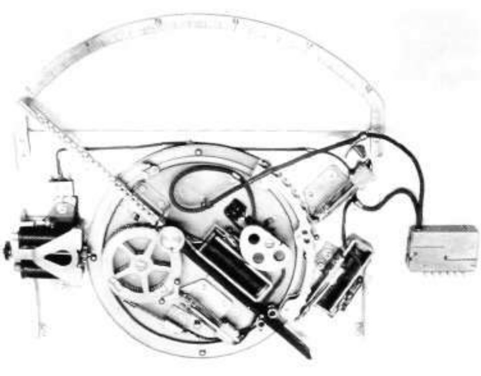


Fig. 3 X 2726
**Final selector**

The first order was for 5,000 lines and a 500-line PBX-group. It was decided that the traffic from the automatic to the manual exchange should as far as possible be handled automatically. Traffic in the opposite direction was to be passed via a few individual circuits at each of the operators' positions in the manual office. In the Delfshaven exchange these circuits terminated on the multiple of a finder group with connection to semi-automatic registers.

An important question to be decided was: semi- or full-automatic? It was said that the Rotterdam business community could not be induced to dial their numbers themselves. For safety's sake it was decided to have only three full-automatic 500-line groups and seven semi-automatic. The intention was, however, to make the entire Delfshaven exchange automatic at a later date, and thereafter the Botersloot exchange as well.

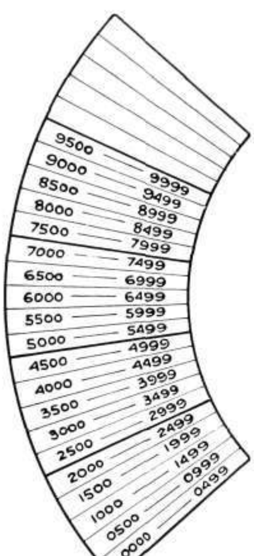



Fig. 4 X 2723
**Numbering of multiple field in a group selector rack**

## The System in Operation

The installation of the equipment went ahead very quickly and the cut-over took place on May 10, 1923. Four 500-line groups with full interworking facilities between the manual and the trunk exchange could be put into operation; and now the first practical experience of the new 500 system began to flow in. The use of the PBX group had to be delayed, however, principally because the requirements on PBX working could not yet be formulated.

An extremely useful device was found to exist in the register control desk, which could be employed for various traffic supervision purposes and was therefore soon rechristened the traffic control desk. All full-automatic registers could be checked at this desk for correct translation and correct operation within the limits of resistance and leakance of the lines. It was also possible to talk to the calling subscriber via the register during the setting up of the connection. The lamp signals on the register desks showed the progress of dialling and operation of the switches. It was found that subscribers could make the strangest of mistakes. Apart from failure to wait for dial tone or to dial the number at all, they often dialled the digits in the wrong order owing

**Fig. 5** X 2724
**Auto-manual operator's positions**

to the Dutch way of wording their numbers. Sometimes, too, they used the finger stop as pointer for the digit dialled so that all digits were one too high. One subscriber even thought that the five-digit numbers had some connection with the five fingers of the hand, which all had to be placed at one time into the holes of the dial and the dial then turned until finger after finger met the stop.

The semi-automatic registers connected to each operator's position could be positioned on the desired number with a keyset.

Semi-automatic setting up of connections, however, was slower than automatic. If an attempt was made to set up a connection in the two ways simultaneously, and the automatic setting up of the connection started at the same time as the operator answered a semi-automatic call, the automatic connection always got through first. Later, when the subscribers learnt to handle their dials and the apprehended protests of the business community remained unvoiced, the idea of conversion from semi- to full-automatic operation began to gain ground. Automatic operation proved to be the proper course.

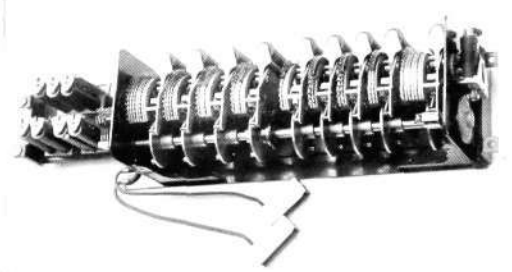


**Fig. 6** X 2727
**Complete register for a 10,000-line system**

## Maintenance

Since the causes of faults could be quickly and reliably traced, maintenance was very simple, and routine testing and preventive maintenance were hardly required. The possibility of maintenance on these principles, of course, was due to the advanced design of the system. In the years following 1923, when telephone experts from the whole world came to Rotterdam to study the system, we often heard criticism of this method of maintenance. It was thought that it might work for a time, but that it would end in a major breakdown which would be very difficult to repair. Yet in the 40 years in which the Delfshaven exchange has been operating, no such breakdown has occurred. On the contrary—though not until the fifties—the maintenance experts revised their opinion and started to realize the soundness of the principle of corrective maintenance that had long been advocated by L M Ericsson.

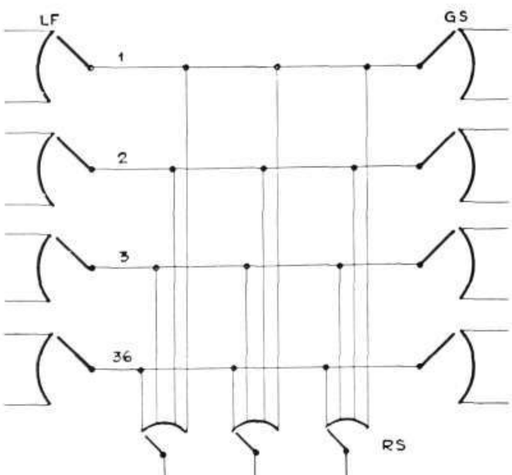



**Fig. 7** X 2725
**Connection of registers to register finders**
GS Group selectors
RS Register finders

## The Delfshaven Exchange and the Development of the Rotterdam Network

The history of the Delfshaven exchange is closely associated with the growth of the Rotterdam network as a whole. The main phases of this development were: The extension of the overall number capacity of the system, the extension of the Delfshaven exchange and its conversion from semi- to full-automatic operation, and finally the introduction of subscriber-dialled trunk traffic.

The original number capacity of the system was 60,000. Thanks to its extreme flexibility its capacity could be easily increased to 80,000. This met the requirements for a considerable time, since the number of connections decreased slightly during the economic crisis from 1930 to 1935. But after 1935 a new extension was necessary, now to 150,000 lines.

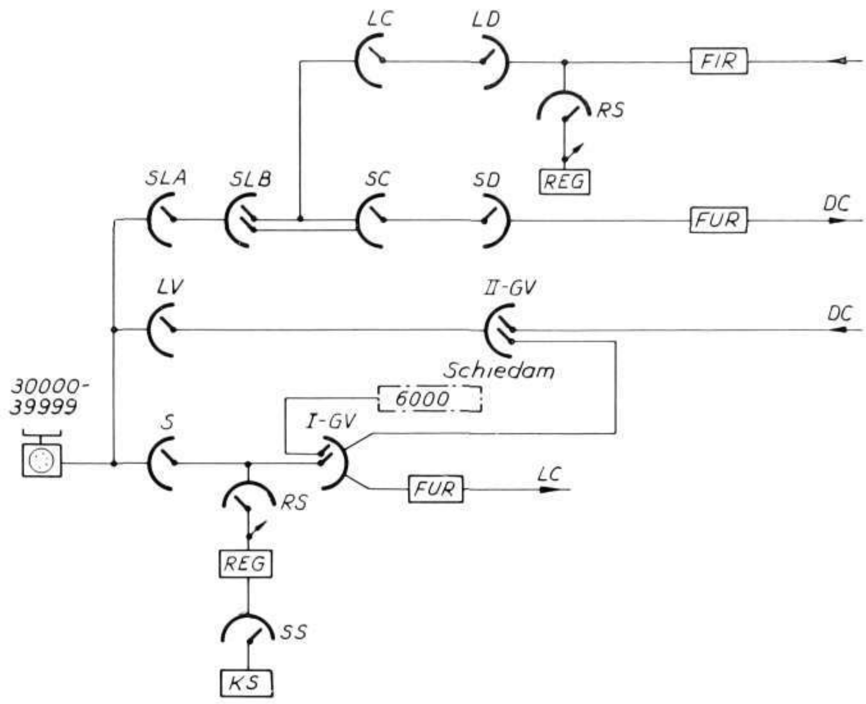



**Fig. 8** X 8442
**The Delfshaven exchange of today, now called Rotterdam West I**
Trunking diagram

## Adaptation to the New Technique

Telephony had developed extremely quickly since 1925, not least in Holland. During this period the switching technique itself has undergone a revolutionary advance, and this has placed great demands on the flexibility and adaptability of the existing equipment. Since May 1962 all telephone traffic in Holland is automatic.

Even the oldest 10,000-line group at Delfshaven, after 40 years of uninterrupted service, has been easily adapted to the latest developments in switching technique. There are therefore good grounds for expecting that the equipment will continue to render reliable and efficient service for many years to come.

# Automatic Transmission Measuring Equipment for Telephone Circuits

## 2. Measurement of Attenuation and Noise

H KARL, TELEFONAKTIEBOLAGET L M ERICSSON, STOCKHOLM

UDC 621.317.74
621.395.73
LME 7121

*This article is a continuation of the description of the automatic transmission measuring equipment for telephone circuits in Ericsson Review No. 2, 1963.*[1] *The present article describes the mode of operation and the units for measuring the circuit equivalent and circuit noise.*

The transmission properties of a telephone circuit are usually checked by measuring the equivalent of the circuit. By this is understood the insertion loss of a circuit when terminated with a resistance of 600 ohms at both ends. In order fully to describe the transmission properties of a communication circuit one should also know its propagation delay, its noise level and its distortion.

For a telephone circuit it is considered quite sufficient to know its equivalent and noise level. The *automatic transmission measuring equipment for telephone circuits*, therefore, contains apparatus only for measurement of the circuit equivalent at 400, 800 and 2,800 c/s, consisting of sending equipment and level measuring set, and for measurement of noise (noise measuring set). The performance of the equipment is based on CCITT recommendations.[2, 3]

## Attenuation Measuring Equipment

The attenuation of a telephone circuit is measured by sending from one end a test signal of defined level and measuring the voltage at the other end. If the output voltage of the signal generator is calibrated against a pure resistance of 600 ohms and the measured circuit is terminated with 600 ohms at both ends, the difference between the transmitted and received levels is identical with the equivalent of the circuit. The principle is shown in fig. 1. An automatic attenuation measuring equipment, accordingly, does not differ in principle from a manual. The difference lies in the fact that an automatic equipment must itself be able to evaluate and record the result. Long-time stability is also desirable so that the equipment may operate for long periods without recalibration.

The block schematic of the equipment developed by L M Ericsson is shown in fig. 2.

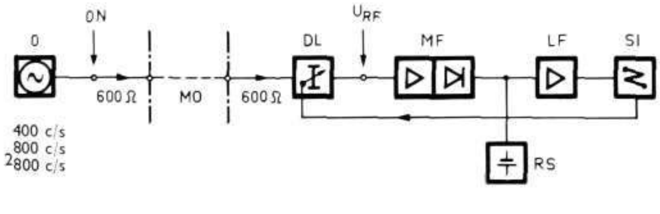



**Fig. 1** X 8419

**Simplified block schematic of the attenuation measuring equipment**

O — sending equipment
MO — telephone circuit to be measured
DL — attenuator
MF — measuring amplifier (amplifier with built-in rectifier)
RS — reference voltage source
LF — d.c. amplifier
SI — signal indicator
$U_{RF}$ — level at reference point

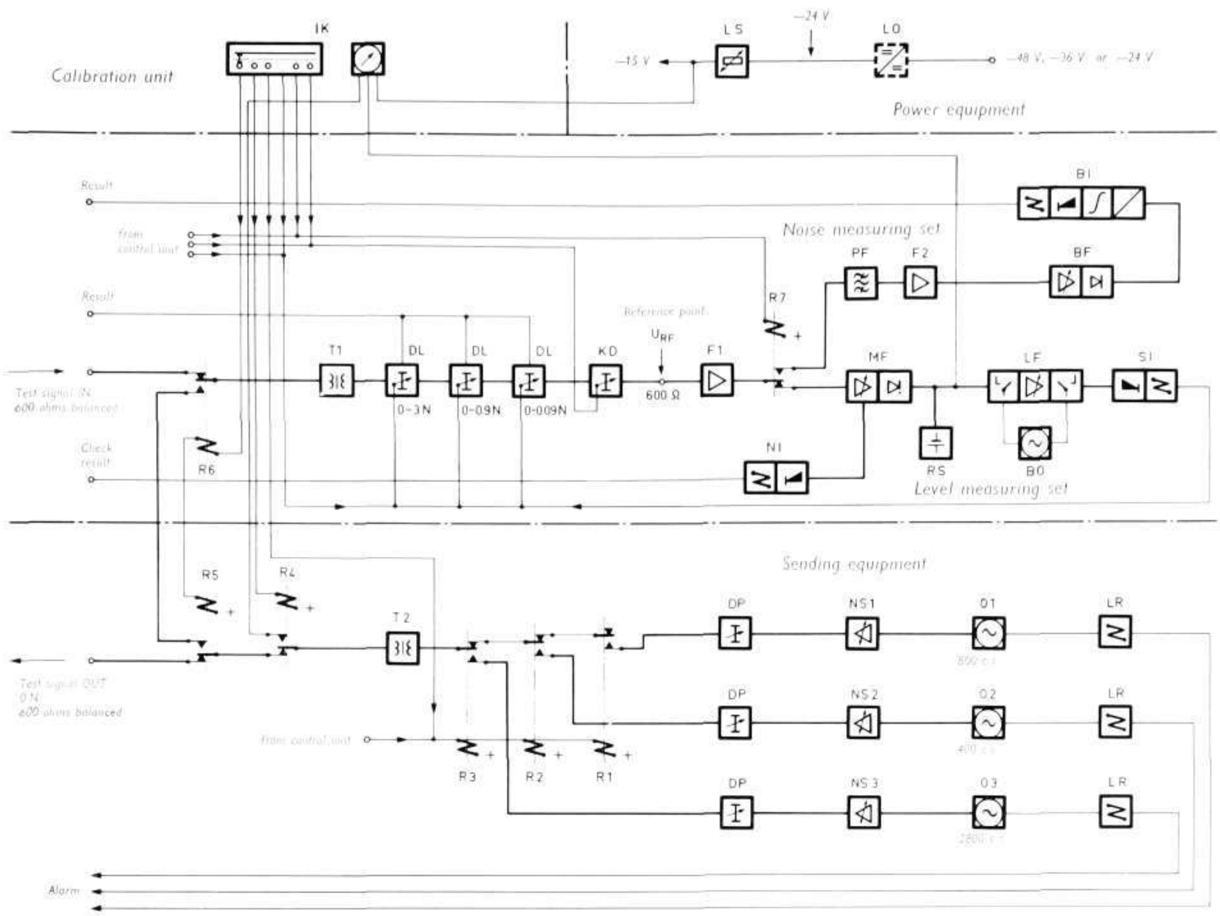



**Fig. 2** X 7880

**Block schematic of attenuation and noise measuring equipments**

| | |
|---|---|
| IK | — calibration unit |
| LS | — d.c. stabilizer |
| LO | — d.c. converter (included only when the exchange battery voltage is 36 or 48 V) |
| O 1-3 | — oscillators |
| NS 1-3 | — level stabilizers |
| DP | — pads |
| T 1-2 | — line transformers |
| DL | — attenuator |
| KD | — control pad |
| F 1-2 | — amplifiers |
| MF | — measuring amplifier |
| RS | — reference voltage source |
| LF | — d. c. amplifier |
| BO | — blocking oscillator |
| SI | — signal indicator |
| NI | — level indicator |
| PF | — psophometric filter |
| BF | — noise measuring amplifier |
| BI | — noise indicator |
| R 1-7 | — control relays |
| LR | — alarm relays |
| $U_{RF}$ | — level at reference point |
| ——— | measuring and test signal paths |
| ——— | control signal paths |

## *Sending Equipment*

The test frequencies are generated in three separate oscillators for 800 c/s (*01*), 400 c/s (*02*) and 2,800 c/s (*03*). Owing to the principle of measurement employed the accuracy of the equipment as a whole is a direct function of the accuracy and stability of the voltages delivered by the sending equipments. The test signal voltages generated in the oscillators are therefore stabilized in a level stabilizer.

The oscillators are bridge-stabilized LC-transistor-oscillators. The basic circuit is identical for the three oscillators; they differ only in the frequency-determining LC link. The oscillators are designed for good frequency stability.

The three level stabilizers *N1–N3* work on the following principle. The incoming signal is amplified in a single-stage transistor amplifier. The amplitude of the signal is thereafter stabilized in a symmetrical limiter made up of zener diodes. The fundamental frequency of the signal is filtered out by a low pass filter.

The level stabilizers maintain the signal level constant against

a) variation of the output voltage of the oscillators within $\pm 0.35$ N,

b) variation of the ambient temperature between $+10$ and $+45°$ C,

c) variation of the supply voltage within $\pm 10\,\%$,

d) variation due to ageing.

The total alteration of the signal level is then less than $\pm 0.01$ N.

The pads *DP* take up the manufacturing tolerances of the individual units. These pads can be adjusted in steps of 0.01 N, thus permitting the 0 N output level of the sending equipment to be set to an accuracy better than 1 %. Adjustment and subsequent checking of this level are done with the built-in calibration unit *IK* which is connected across the contacts of relay *R4* to the output of the sending equipment and terminates it with 600 ohms.

Each test frequency is thus generated by a separate group of sending equipments, each consisting of an oscillator, a level stabilizer and a pad. Connection of the respective frequencies to the circuit to be measured is made by relays *R1*, *R2* and *R3* which are controlled by a special control unit.[1] The output is 1 mW (absolute voltage level 0 N/600 ohms).

## *Level Measuring Set*

As shown in figs. 1 and 2, the incoming test signal passes through an attenuator-amplifier chain which compensates for the attenuation of the test tone in the circuit under test. The test signal is then rectified and compared with a highly stable reference voltage (*RS*). If the two voltages are equal, the difference voltage at the input of the subsequent d.c. amplifier (*LS*) will be 0 V and the signal indicator *SI* will not react.

The level at the reference point is then

$$U_{RF} = 0 - 2.99\ \mathrm{N} - A_{KD} - A_{T1}$$

irrespective of the setting of the attenuator. The notations are as follows:

| | |
|---|---|
| 0 | 0 N level of the sending equipment |
| − 2.99 N | the lowest measurable level |
| $A_{KD}$ | the attenuation of the control pad *KD* |
| $A_{T1}$ | the attenuation of the line transformer *T1*. |

As soon as the level at the reference point becomes greater than $U_{RF}$, the difference voltage at the input of the d.c. amplifier becomes positive and the signal indicator causes the attenuator *DL* to increase the attenuation until the level at the reference point reaches the value $U_{RF}$. If the level at the reference point is less than $U_{RF}$, the attenuation in the attenuator is reduced. The attenuation $A_{DL}$ set on the attenuator is a measure of the equivalent of the circuit $A_R$, which is

$$A_R = 2.99\ \mathrm{N} - A_{DL}$$

The subtraction 2.99 N − $A_{DL}$ is done already in the evaluation of the setting of the attenuator. The value delivered from the level measuring set via the "result wire" is accordingly the value of the circuit equivalent $A_R$.

The input impedance of the level measuring set is 600 ohms within the 400–2,800 c/s band. The level measuring set is matched to the circuit to be measured by means of the line transformer *T1*. As shown in the block diagram in fig. 2, the signal voltage is thereafter passed to the attenuator *DL*, which consists of three attenuation networks in series, the first being variable between 0 and 3 N in steps of 1 N, the second between 0 and 0.9 N in steps of 0.1 N, and the third between 0 and 0.09 N in steps of 0.01 N. The resistors which determine the attenuation are switched in by relays which are controlled by the signal indicator *SI* (fig. 3). After the attenuator there follows a control pad (*KD*) for various control purposes; this is also switched by relays controlled by the control unit. For measurement of the circuit equivalent the control pad has an attenuation of 0.06 N. The test signal is thereafter amplified in the preamplifier *F1*, a two-stage transistor amplifier with $F = 3$ N.

Line transformer *T1*, attenuator *DL*, control pad *KD* and preamplifier *F1* are used for measurement both of circuit equivalent and of circuit noise. After the preamplifier, therefore, the measuring equipment branches into a level measuring set and a noise measuring set.

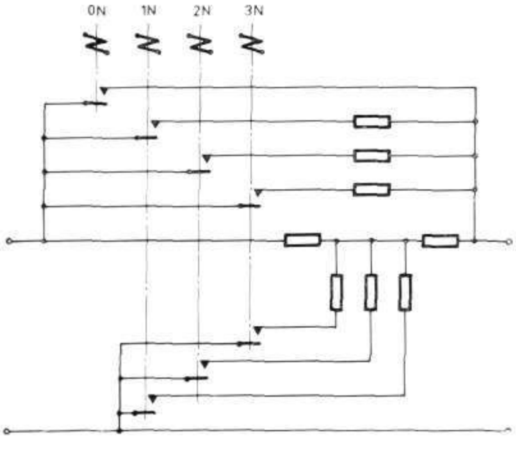



**Fig. 3** X 2693

**Circuit diagram of an attenuation network for the attenuator *DL***

The illustrated network is for 0-3 N

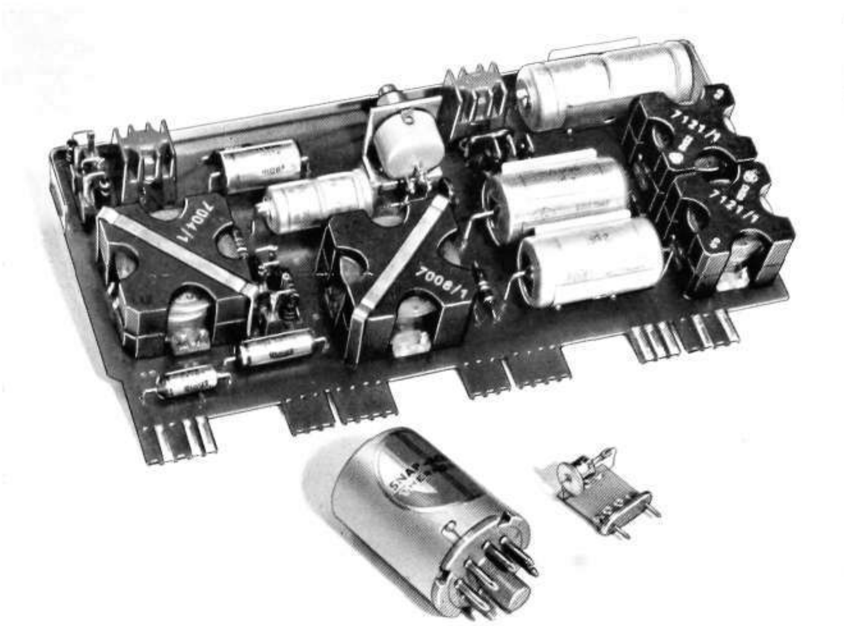


**Fig. 4** X 8427
**Measuring amplifier and reference voltage source**

For measurement of the circuit equivalent the test signal is passed by relay *R7* to the measuring amplifier *MF*. The latter is an amplifier-rectifier and delivers a non-earthed d.c. voltage corresponding to the arithmetic mean value of the test signal. The magnitude of the d.c. voltage is directly proportional to the a.c. voltage on the input of the measuring amplifier. The rectified test signal is smoothed and compared with the reference voltage *RS*.

The reference voltage source *RS* is a zener diode with low temperature coefficient. To render the reference voltage still more independent of temperature, the diode is placed in a thermostat. The variation of the reference voltage for a variation of the ambient temperature between + 5 and + 50° C is less than 1 part in 2,000.

The measuring amplifier *MF* and the source of the reference voltage *RS* are shown in fig. 4.

The difference voltage between the test signal and the reference voltage is amplified in the d.c. amplifier *LF*. The amplifier is chopper-stabilized, i.e. the d.c. voltage signal on the amplifier input is converted to a square wave signal by periodic short-circuiting of the amplifier input. The signal is amplified in a broad band a.c. amplifier, rectified again at the output by another chopper and smoothed. Transistors are used as input and output choppers. They are synchronously driven by a free-running blocking oscillator *BO* which generates a square wave voltage with a pulse frequency of 1,500 c/s.

The output signal of the d.c. amplifier is fed into the signal indicator *SI*. Its purpose is to convert the electronic evaluation into a mechanical function; if the difference voltage at the d.c. amplifier input is $\geq + 20$ mV, the signal indicator relay operates. The relay contacts thereafter control the attenuator *DL*.

The level measuring set also contains a level indicator *NI* which checks whether a test signal in fact arrives at the level measuring set ("check result" in block schematic, fig. 2). The electrical design is similar to that of the signal indicator.

On completion of the measurement an automatic check of the result is made as follows.

After a measurement the level $U_{RF}$ at the reference point may have a value such that

$$U_{RF} - 0.01\ \text{N} < U_{RF} < U_{RF} + 0.01\ \text{N}$$

Thus the signal indicator still signals either *too high level (+)* or *too low level (−)*. In the + position, therefore, the attenuation of the control pad *KD* increases from 0.06 N to 0.12 N. The signal indicator shall then change to − sign, otherwise the measured circuit equivalent $A_R$ is incorrect owing to instability of the test signal arriving at the level measuring set during the measurement. If the signal indicator signals a − sign, the attenuation of the control pad diminishes from 0.06 N to 0 N. The signal indicator should then change to + sign.

Like the sending equipment the level measuring set is also checked solely with the built-in calibration unit *IK* without the aid of external measuring equipment. The sender of the measuring equipment itself is here used as standard signal source and is connected to the input of the level measuring set (line transformer *T1*). The attenuator *DL* and the control pad *KD* is adjusted to such level that the reference point is equal to $U_{RF}$. The control of the attenuator and of the control pad and relays *R1–R7* has thereby been taken over by the calibration unit. The d.c. voltage on the input of the d.c. amplifier is adjusted to 0 V by variation of the amplification of the measuring amplifier, and the signal indicator should now indicate the − sign.

## Noise Measuring Set

Contrary to the attenuation measuring equipment, the noise measuring set does not present the result in numerical terms but simply checks whether the noise voltages of the transmission circuit exceed a permissible noise power $P_{Br}$ or not. The reason why a correct value of the noise voltage level of a circuit is not obtained otherwise than by measuring the r.m.s. value is that the noise voltages add in a random manner, i.e. their sum cannot be treated as a periodic curve with known form factor. One instead measures the power level of the noise voltages

$$F = \frac{1}{2}\ln\frac{P_{Br}}{1\ \mathrm{mW}} = \frac{1}{2}\ln\left(\frac{U_{Br}^2}{R_M}\cdot\frac{600\ \Omega}{(0.775\ \mathrm{V})^2}\right)$$

by forming the r.m.s. value $U_{Br}^2$ of the noise voltage $U_{Br}$ as it occurs during a period of 5 ± 1 seconds after passing a psophometric filter designed according to the CCITT recommendations. $R_M$ here corresponds to the resistance across which the squared voltage $U_{Br}^2$ can be measured. The threshold of unacceptable noise should be − 6 N, switchable to − 5 N or − 4 N (referred to 0.775 V).

If, for manual measurement, a CCITT psophometer is used as shown in fig. 5, the deflections of the pointer instrument *I* vary in time with the noise voltage.[3] The observer keeps the instrument under observation during a given period and assesses the mean power of the noise. One may also say that the observer integrates by eye.

With automatic control there must be an objectively evaluating unit which measures the mean power of the noise and issues a signal when it exceeds the threshold value. The first process is carried out in an electronic integrator, the second in a signal indicator.

During the measurement of noise the sender of the measuring equipment is isolated from the transmission circuit. Both ends of the circuit are instead terminated with the noise measuring equipment which has an input impedance of 600 ohms.

The incoming noise signal takes the same path as the test signal for measurement of the circuit equivalent, i.e. from the input via the line trans-

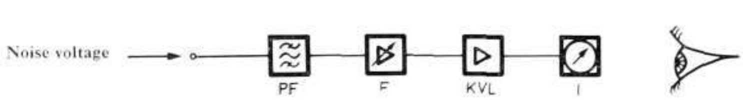



**Fig. 5** X 8420
**Block schematic of a CCITT psophometer**

PF — psophometric filter
F — amplifier
KVL — square-law detector
I — pointer instrument

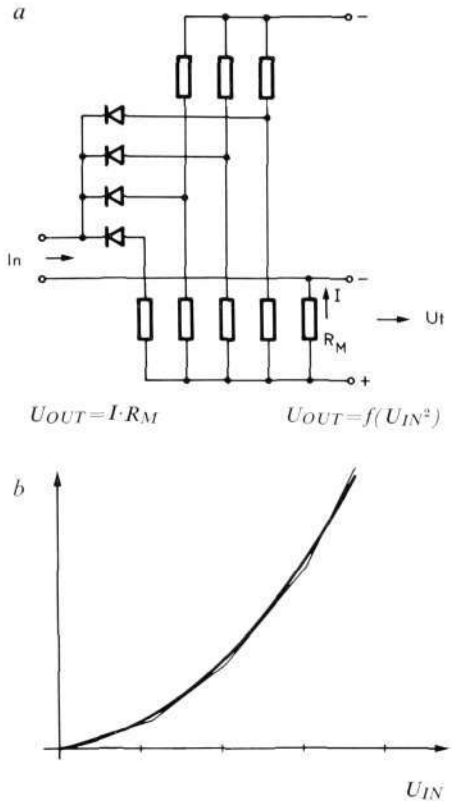
former $T1$, attenuator $DL$, control pad $KD$ and preamplifier $F1$ to relay $R7$. In the meantime the attenuator has been set by the control unit to 0 N. The control pad will have a value of either 0 N, 1 N or 2 N according to whether the threshold value for unacceptable noise is to be − 6 N, − 5 N or − 4 N. Accordingly the level for a sinusoidal signal at the reference point is always

$$U_{RF} = -6\ \text{N} - A_{T1}$$

when it is equal to the threshold value.

Relay $R7$ now connects the noise voltages to the noise measuring set during a period of 5 ± 1 seconds. The noise voltages amplified in the preamplifier are weighted in a psophometer filter and are amplified a further 1.4 N in a voltage amplifier $F2$ before being fed to the noise measuring amplifier $BF$. Like the measuring amplifier $MF$ the noise measuring amplifier $BF$ is an amplifier-rectifier and delivers a non-earthed, non-smoothed, full-wave rectified signal which corresponds to the arithmetic mean value of the noise signal.

To obtain the r.m.s. value the linearly rectified noise signal is then squared in the noise indicator $BI$. The squaring function is performed in a network of diodes and resistors. The network and its characteristic are shown in fig. 6. The characteristic is a polygon which approximates a parabola through a close succession of linear segments. The squared signal is integrated and linearly amplified in a d.c. transistor amplifier with the integration capacitor in the feedback network (Miller integrator). After passing through the integrator the noise signal is checked by the indicator section of the noise indicator. The threshold value of the unit is formed by a combination of a transistor and zener diode so designed that the indicator relay operates when the signal at the reference point exceeds the value $U_{RF}$.




X 2694
X 2695

**Fig. 6**

**Square-law network of noise indicator**

a) Circuit diagram
b) Square-law characteristic of the network
—— parabola curve
—— approximation

The calibration and check of the noise measuring set are done exclusively by internal means: the 800 c/s tone from the sending equipment is passed by the calibration unit $IK$ to the noise measuring set during a period of 5 seconds. The control pad has then been set to 6 N. The amplification of the noise measuring amplifier is so adjusted that the noise indicator relay operates after precisely 5 seconds' measuring time.

## Power Supply

The measuring equipment is supplied from the exchange battery. The voltage variations of the battery are smoothed out in a d.c. stabilizer $LS$ which maintains the output voltage constant within a maximum deviation of ± 0.5 % for a variation in battery voltage of ± 20 %. The active elements consist of transistors.

If the exchange battery voltage is above 24 V, a d.c. converter $LO$ which can be strapped to 36 V and 48 V is connected between the d.c. stabilizer $LS$ and the battery.

The output voltage of the stabilizer is controlled by the calibration unit $IK$.

## Calibration Unit

The calibration unit $IK$ contains all instruments and controls required for adjustment, control and recalibration of the attenuation measuring set and noise measuring set without the need for external measuring instruments such as test tone generator, level test set, or the like. Fault tracing can also be done by the built-in calibration unit.

The absence of external measuring instruments excludes the possibility of error due to the use of different instruments on different occasions. The difference in accuracy between different instruments is, in fact, of the same order as the accuracy of the measuring equipment itself. The relative accuracy is therefore very much greater. In addition, the calibration unit greatly simplifies the maintenance work.

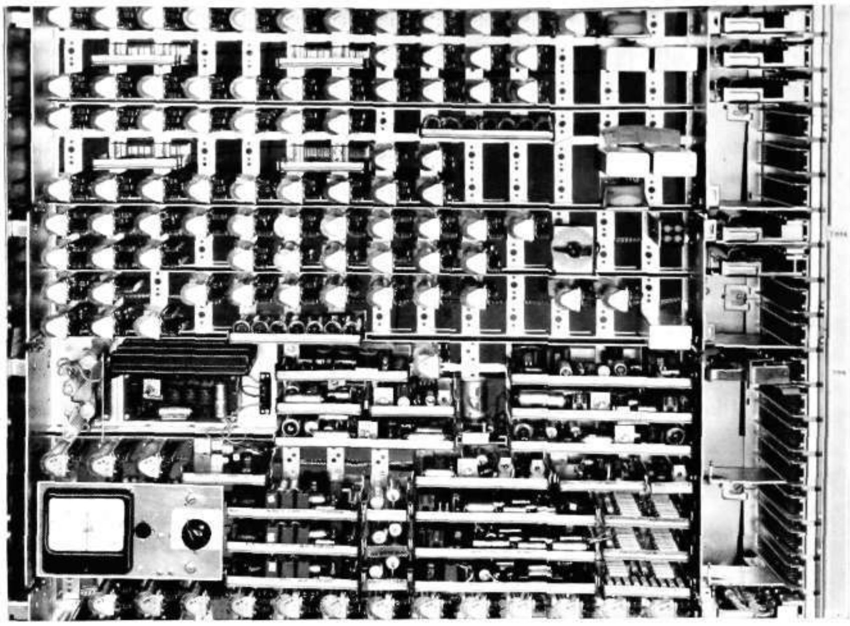


**Fig. 7** X 8428
**Attenuation and noise measuring equipment**

## Mechanical Features of the Equipment

The mechanical construction of the apparatus follows the new Ericsson principles for electronic equipments in telephone exchanges,[4] based primarily on the printed wiring board and on transistorization and miniaturization of electrical apparatus to allow an increasing use of electronic circuits. All units of the measuring equipment are constructed on this principle with the exception of the relays, line transformers, calibration unit and reference voltage source. Each printed wiring board constitutes a functional unit such as an amplifier, oscillator etc. The measuring amplifier is shown in fig. 4. Fig. 7 shows the complete attenuation and noise measuring equipment plugged into telephone exchange relay mountings.

## Technical Data

### *General*

| | |
|---|---|
| Power supply | – 24 V, – 36 V or – 48 V $^{+20\%}_{-10\%}$ |
| Power consumption | approx. 32 W |
| Operating voltage of individual units | –15 V |
| Ambient temperature | + 10 to + 45° C |

### *Sending Equipment*

| | |
|---|---|
| Frequency | 400, 800, 2,800 c/s ≦ ± 3 ‰ |
| Impedance | 600 ohms, balanced |
| Nominal level | 0 N |
| Adjustment tolerance | ≦ ± 0.005 N |
| Distortion factor | ≦ 3 ‰ |

### *Level Measuring Set*

| | |
|---|---|
| Frequency range | 400–2,800 c/s (fig. 8) |
| Impedance | 600 ohms, balanced |
| Measuring range | – 2.99 N to + 0.99 N at a noise threshold of – 6 N<br>– 2.80 N to + 0.99 N at a noise threshold of – 5 N<br>– 1.80 N to + 0.99 N at a noise threshold of – 4 N<br>(in steps of 0.01 N) |

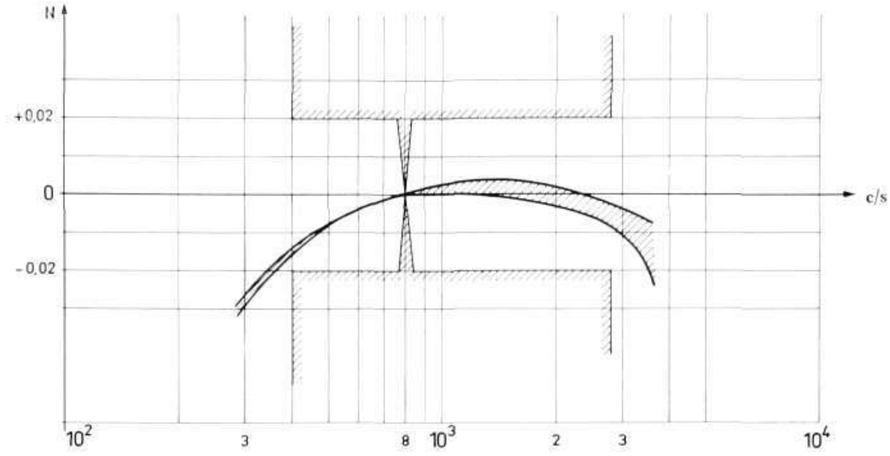



**Fig. 8** X 8421

**Frequency response of level measuring set**

The shaded area indicates the deviation due to variation of the ambient temperature between + 5 and + 50° C for six prototypes.

| | |
|---|---|
| Operational sensitivity | approx. 1 mN |
| Accuracy (with newly calibrated equipment) | |
| at 800 c/s | better than ± 0.02 N |
| at 400 and 2,800 c/s | better than ± 0.04 N |

## *Noise Measuring Set*

| | |
|---|---|
| Duration of measurement | 5 ± 1 s |
| Level | − 6 N, − 5 N or − 4 N (the set issues a signal when the r.m.s. value of the noise voltage measured during 5 ± 1 s exceeds the specified threshold) |
| Frequency range | 50−5,000 c/s |
| Frequency response | as per CCITT recommendations |
| Impedance | 600 ohms, balanced |
| Deviation of square-law characteristic from a parabola measured as per CCITT recommendations | ≦ ± 0.02 N |
| Linearity | as per CCITT recommendations |
| Accuracy (with newly calibrated equipment) | better than ± 0.03 N at 800 c/s (At other frequencies the tolerances of the psophometer curve allowed by CCITT must be added.) |
| Delay before the measuring set is ready for a new measurement | approx. 150 ms |

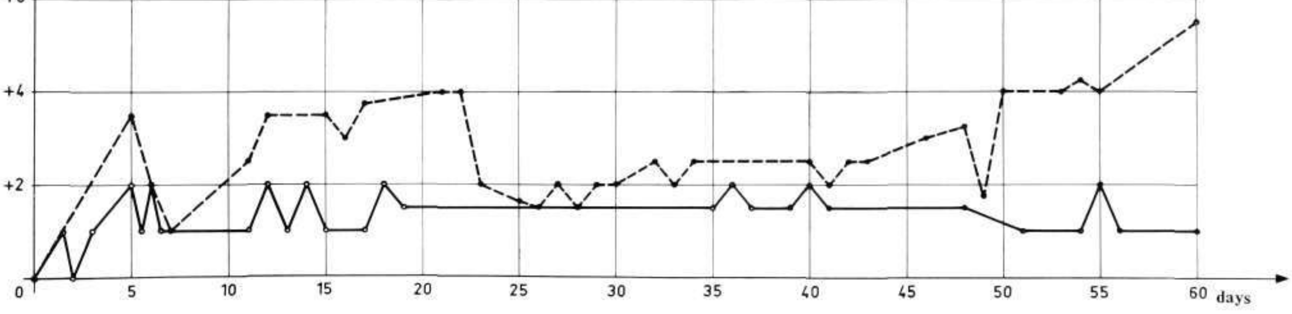
**Fig. 9** X 7865 X 9157

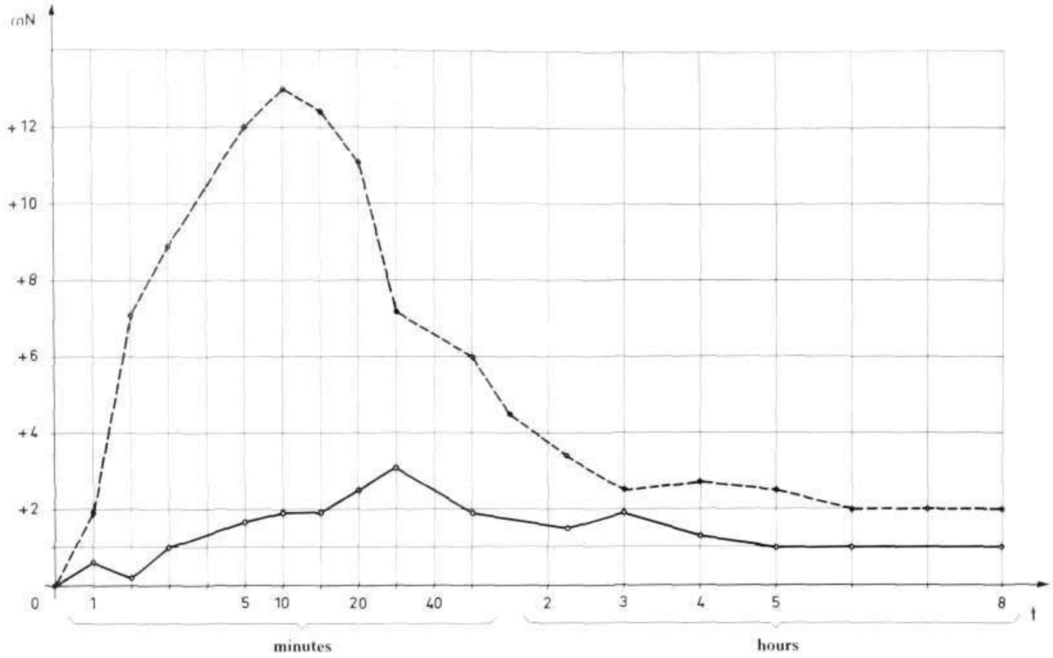
**Long-time stability of the attenuation measuring equipment**

The diagram shows the variation in output level of the sending equipment and the deviation of the level measuring set from nominal during a period of 60 days.

——o——o—— sending equipment

— —•— —•— — level measuring set






X 7866
X 9157

**Fig. 10**

**Stability of the attenuation measuring equipment when first put into service**

The diagram shows the variation in output level of the sending equipment and the deviation of the level measuring set from nominal during its first 8 hours in service.

——○——○—— sending equipment
—◆—·—◆—— level measuring set

## Conclusion

The automatic transmission measuring equipment for telephone circuits is designed to assist telephone administrations in their efforts to automatize and rationalize the maintenance and supervision work needed for any engineering equipment. As a natural consequence the first thing required of an automatic measuring equipment is long-time stability with at least the same accuracy as possessed by the manual equipments that have been used hitherto. The accuracy of the equipment has been attained through the measuring circuits employed. Through a careful choice of components and circuits—such as the use of transistors as active elements and of amplifiers with very high negative feedback—the requirements of temperature stability and long-time stability have been more than adequately met. The variations in output level of the sending equipment and in accuracy of the level measuring set over a period of two months are shown in fig. 9. The equipment had then been in service around-the-clock *without* recalibration. After another three months' around-the-clock service, i.e. after five months' around-the-clock service *without* recalibration, the accuracy was still within the tolerances recommended by CCITT:

$\pm$ 0.01 N for the sending equipment

$\pm$ 0.02 N for the level measuring set at 800 c/s

$\pm$ 0.04 N for the level measuring set at 400 and 2,800 c/s

$\pm$ 0.35 N for the noise measuring set at 800 c/s

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# Economic Optimum in Design of Loaded and Unloaded Telephone Cables

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UDC 621.3.054.3
LME 8414

*The dimensioning of an unloaded telephone cable for physical circuits is dependent on the desired attenuation and the resistance. But an economic optimum problem is also involved, depending on how the cable cost at the desired attenuation varies with the mutual capacitance and conductor resistance.*

*In the design of a loaded telephone cable consideration must also be paid to a number of technical factors, but an economic optimum problem is again involved. If the plant is treated from this point of view, the dimensioning of the cable can be undertaken separately and on the same principles as for an unloaded cable.*

Since the end of last century, when paper-insulated telephone cables came into use, there have been no major changes in the mutual capacitance. On the other hand the costs of cables have changed through the use of new materials, especially plastics, and through variations in prices of the raw materials. The change in cost of unloaded cables has been particularly great in recent years owing to the great drop in the costs of loading coils, compared with cable costs, as a result of improved coil design.

It was therefore thought advisable to consider the question of telephone cable design as an economic optimum problem based on present cable types and costs.

## Notations and Formulae

The following notations are introduced:

$c$ = mutual capacitance of cable per km

$C$ = mutual capacitance of a loaded section

$r$ = loop resistance of cable per km

$R$ = resistance of a loading coil

$L$ = inductance of a loading coil

$l$ = inductance per km

$g$ = shunt conductance of cable per km

$s$ = length of a loaded section in km

$f$ = frequency

$\omega = 2 \cdot \pi \cdot f$

$f_0$ = cut-off frequency

$\alpha$ = attenuation in N/km

$Z$ = impedance

$v$ = group velocity in km/sec.

For unloaded telephone cable the attenuation at low frequencies is

$$\alpha = \sqrt{\frac{\omega \cdot r \cdot c}{2}} \qquad (1)$$

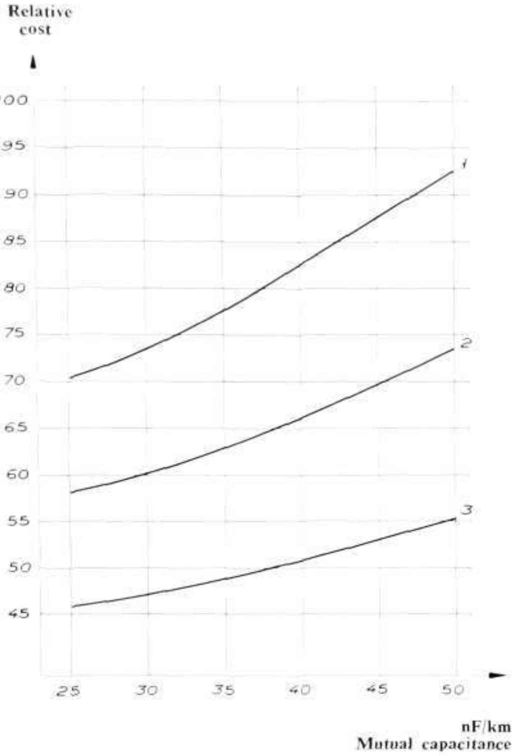


**Fig. 1** X 2707
**Cost of 50-quad paper-insulated star quad cable with lead sheath and polyethylene cover**

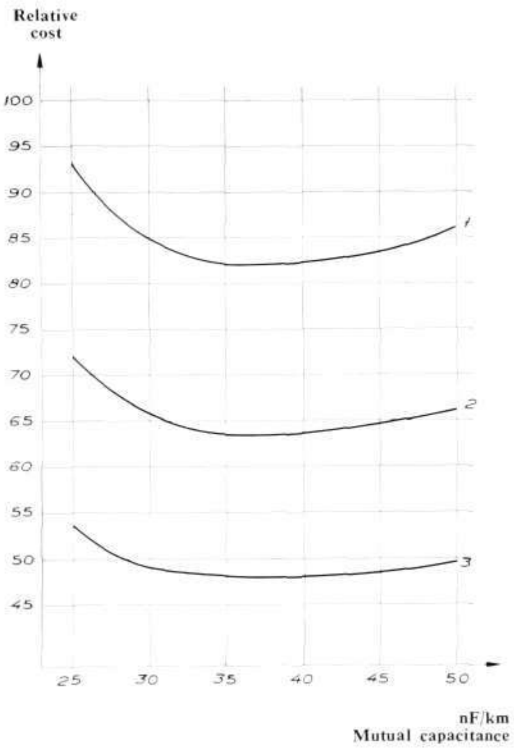


**Fig. 2** X 2708
**Cost of 27-quad polyethylene-insulated screened star quad cable with polyethylene sheath**

For loaded cable the following relations hold:

$$L = l \cdot s \qquad (2)$$

$$C = c \cdot s \qquad (3)$$

$$f_0 = \frac{1}{\pi\sqrt{L \cdot C}} = \frac{1}{s \cdot \pi\sqrt{l \cdot c}} \qquad (4)$$

$$v = \frac{s}{\sqrt{L \cdot C}} = \frac{1}{\sqrt{l \cdot c}} \qquad (5)$$

Eqs. 4 and 5 give

$$s = \frac{v}{\pi \cdot f_0} \qquad (6)$$

$$Z = \sqrt{\frac{L}{C}} = \sqrt{\frac{l}{c}} \qquad (7)$$

Eqs. 3, 5 and 7 give

$$Z = \frac{1}{v \cdot c} \qquad (8)$$

$$\alpha = \left\{\left[\frac{r}{2}\left(1 - \frac{2}{3}\left(\frac{f}{f_0}\right)^2\right) + \frac{R}{2 \cdot s}\right]\sqrt{\frac{C}{L}} + \frac{g}{2}\sqrt{\frac{L}{C}}\right\} \cdot \frac{1}{\sqrt{1 - \left(\frac{f}{f_0}\right)^2}} \qquad (9)$$

The attenuation has its minimum at unchanged values of $r$, $c$ and $g$, when the inductance has been increased so much that

$$\frac{r}{l} = \frac{g}{c} \text{ or } l = \frac{r \cdot c}{g}$$

For technical reasons the loading cannot be increased to the point of minimum attenuation. If, therefore, the degree of loading is increased without change of cable data, this always means a reduction of attenuation.

For rough calculation of loaded cables at low frequencies the attenuation may be written in simplified form:

$$\alpha = \frac{r}{2}\sqrt{\frac{c}{l}} \qquad (10)$$

Introducing the group velocity according to eq. 5:

$$\alpha = \frac{v}{2} \cdot r \cdot c \qquad (11)$$

By making the group velocity a parameter, the attenuation of a loaded cable will be a function of $r \cdot c$ in the same way as the attenuation of an unloaded cable in accordance with eq. 1 is a function of $r \cdot c$.

The group velocity $v_f$ at an arbitrary frequency $f$ within the transmitted frequency band is

$$v_f = v\sqrt{1 - \left(\frac{f}{f_0}\right)^2} \qquad (12)$$

If the highest transmitted frequency is $f_1$ and the lowest is $f_2$, the phase distortion between the frequencies $f_1$ and $f_2$ will be

$$\frac{1}{v}\left[\frac{1}{\sqrt{1 - \left(\frac{f_1}{f_0}\right)^2}} - \frac{1}{\sqrt{1 - \left(\frac{f_2}{f_0}\right)^2}}\right]$$

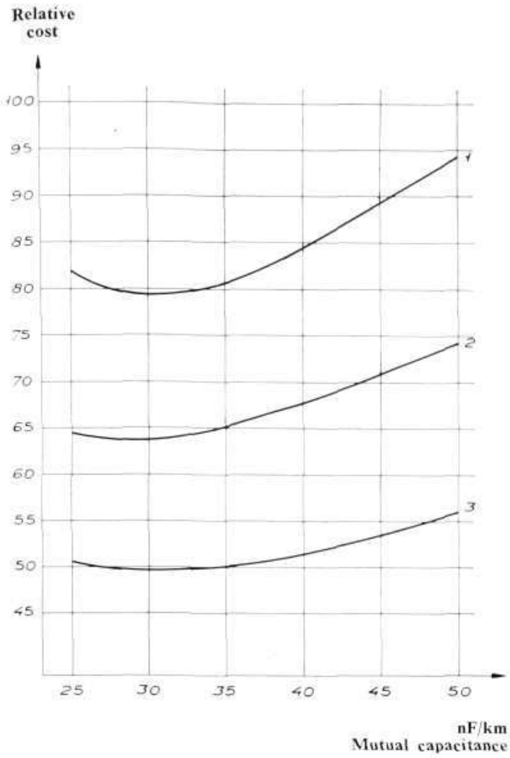


**Fig. 3** X 2709

**Cost of 50-quad paper-insulated multiple twin quad cable with lead sheath and polyethylene cover**

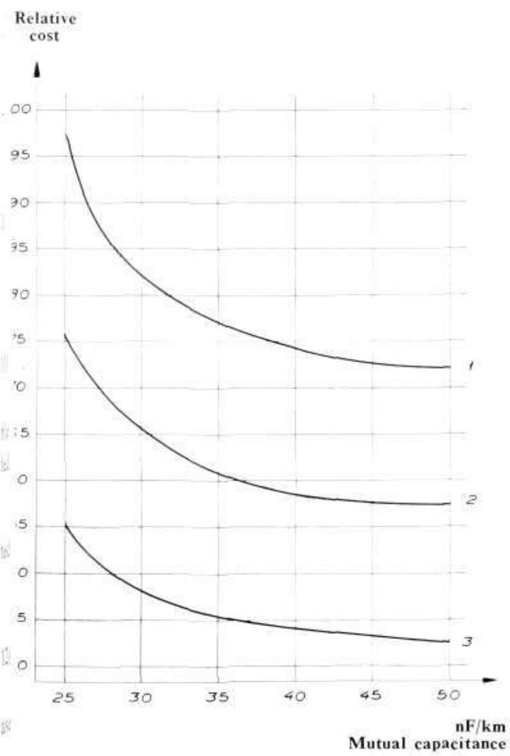


**Fig. 4** X 2710

**Cost of 27-quad polyethylene-insulated screened multiple twin quad cable with polyethylene sheath**

which expression, if $f_2$ is small compared with $f_0$, gives

$$\frac{1}{v}\left[\frac{1}{\sqrt{1-\left(\frac{f_1}{f_0}\right)^2}}-1\right] \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (13)$$

The crosstalk attenuation $A$ between two side circuits with characteristic impedances $Z_1$ and $Z_2$ due to the capacitive coupling is

$$A=\ln\frac{8}{k\cdot\omega\sqrt{Z_1 Z_2}} \text{ nepers} \quad \ldots\ldots\ldots\ldots \quad (14)$$

where $k$ = the capacitive unbalance in pF.

## Unloaded Cable

The variation of cable cost with the mutual capacitance and with the attenuation as parameter is shown in figs. 1–6 for some different types of cable. The mutual capacitance in figs. 1–4 has been taken as the overall average mutual capacitance for a specified cable section (see Technical Specifications for Junction, Trunk, Carrier and Coaxial Cables, BK 2, issued by the Royal Board of Swedish Telecommunications) and in figs. 5–6 as the maximum permissible average capacitance of a length of cable. The curves hold also for loaded cable at a specific relationship between the attenuation and the group velocity in accordance with eq. 11.

**Table 1. Attenuation, group velocity and wire diameter for curves 1—3 in figs. 1—4.**

| Curve no. | Unloaded cable $\alpha$ N/km at 800 c/s | Loaded cable | | | | Wire diameter mm | |
|---|---|---|---|---|---|---|---|
| | | $v$ km/sec. | $\alpha$ N/km | $v$ km/sec. | $\alpha$ N/km | at 25 nF/km | at 50 nF/km |
| 1 | 0.071 | 15,000 | 0.015 | 30,000 | 0.030 | 0.79 | 1.13 |
| 2 | 0.082 | 15,000 | 0.020 | 22,500 | 0.030 | 0.67 | 0.96 |
| 3 | 0.100 | 15,000 | 0.030 | 15,000 | 0.030 | 0.54 | 0.77 |

Attenuation values for unloaded cable and examples of attenuation and group velocity for loaded cable are shown in table 1. The tabulated values relate to curves 1–3 in figs. 1–4. The attenuation values for curves 1–2 in figs. 5 and 6 are given in the same way in table 2. The tables also show the limits of variation of the wire diameter for each curve.

**Table 2. Attenuation and wire diameter for curves 1—2 in figs. 5 and 6.**

| Curve no. | $\alpha$ N/km at 800 c/s | Wire diameter mm | |
|---|---|---|---|
| | | at 35 nF/km | at 60 nF/km |
| 1 | 0.096 | 0.64 | 0.86 |
| 2 | 0.135 | 0.47 | 0.61 |

The curves in figs. 1 and 2 are constructed for star quad cables. Fig. 1 shows the cost of paper-insulated and lead-sheathed underground cable with polyethylene cover. The lowest cable cost is obtained for a mutual capacitance

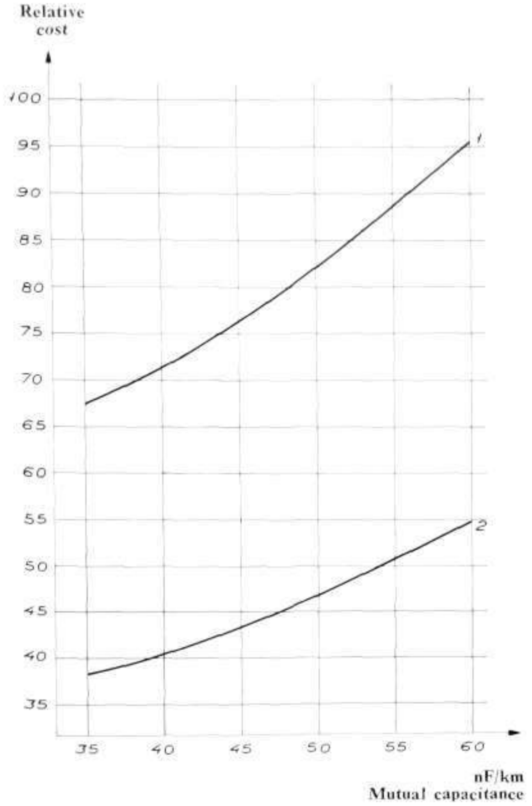


Fig. 5 X 2711

**Cost of 100-pair paper-insulated symmetrical pair cable with lead sheath**

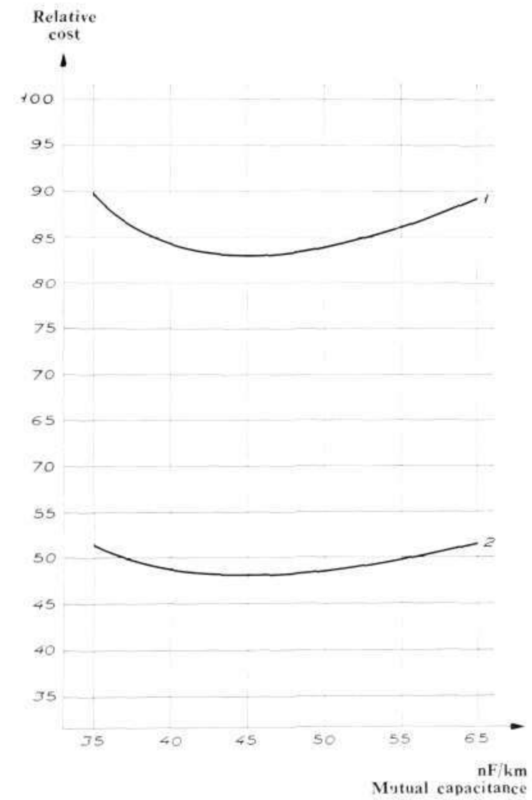


Fig. 6 X 2712

**Cost of 100-pair self-supporting plastic-insulated cable**

below 25 nF/km. Fig. 2 shows the cost of polyethylene-insulated, screened and polyethylene-sheathed underground cable. The lowest cable cost is obtained for a mutual capacitance of about 37 nF/km.

Figs. 3 and 4 relate to multiple twin quad cables. Fig. 3 shows the cost of paper-insulated and lead-sheathed underground cable with polyethylene cover. The lowest cable cost is obtained for a mutual capacitance of about 30 nF/km. Fig. 4 shows the cost of polyethylene-insulated, screened and polyethylene-sheathed underground cable. The lowest cable cost is obtained in this case for a mutual capacitance above 50 nF/km.

Figs. 5 and 6 are constructed for symmetrical pair cables. Fig. 5 shows the cost of paper-insulated lead-sheathed cable, fig. 6 the cost of self-supporting plastic-insulated cable, i.e. polyethylene-insulated polyethylene-sheathed cable with built-in suspension wire and figure-of-eight sheath. The lowest cable cost is obtained for a mutual capacitance below 35 nF/km in fig. 5 and about 46 nF/km in fig. 6.

The curves represent cable types as at present made in Sweden to the specifications of the Royal Board of Telecommunications. The cables in figs. 1–4 comply with the aforementioned Technical Specifications (BK) and in figs. 5 and 6 with Specifications Pa-663 and Pa-672. The materials in the cables are based on present prices, i.e. copper 31 cents per lb, lead 8 cents per lb, and polyethylene 25–26 cents per lb depending on the quality.

The curves are based on cables of normal diameter. For reasonable variations of the cable make-up, and so of the cable diameter, the curves will have the same character. But for very small or very large cables, or for cables with especially small-gauge wires, or in fact for cables which differ considerably in structure from the types described, it is safest to draw up a cost estimate in each particular case.

For paper-insulated cables made with sheaths of other material than lead, e.g. aluminium or steel or solely polyethylene, the curves hold good only if the sheath cost is the same as for the types described. If the sheath cost is lower, the minimum cable cost shifts towards lower capacitance than that shown in the curves. For high sheath cost the reverse applies.

If in plastic-insulated cables the solid polyethylene conductor insulation can be replaced by cellular polyethylene, which results in a cheaper insulation and smaller cable dimensions, and so lower cost of sheath, the minimum cable cost shifts towards lower capacitance than that shown in the curves. The same result follows from a lowering of the price of polyethylene.

A lowering of the price of copper would shift the minimum cable cost towards larger conductor diameter and higher capacitance. The reverse would apply if the price of copper were raised.

It becomes apparent from the curves that for optimum economic design of unloaded paper-insulated cable, a lower mutual capacitance should be used than is usually indicated in cable specifications. This is only on condition, however, that account need not be taken of the resistance and so of the conductor diameter or outside diameter of the cable, which increases with reduction of mutual capacitance for unchanged attenuation. For unloaded plastic-insulated cables, on the other hand, the specified values of mutual capacitance appear to be in the vicinity of those required for optimum economic design.

As regards the actual cable in a loaded cable system the same remarks apply as to unloaded cable, but in this case attention must be paid to the additional technical requirements in respect of loaded cable.

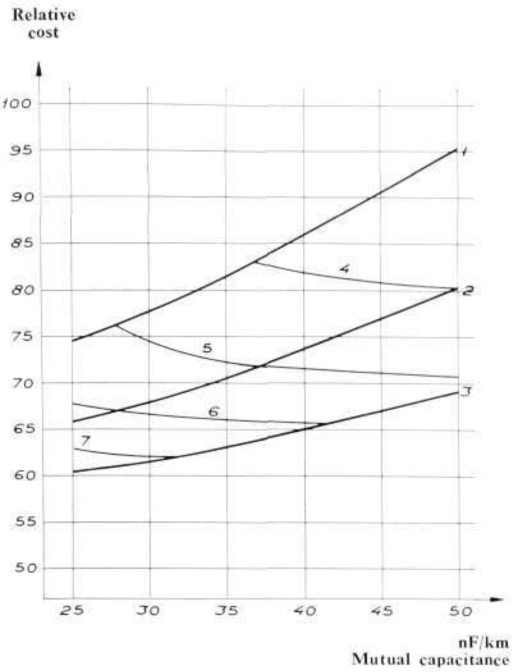


**Fig. 7** X 2713

**Cable and loading cost for 50-quad paper-insulated star quad cable with lead sheath and polyethylene cover**

# Loaded Cable

In figs. 7–10 the sum of the cable and loading costs has been calculated as function of the mutual capacitance at an attenuation of 0.030 N/km and a cut-off frequency of 4,300 c/s for the same types of cables as in figs. 1–4. According to eq. 6 the distance between loading coils is inversely proportional to the cut-off frequency. A high cut-off frequency requires a short distance between loading coils and higher loading costs. Here a cut-off frequency of 4,300 c/s has been chosen, which permits the transmission of frequencies up to 3,400 c/s in accordance with CCITT's recommendations. Curves 1–3 in each figure have been drawn with the group velocity as parameter, and curves 4–7 with the impedance as parameter. Table 3 shows the values of attenuation, cut-off frequency, group velocity and impedance for each curve.

**Table 3. Attenuation, cut-off frequency, group velocity and impedance for curves 1—7 in figs. 7—10.**

| Curve no. | $\alpha$ N/km | $f_0$ c/s | $v$ km/sec. | $Z$ ohms |
|---|---|---|---|---|
| 1 | 0.030 | 4,300 | 30,000 | — |
| 2 | 0.030 | 4,300 | 22,500 | — |
| 3 | 0.030 | 4,300 | 15,000 | — |
| 4 | 0.030 | 4,300 | — | 950 |
| 5 | 0.030 | 4,300 | — | 1,250 |
| 6 | 0.030 | 4,300 | — | 1,700 |
| 7 | 0.030 | 4,300 | — | 2,200 |

The first thing revealed by figs. 7–10 is that the sum of cable and loading costs falls quickly with group velocity, i.e. with heavier loading. In loaded cables in Sweden the group velocity is at present about 18,000 km/sec.; abroad the figure is usually rather higher. For the national part of an international circuit CCITT recommends that the group delay shall not be longer than 50 ms and that the difference between the longest and shortest group delay for the relevant frequency range shall be less than 10 ms. For a distance of 50 km and a group velocity of 18,000 km/sec. the group delay will be about 3 ms and the phase distortion according to eq. 13 at a cut-off frequency of 4,300 c/s and a highest transmitted frequency of 3,400 c/s will be about 1.8 ms. As will be seen, these values are fairly small compared with CCITT's recommendations. And in fact loaded circuits which have a low group velocity compared with carrier circuits are not employed over particularly long distances in national sections of an international circuit. A group velocity of the order of 18,000 km/sec. in a loaded cable plant should, therefore, be fully adequate in the great majority of cases.

If the group velocity alone had to be taken into account, the lowest cost would come at the minimum point of the curve constructed for the lowest conceivable group velocity. But this would involve disregarding the impedance, which cannot be too high in a loaded cable since according to eq. 14 the crosstalk attenuation is inversely proportional to the impedance. For multiple twin quad loaded cables, therefore, the impedance should not be above about 1,600 ohms and for star quad loaded cable not above about 2,000 ohms.

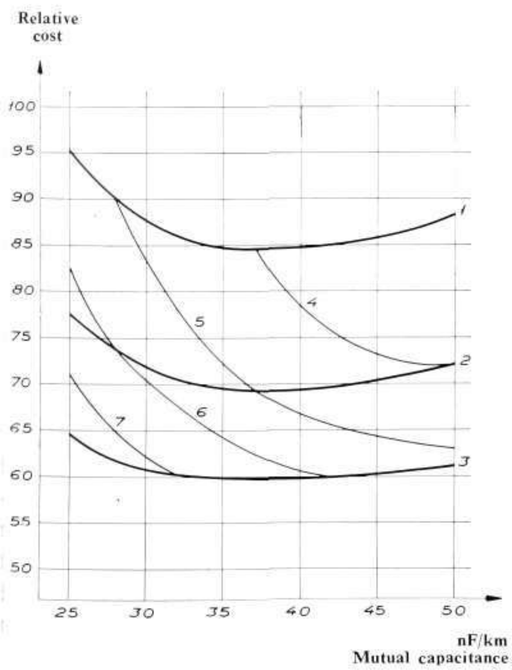


**Fig. 8** X 2714

**Cable and loading cost for 27-quad polyethylene-insulated screened star quad cable with polyethylene sheath**

In figs. 7–10 the slope of curves 4–7 with constant impedance is such that the cost diminishes with increased mutual capacitance. For curves 1–3 with constant group velocity, however, the slope differs according to the type of cable. For paper-insulated cable the lowest cost comes at the point of intersection between the curve for the lowest conceivable group velocity and the curve for the highest conceivable impedance. The Royal Board of Swedish Telecommunications has recently introduced a new form of loading for multiple twin

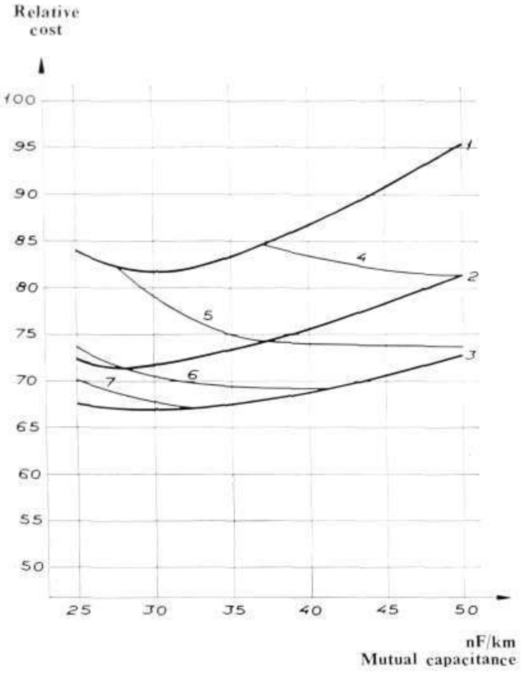


**Fig. 9** X 2715

**Cable and loading cost for 50-quad paper-insulated multiple twin quad cable with lead sheath and polyethylene cover**

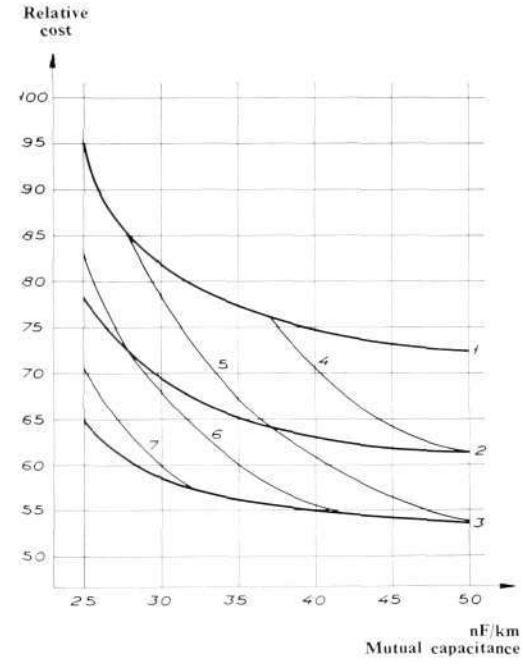


**Fig. 10** X 2716

**Cable and loading cost for 27-quad polyethylene-insulated screened multiple twin quad cable with polyethylene sheath**

quad cable with paper insulation, the impedance being put a 1,600 ohms, the group velocity at 17,000 km/sec., and the cut-off frequency at 4,300 c/s. This gives according to fig. 9 a mutual capacitance of 39 nF/km, which is the figure given in the Swedish cable specifications. Other data are: distance between loading coils max. 1,250 m, coil inductance 118 mH. For the phantom circuits the attenuation is in principle the same as for the side circuits, the coil inductance being 55 mH, which gives an impedance of 850 ohms, a cut-off frequency of 5,000 c/s, and a group velocity of 19,500 km/sec.

For a loaded star quad cable with paper insulation the mutual capacitance according to fig. 7 at a group velocity of 17,000 km/sec. and an impedance of 1,930 ohms is 32 nF/km, which is the figure given in the Swedish cable specifications. Other data for this loading are: cut-off frequency 4,300 c/s, distance between loading coils max. 1,250 m, coil inductance 145 mH.

For plastic-insulated cable (figs. 8 and 10) the slope of curves 1–3 with constant group velocity differs from that for paper-insulated cable. This means that the lowest cost no longer comes at the highest conceivable impedance as happened with paper-insulated cable. Starting, as before, from a cut-off frequency of 4,300 c/s and group velocity of 17,000 km/sec., giving a distance of 1,250 m between loading coils, the lowest cost for a star quad cable (fig. 8) comes at a mutual capacitance of 39 nF/km and an impedance of 1,600 ohms. For a multiple twin quad cable (fig. 10) the corresponding values are 52 nF/km and 1,150 ohms.

If the impedance is increased in a loaded cable with given attenuation, one obtains a higher conductor resistance and so a smaller wire diameter. The same applies to unloaded cable if one chooses low capacitance values.

Various systems of signalling may be employed. D.c. signalling is cheaper, but its usability is limited by the fact that the loop resistance must not be too high. A.c. signalling has a very much greater range than d.c. signalling, but is more expensive; it also requires line transformers.

Loaded multiple twin quad cables, in which the phantom circuits are also utilized, are cheaper per circuit than loaded star quad cables if attention is paid solely to cable and loading costs. On long loaded circuits, on which a.c. signalling must be employed irrespective of quad type, therefore, multiple twin quad cables are cheaper than star quad cables. On fairly short loaded circuits, on the other hand, d.c. signalling can be used with star quad cables, and these may then be cheaper than multiple twin quad cables. In such cases, to limit the loop resistance, it may be necessary to use a lower impedance in the loaded star quad cable than would be desirable from the point of view of optimum economic design.

# SIKATEN — a New Insulating Material

B GUSTAFSSON, SIEVERTS KABELVERK AB, SUNDBYBERG

UDC 621.315.616.96
LME 5546

*Polyethylene is widely used in the manufacture of telephone cable owing to its good electrical properties. Its use in power cables, on the other hand, has been limited by its low melting point, 105–115° C.*

*By cross-linking of the molecules in the plastic in roughly the same way as in the vulcanization of rubber, a new material has been created, SIKATEN*, which does not melt but carbonizes at 250–300° C.*

Polyethylene has been used in cable-making for several decades and its consumption is growing at an ever increasing rate.

Factors which have contributed to the popularity of this plastic—apart from the fact that its production started at an early stage—have been its low price, good electrical properties, ease of processing and dyeing, and its insusceptibility to chemical action.

The great disadvantage of polyethylene, on the other hand, is its low softening and melting temperature, 105–115° C. Many attempts have been made to overcome this problem and some progress was achieved during the fifties through improved production methods which yielded a more uniform product with higher degree of crystallization and fewer molecular branches. A larger size of molecule with lower melting index is also a step in this direction.

These modifications did not, however, lead to any essential improvement. It is all the more gratifying, therefore, that a chemical vulcanization process has now been brought to the stage at which it is technically fully possible to make products of vulcanized polyethylene in conventional equipment for the manufacture of rubber. For this reason the product is said to be vulcanized, but other adequate designations are cured or cross-linked polyethylene.

The insusceptibility of polyethylene to take part in chemical reactions is due to its almost complete lack of double bonds and polar groups. The belief was long held, therefore, that cross-linking of the finished material could be effected only under very special conditions. It was found at an early stage, for example, that by irradiating polyethylene with electrons it could be given properties indicative of cross-linkage, such as lesser solubility in xylene, change of tensile strength, and better temperature stability.

Several irradiation processes have been developed in the cablemaking industry which to some extent are being successfully employed. But cross-linking of polyethylene by irradiation requires rather large dosages of high energy radiation, so that the procedure is expensive and can only be used for special purposes.

Another way of cross-linking polyethylene is to irradiate the plastic with ultraviolet light. In order that the irradiation shall be effective, a small quantity of UV-sensitive material such as benzophenone must be admixed with the plastic. Under the influence of ultraviolet light on benzophenone a radical is formed of the same type as in the decomposition of peroxide by the radical mechanism. Organic peroxides have long been used for cross-linking of plastic and rubber, e.g. polyester and silicon rubber. Since the late fifties much work has been done in the attempt to cross-link polyethylene with peroxides and we now possess a considerable knowledge of this interesting subject.

Sieverts Kabelverk has closely followed these developments both by keeping a watch on the literature and by devoting several years to experiments in the laboratory. Sieverts was therefore the first cable manufacturer in Sweden to introduce and gain practical experience of vulcanized polyethylene, SIKATEN.

* Trade name of Sieverts Kabelverk's vulcanized polyethylene.

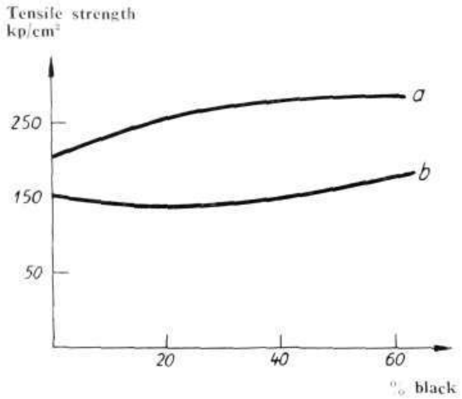


**Fig. 1** X 2699

**Tensile strength as function of black content**

(LD polyethylene, MT black)
a unvulcanized polyethylene
b vulcanized polyethylene

## Composition and Processing

For the preparation of a polyethylene mixture for vulcanization one usually starts from LD polyethylene with a fairly low melting index. HD polyethylene can admittedly be used but has no particular advantage over LD polyethylene, which is cheaper.

For outdoor applications a few per cent of carbon black is usually admixed with the polyethylene as protection against oxidative disintegration, and it is therefore natural that carbon black—polyethylene mixtures have attracted great interest. The admixture of large quantities of black, e.g. 60 %, in unvulcanized polyethylene improves its mechanical properties to some extent (fig. 1), but on the other hand the material becomes stiff and brittle. The reason for the brittleness is that the polyethylene has a great tendency to crystallize. The crystalline regions give off filler, carbon black, to the amorphous part. It has been found that the carbon black content in the amorphous part may be twice as high as in the crystalline, and the result is stress corrosion with tendency to rupture.

Larger quantities of black have a greater effect in improving the mechanical properties of vulcanized than of unvulcanized polyethylene (fig. 1). This is because, in being vulcanized, apart from reacting with itself, the polyethylene is also linked chemically to the black. There is no tendency to brittleness in this case in view of the lesser susceptibility to crystallize.

For vulcanized polyethylene used as insulating material a black of fairly large particle size, for instance type MT, is employed. A finer black results in too great a deterioration of the electrical properties.

Apart from black, small quantities of antioxidants, usually nitrogen compounds, are used to protect the polyethylene from oxidative disintegration, especially if the product is to be exposed to high temperatures during a long period. These antioxidants must be chosen with great care since they have often been found to have a disturbing effect on the vulcanizing process. In the same way as in rubber technology, furthermore, additions of different types may be used to modify a particular property of the final product or to improve the workability.

One of the difficulties in chemical vulcanization of polyethylene is to find a peroxide which is so stable that it can be admixed in the compound from which the finished product is to be made. At the same time it is required that the decomposition, when it starts at an elevated temperature, shall proceed rapidly and uniformly so as to ensure quick and efficient vulcanization.

An additional condition, of course, is that the decomposition products of the peroxide do not affect the properties of the final product.

The ingredients are usually mixed in a Banbury mixer. To ensure good dispersion of the black the temperature is raised to a level well above the melting point of polyethylene, for instance to 150–170° C.

## Properties of Vulcanized Polyethylene

As already stated, ordinary unvulcanized polyethylene has been widely used in cable manufacture thanks to its excellent electrical properties, its resistance to moisture, its lightness and flexibility, its good mechanical properties, its resistance to cold, chemical stability, resistance to ozone, and low price.

The chief disadvantage of unvulcanized polyethylene is its low softening temperature (105–115° C) and, to some extent, its poor fire resistance, its tendency to crack on contact with certain organic surface-active elements (stress-cracking), and its poor dimensional stability owing to the crystallizing tendencies of the plastic.

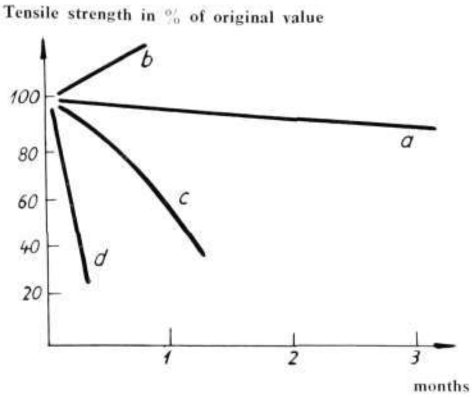


Fig. 2 X 2700
**Ageing in hot air at 120° C**

a SIKATEN
b PVC
c Butyl rubber
d Natural rubber

Vulcanized polyethylene retains all the good properties of the original material in practically unchanged state. Some deterioration of the electrical properties as a result of the addition of black is inevitable, but the material is nevertheless superior in this respect to most other plastics that are used for cable insulation.

Vulcanized polyethylene carbonizes at 250–300° C without melting. The stress-cracking tendency of unvulcanized polyethylene has entirely disappeared and the dimensional stability and fire resistance have appreciably approved, the latter thanks to the addition of black. The vulcanized material also has exceptionally good resistance to ageing in hot air.

The properties of SIKATEN are listed in table 1. The properties of butyl rubber, natural rubber and PVC (normal cable-insulating grades) are shown for comparison.

**Table 1.**

| | SIKATEN | LD poly-ethylene | Butyl rubber insulation | Natural rubber insulation | PVC insulation |
|---|---|---|---|---|---|
| Ultimate tensile strength ($kp/cm^2$) | 140 | 140 | 40 | 100 | 150 |
| Ultimate elongation (%) | 200 | 400 | 400 | 400 | 250 |
| Dielectric constant (50 c/s) | 5.0 (2.3) | 2.25 | 3.5 | 3.5 | 7 |
| Power factor (50 c/s) | $1 \times 10^{-2}$ ($5 \times 10^{-4}$) | $1 \times 10^{-4}$ | $1 \times 10^{-2}$ | $2 \times 10^{-2}$ | $4 \times 10^{-2}$ |
| Volume resistivity Ω cm | $10^{15}$ ($10^{16}$) | $10^{16}$ | $10^{15}$ | $10^{14}$ | $10^{14}$ |
| Breakdown strength kV/mm (50 c/s, 1 kV/s) | 15 (25) | 25 | 25 | 25 | 30 |
| Cold resistance | Excellent | Excellent | Good | Excellent | Poor |
| Abrasion resistance | Excellent | Excellent | Poor | Moderate | Good |
| Tear resistance | Excellent | Excellent | Moderate | Poor | Excellent |
| Moisture resistance | Excellent | Excellent | Good | Moderate | Good |
| Resistance to deformation at 150° C | Excellent | Melts | Moderate | Good | Poor |
| Resistance to oils | Good | Moderate | Poor | Poor | Good |
| Fire resistance | Moderate | Poor | Poor | Poor | Excellent |
| *Durability* | | | | | |
| at 100° C | Excellent | Moderate | Good | Poor | Moderate |
| at 120° C | Good | Melts | Moderate | — | Poor |
| at 150° C | Moderate | Melts | Poor | — | — |

The figures in brackets apply to high voltage grades.

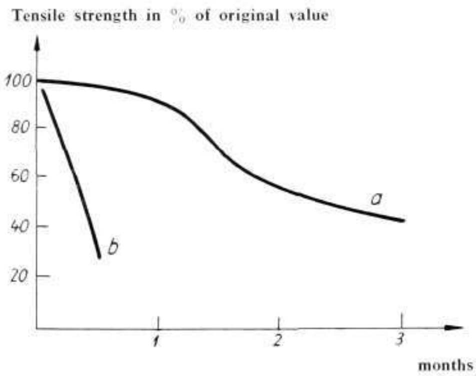


Fig. 3 X 2701
**Ageing in hot air at 150° C**

a SIKATEN
b Butyl rubber

Figs. 2 and 3 show the behaviour of the material on hot air ageing. The tensile strength in per cent of the original value is given as function of the testing time at 120 and 150° C respectively. The curves for butyl rubber, natural rubber and PVC are drawn for comparison at 120° C, and for butyl rubber at 150° C; the two other materials have so poor durability at 150° C that tests at this temperature would be pointless.

The elongation in per cent of the original value follows the tensile strength curves, generally speaking, except for PVC, for which the elongation diminishes and the tensile strength increases.

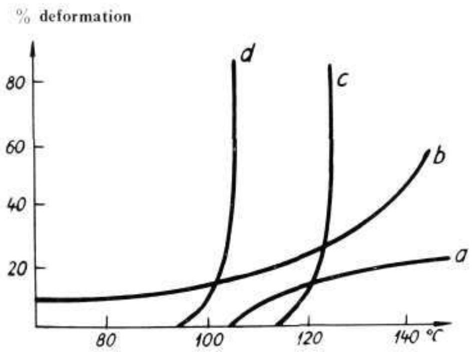


Fig. 4 X 2702
**Deformation test**
according to ASTM D 734

a SIKATEN
b PVC
c HD polyethylene
d LD polyethylene

The good mechanical properties of vulcanized polyethylene at elevated temperature may be illustrated by deformation tests as specified in ASTM D 734 (fig. 4). The curves for LD and HD polyethylene and for PVC are shown by way of comparison.

Deformation tests in accordance with Swedish specifications SEMKO 8A 1957, § 11, have been performed on 2.5 $mm^2$ cable insulated with vulcanized polyethylene, butyl rubber and PVC at 150° C and 2 hours loading. The deformation of vulcanized polyethylene was 5 % at 300 g, while for butyl rubber and PVC it was as much as 70 % and 100 % at 300 g and 175 g, respectively.

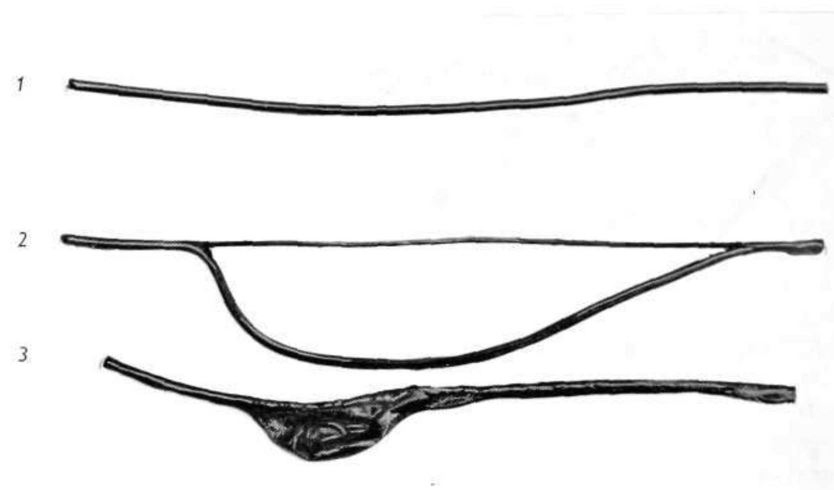


Fig. 5 X 8243

**Comparative current loading tests**

1 SIKATEN 420° C 10 mins.
2 Butyl rubber 320° C 10 mins.
3 PVC 220° C 10 mins.

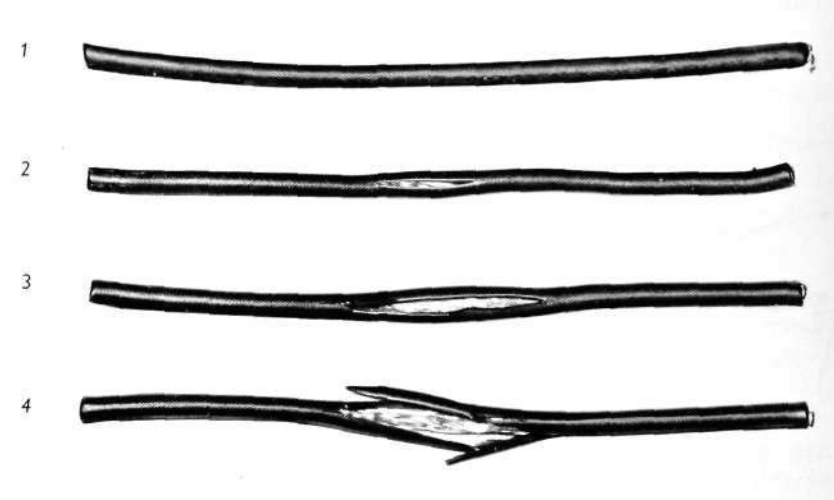


Fig. 6 X 8424

**Low temperature impact tests, weight 350 g, drop 600 mm**

1 SIKATEN — 40° C
2 PVC — 20° C
3 PVC — 25° C
4 PVC — 40° C

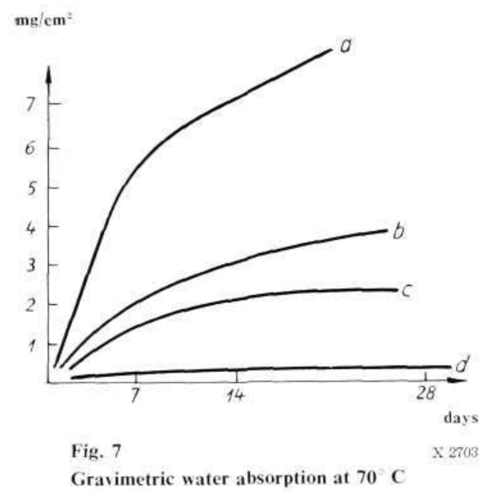


Fig. 7 X 2703

**Gravimetric water absorption at 70° C**

a Neoprene rubber, b Butyl rubber, c PVC, d SIKATEN

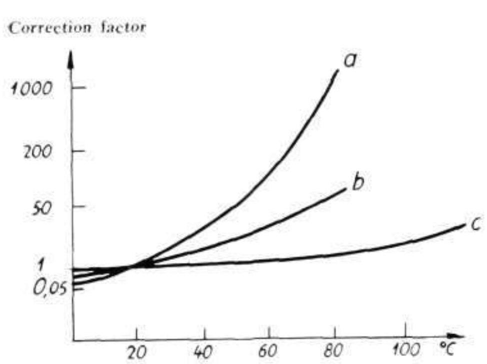


Fig. 8 X 2704

**Temperature dependence of conductivity relative to value at 20° C**

a PVC, b Butyl rubber, c SIKATEN

To see how a cable behaves under overload—short-circuiting—comparative current loading tests were made on 2.5 mm² cables insulated with vulcanized polyethylene, butyl rubber and PVC (fig. 5).

The good low temperature stability of vulcanized polyethylene compared with PVC is illustrated in fig. 6.

The new material has a very low water absorption even at elevated temperature (fig. 7). Its electrical properties are therefore little affected by moisture.

Fig. 8 shows the dependence of the insulation resistance of SIKATEN on temperature, compared with PVC and butyl rubber. The impaired resistance of insulating materials at elevated temperature is an important factor when cables are used at high temperatures.

## Cable Applications

The temperature stability of most of the traditional rubber and plastic materials for cables is so limited that they are placed in the 60–80 degree class. By using a polymeric plasticizer in PVC it has been possible to bring one grade of PVC up into the 100 degree class. But what was gained in high temperature stability was lost in low temperature stability. To get above 100° C a material in a quite different price class must be used. The difference in price between PVC and silicon rubber, which is next superior to 100 degree PVC and can be used up to 170° C, is 5 dollars per kg.

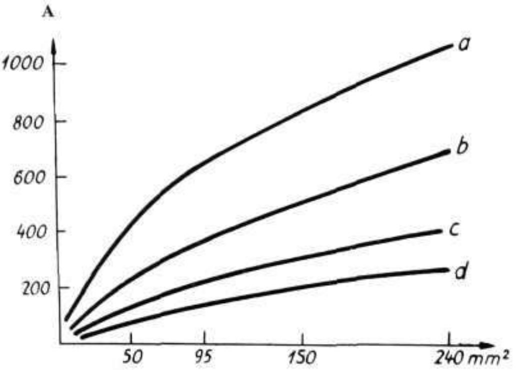


**Fig. 9** X 2705

**Permissible load in amps. on single core cable at 45° C ambient temperature**

a Silicon rubber (max. 170° C)
b SIKATEN (max. 120° C)
c Butyl rubber (max. 80° C)
d Natural rubber (max. 60° C)

**Fig. 10** X 2706

**Spot lights in modern provisions store**

The maximum temperatures normally specified for the most common cable insulations and for SIKATEN are listed in table 2. It will be seen that a considerably higher working temperature is obtained for cable insulated with SIKATEN. This means that a smaller SIKATEN-insulated cable can be selected for the same current loading.

**Table 2**

| Loading | Working temperature, °C, for cable insulated with | | | | | | |
|---|---|---|---|---|---|---|---|
| | SIKATEN | LD polyethylene | PVC 100° | PVC normal | Butyl rubber | Natural rubber | Paper |
| Normal .... | 120 | 65 | 100 | 65 | 80 | 60—75 | 85 |
| Short-circuit . | 250 | 90 | 150 | 135 | 200 | 150—200 | 200 |

Fig. 9 shows the loading capacity of single core cable with different insulations and designed for an ambient temperature of 45° C.

Cables and cords are often designed chiefly on the basis of mechanical stress. Since vulcanized polyethylene has very good mechanical properties, it may be expected that insulations with this material can in due course be reduced in thickness, so bringing a further saving in cost.

From what has been said it is apparent that vulcanized polyethylene should find a very wide range of applications for cable insulations which are today made of natural rubber, butyl rubber, polyethylene and PVC, e.g. for ships' cable, connecting wire, ignition cable, feeder cable for electric furnaces, and remote control cable for industry with severe local conditions such as high temperature and strongly corrosive atmosphere. Thanks to its excellent electrical properties vulcanized polyethylene should also be of value for high voltage applications; compared with PVC and butyl insulation it is subject to lower loss and allows a higher working temperature.

Fields in which tests have already shown SIKATEN-insulated cable to give excellent results are as heating cable for special purposes and as Turkish bath cable.

SIKATEN-insulated cable is also used for leads in electric motors. It stands up well to the stresses caused by sharp metal edges at high temperatures.

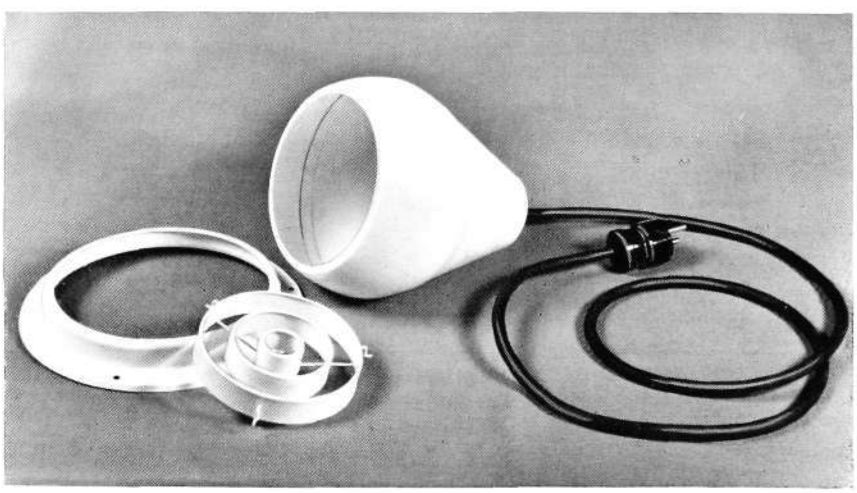

**Fig. 11** X 8425

**Spot light and cable with SIKATEN insulation**

Fig. 10 shows how the lighting can be arranged in a modern provisions store with spot lights. The lamp fitting is attached to a ventilated ceiling and the part of the shade which enters the ceiling must therefore not contain ventilating holes (fig. 11). There has earlier been great difficulty in the use of ordinary installation cable at the high temperatures encountered with this type of fitting. The advent of SIKATEN cable has therefore been greeted with satisfaction.

It has been said in the cable industry that vulcanized polyethylene is without exaggeration the most significant innovation in the materials field in the last 15 years. Considering that innumerable new materials are developed every year, it will be appreciated that high expectations are placed on vulcanized polyethylene, which may be said to meet a great and long felt need.

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# Universal, All-Plastic Cable Terminal Box

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UDC 621.315.673
LME 7375

*L M Ericsson's Network Department has developed a new, universal type of cable terminal box which can be used in all climates, on a wall or pole, indoors or outdoors, and is suited both for plastic-insulated and for paper-core lead-covered cables. Requiring no maintenance, and having a wide range of applications, the box is calculated to reduce the total initial and operating costs of a telephone network.*

**Fig. 1** X 2738
**The new distribution box on a tubular steel pole**

Between the multipair cable from the exchange and the single-pair subscriber lines there is always a distribution point. At this point a distribution box is placed which terminates the cable and permits a quick and effective connection to be made between the cable conductors and the distribution pairs. This is required irrespective of whether plastic-insulated or paper-core lead-covered (PCLC) cable is used in the cable network, whether the distribution point is indoors or outdoors, on a wall or pole, and irrespective of the type of distribution system and size of the network. The distribution box may therefore be said to constitute the least common denominator of the city cable plant.

To shorten the expensive distribution lines, there should be a large number of distribution points strategically spread throughout the entire city network. The number of line pairs per distribution point should therefore be restricted, suitably to 10 pairs. The percentage of fill for these pairs will then generally be low. The capacity on a pair basis will be roughly double that of the exchange capacity.

A suitably designed distribution box, combining efficiency and low price, and simplifying the manual work to be performed in it, can contribute essentially to reducing the overall initial and operating costs of the network. An appreciable economy in the form of standardization and simplified stockholding would be attained if a single type of cable terminal box could be used in all climates, for pole or wall mounting, and if it were equally well suited to plastic or PCLC cables. Furthermore it may be desirable that the same distribution box should be usable outdoors and indoors.

With these goals in view a cable terminal box has been designed at L M Ericsson's Network Department. The properties of the modern plastics have been utilized for the construction of a universal type of box (figs. 1 and 2) which, with the exception of the terminals of anti-corrosion treated brass, is entirely of plastic.

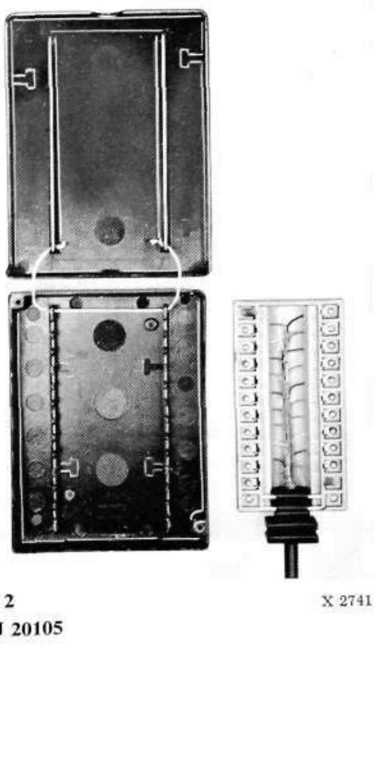


**Fig. 2** X 2741
**NEJ 20105**

The bottom of the box has knock-outs for the admission of the 10-pair cable and the individual single-pair lines. The latter may be brought in from the rear, from the side or from below. The top of the box is attached to the bottom by plastic strings which serve as "hinges". The top is simply pressed onto the bottom and remains in position owing to the resilience of the plastic. In special cases the top may be locked with two screws, likewise of plastic. The single-pair distribution lines, which are assumed to be plastic or neoprene insulated, should preferably be brought in from the side. By placing neoprene bushings, *SRG 12102*, in the holes, the inside of the box is rendered practically dustproof and insectproof. The same facility exists if the single-pair lines are brought in from the rear.

The inner block (fig. 3) carrying the terminals is also of plastic. It is made in three models, with screw terminals or with outward or inward pointing tags for the multipair cable, all models having screw terminals for the single-pair

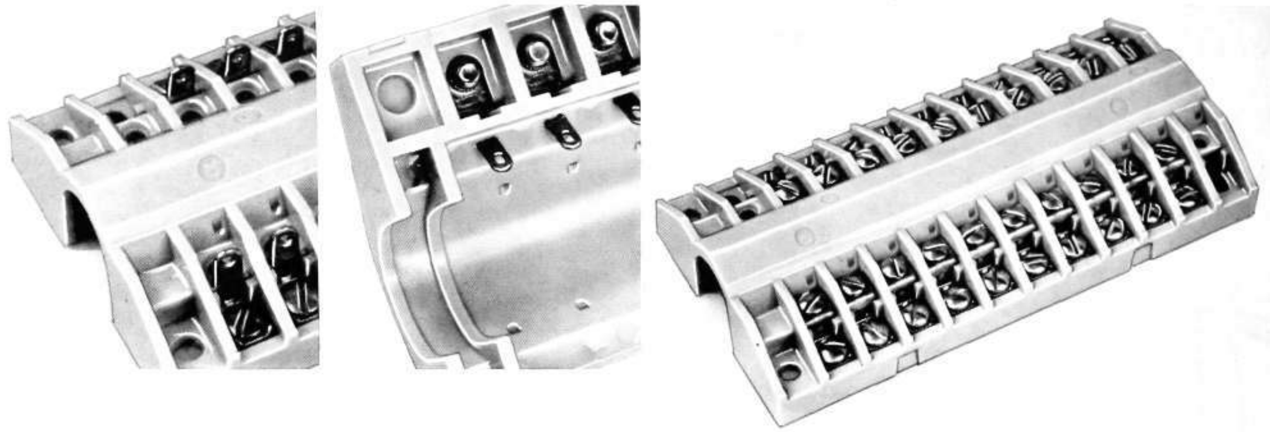


**Fig. 3** X 7882
**The three models of the inner block**
**(From left) NEM 17001, NEM 17005 and NEN 50501**

lines. The design of the box results in long leakage paths between the terminals, which, in conjunction with the plastic material employed, ensures very high insulation. The wires of the single-pair lines may be up to 1.3 mm in diameter. The rear side of the terminal block is shaped as a trough in which the cable can be conveniently placed and which, if desired, can be filled with resin compound. Normally this extra protection is not necessary. A 10-pair plastic cable is brought in through a simple neoprene bushing. PCLC cable is spliced to a sealing thimble in the box (fig. 4) which provides a hermetic seal of the cable end. A PCLC cable may also be placed under continuous pressure (pressurized cable).

To simplify stockholding and to enable the local installation personnel to choose the most suitable combination, the box and certain of its components have been given code numbers. The box is always supplied with the individual single-pair bushings in a separate bag. The fittings for entry of the 10-pair cable may be ordered separately or with the box, and can be supplied for plastic or PCLC cable. The fixing screws, which should be No. 10 wood screws, and the bracket *NSD 51201*, which is used for erection on tubular steel poles, should always be ordered separately. The components with code numbers are tabulated below.

The box is 155 mm high, 116 mm wide and 31 mm deep. It weighs 365 g. Patents are pending.

Fig. 4 X 2739
**NEJ 20122**

| Code numbers | Terminals | Bushing and sealing thimble, if required, for 10-pair cable |
|---|---|---|
| *NEJ 20101* ..... | Outward tag/screw | None |
| *NEJ 20105* ..... | » » » | *670449* for plastic cable |
| *NEJ 20121* ..... | » » » | *655899* + *NDK 1301* for PCLC cable* |
| *NEJ 20131* ..... | Screw/screw | None |
| *NEJ 20135* ..... | » » | *670449* for plastic cable |
| *NEJ 20102* ..... | Inward tag/screw | None |
| *NEJ 20106* ..... | » » » | *670449* for plastic cable |
| *NEJ 20122* ..... | » » » | *655899* + *NDK 1301* for PCLC cable* |

* In these cases the bushing and sealing thimble are supplied connected to the terminal block. The only work to be done on site is to connect the PCLC cable to the conductors projecting from the sealing thimble with an ordinary straight splice. No resin compound filling is therefore required.

# NEWS *from* *All Quarters of the World*

## Distinguished Visitor:

## President Bourguiba at L M Ericsson

The President of Tunis, Mr. Habib Bourguiba, and his wife made an official visit to Sweden at the beginning of June. Their full-packed programme included a call at the Ericsson headquarters at Midsommarkransen.—L M Ericsson, as is known, has very large interests in Tunisia, being responsible for the re-equipping of the Tunisian telephone network.

Being hard pressed for time, the President had only a bare half-hour to spare. He was accompanied by, among others, his Minister of Communications, Mr. Rachid Driss, and Foreign Minister, Mr. Mongi Slim—both well known from previous visits to the head factory—and the Swedish Minister of Communications, Mr. Gösta Skoglund.

The chairman of the board of L M Ericsson, Dr. Marcus Wallenberg, presented an address of welcome, after which Mr. Sven T Åberg gave a brief account of L M Ericsson and its activities. The traditional round was then made of the Exhibition Room, where President Bourguiba demonstrated his interest in many of the exhibits.

The Ericovox was, as usual, in the foreground. In the photograph below Mr. Eric Lundqvist is demonstrating the instrument to the President, with

many interested lookers-on. From the left in the front row, starting from Mr. Lundqvist, are Mr. Rachid Driss, Minister of Communications, Mr. Ahmed Ben Salah, Minister of Finance, Mr. Habib Ben Ammar, Permanent Secretary of the Ministry of Defence, and Mr. Skoglund, Swedish Minister of Communications. Between Mr. Driss and Mr. Ben Salah in the background is seen Dr. Marcus Wallenberg.

President Bourguiba was presented by Mr. Åberg with an Ericovox with Ericofon (picture above) under the glad eye of Mr. Gösta Skoglund.

The photograph at the top shows President Bourguiba inscribing his name for display in the Exhibition Room.

Recife is a highly modern and fast expanding city. (Left) A view of the Santo Antonio district.

(Below) Inauguration of one of the Recife exchanges.

# L M Ericsson Installation for Recife, Third City of Brazil

Recife is Brazil's third largest city, with over 800,000 inhabitants, capital of the State of Pernambuco and main centre in north-eastern Brazil, an area with some 25 million inhabitants. Recife is an important cultural, administrative and commercial centre with a lively harbour. Modern multistorey buildings dominate the centre of the city, which is growing apace. A stark contrast is offered by its neighbouring town and one-time capital of Brazil, Olinda, with its old churches.

The need for satisfactory telecommunications has long been acute. The two towns have been served by an outmoded telephone plant of only some 6,000 lines. In 1960 a newly formed telephone company, Companhia Telefônica de Pernambuco, contracted with Ericsson do Brasil for a new telephone plant for Recife and Olinda, comprising seven exchanges of altogether 20,600 lines of Ericsson Crossbar equipment, and an entirely new cable plant.

The digging of the first underground cable conduits started in May 1960, and since then a very extensive cable network has been laid, principally underground. The exchange equipment has been mostly supplied by the parent company, while Ericsson do Brasil has carried out wiring and testing.

On January 17, 1963, three exchanges totalling 14,000 lines were placed in service. A 1,000-line exchange followed in February, and a 2,000-line exchange in May. The entire project is to be completed by the summer.

Björn Lundvall

## Organizational Changes

Mr. Hugo Lindberg, having attained pensionable age, will retire on July 31, 1963, from his appointments as Executive Vice President and Chief Administrative Officer of the Ericsson Group. The Board of Directors has appointed Vice President Björn Lundvall as his successor.

In order to delegate the responsibilities within the management of the rapidly expanding group, the Board has appointed the following Executive Vice Presidents as from July 1, 1963: Mr. Malte Patricks, Chief Operations Officer; Mr. Christian Jacobæus, Chief Technical Officer; Mr. Arne Stein, Chief Sales Officer; Mr. Hans Werthén, Chief Production Officer.

Mr. Gunnar Svalling, Vice President, Finance, has been appointed an executive officer.

Mr. Nils Svensson, Head of the Personnel Department, has been appointed Vice President.

Mr. Sten Engström, Chief Engineer, has been appointed Head of the Long Distance Division.

At the end of May L M Ericsson had a visit from Liberia. (Above left) Mr. S. H. Butler, Commissioner of Communications, and Mr. L. Grigsby, Inspector of Post and Telegraph, converse on Ericsson telephones from different centuries.

(Above right) Mr. I. Boberg, Sales Manager of L M Ericssons Signal AB, demonstrates a block-controlled model railway to Ceylon's Minister of Industry and Culture, Mr. Maithripala Senanayake, during his visit to Midsommarkransen. In the background are (from left) Consul General B. Hallström, Colombo, and Messrs G. Fernstedt, B. L. Thul, and H. Lindberg of L M Ericsson.

In connection with a lecture, "This is Egypt", by Mr. Adly Fuad Bishara, head of an Egyptian study group at L M Ericsson, the company received a visit from the Embassy of the United Arab Republic in Stockholm. In the photo below Ambassador Salah El-Din Gohar (second from right) is given a demonstration of the Dialog by Mr. E. Lundqvist. With him are (from left) Asst. Chief Engineer Abdulazis Kamel (UARTO), Counsellor Mahmoud Seliem, Personal Secretary Salah Saleh, and Mr. Bishara.

The commercial counsellors and commercial attachés in Stockholm from fourteen countries visited L M Ericsson at the end of May. (Above) The group is listening to an address in the Exhibition Room.

Miss Anna Nymalm of Helsinki recently visited L M Ericsson, Midsommarkransen. She was on her way to Copenhagen, her trip being a departing gift from management and colleagues at the Helsinki Telephone Association, from which she retired on pension at the end of April this year at the ripe age of 94.

**L M Ericsson has acquired new production facilities through the purchase of the ABN-bolagen factory at Bollmora outside Stockholm. The new premises, which will be occupied principally by AB Svenska Elektronrör and Division Erga, have a gross floor area of nearly 200,000 sq.ft. The site has space for new buildings amounting to an additional 270,000 sq.ft. The staff will start moving in this autumn, and the entire Bollmora plant will be occupied during 1964. It is expected that some 600 persons will be working there.**

# Appointment in Danish L M Ericsson

Mr. Frans Liisberg has been appointed Vice President and Executive Officer of L M Ericsson's Danish subsidiary, L M Ericsson A/S, as from April 26, 1963. Mr. L C Nørrelund remains the president of the company.

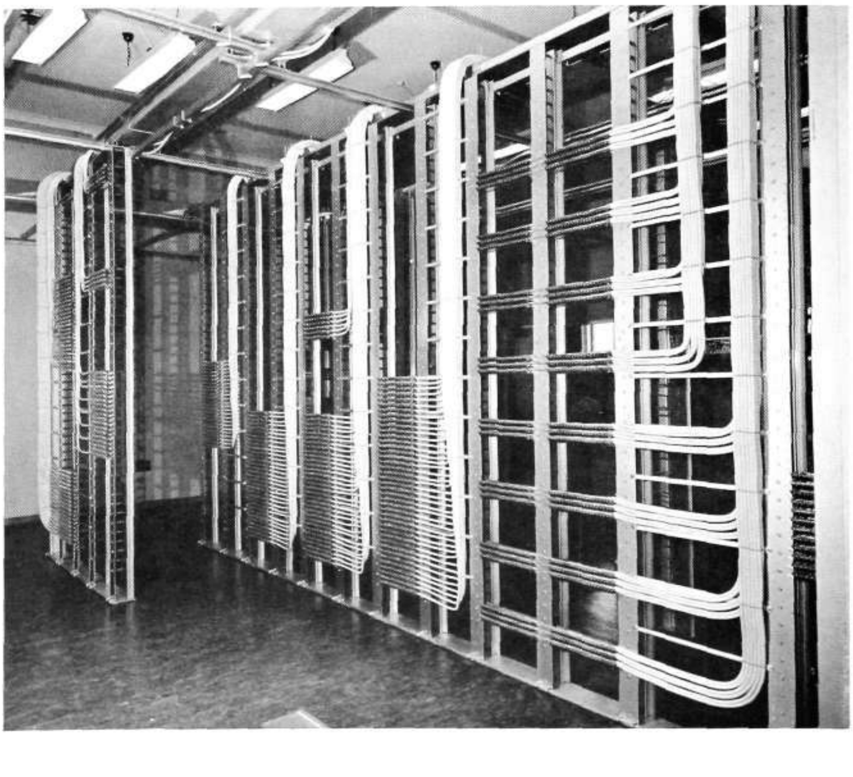
Mr. Liisberg was born at Frederiksberg in 1921. After graduating as M.Sc. in 1945 he joined the company in the same year and has since been engaged on sales to the Danish telephone administrations. He has had an active part in the breakthrough of our crossbar switching technique in Denmark, initiated by the opening of the Aarhus exchanges in 1953 and consolidated to the extent of over 300,000 local lines in service today, with another 200,000 lines on order.

Mr. Liisberg is well-known to many of the group's staff from their numerous visits to Denmark for discussion and negotiations with our Danish clients, and likewise to our customers among the various telephone administrations all over the world which have sent delegates to Denmark to study our crossbar systems.

# New Reference List

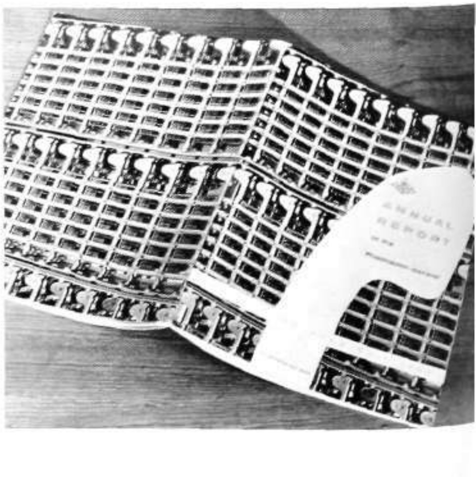
A new reference list of public automatic exchanges has been issued as of January 1, 1963. The number of automatic lines delivered by the Ericsson Group and installed at January 1, 1963, was 4,952,000 as against 4,565,000 one year earlier. The number of lines on order at the same date was 1,514,000. The total of lines installed and on order was 6,466,000 against about 6,000,000 in the previous year.

Of the total lines installed 74 per cent are connected to 500-selector exchanges (78 per cent in the previous year) and 26 (22) per cent to crossbar exchanges. The corresponding figures for lines installed during 1962 are 29 (47) per cent for 500-selector and 71 (53) per cent for crossbar exchanges.



**For the cover of its 1962 Annual Report the Australian Post Office chose an L M Ericsson crossbar switch design as seen below.**

**The Australian telephone network is being rapidly expanded on the basis of Ericsson crossbar. The latest addition to the A. P. O. series of crossbar exchanges is Petersham, Sydney, where 2,800 lines were cut-over on May 18, 1963. The ultimate capacity of the exchange is 8,000 lines. The I.D.F.s are shown in the photo on the left.**



UDC 621.395.343
LME 8342

WIENEKE, G H: *40th Anniversary of Ericsson 500 Line Selector Exchange in Rotterdam.* Ericsson Rev. *40*(1963): 3, pp. 74—77.

On May 10 this year L M Ericsson's oldest 500-selector exchange in the world, at Rotterdam—Delfshaven, Holland, completed 40 years of service. It was Rotterdam that provided the first valuable experience of automatic operation, which proved the advanced design and efficiency of the 500 system. The article gives a resumé of the events which led up to the decision to install this exchange, and of its performance during these 40 years.

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UDC 621.317.74
621.395.73
LME 7121

KARL, H. *Automatic Transmission Measuring Equipment for Telephone Circuits. 2. Measurement of Attenuation and Noise.* Ericsson Rev. *40* (1963): 3, pp. 78—86.

This article follows on from the description of the automatic transmission measuring equipment for telephone circuits in Ericsson Review No. 2, 1963. The present article describes the mode of operation and the units for measuring the circuit equivalent and circuit noise.

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UDC 621.3.054.3
LME 8414

CRONVALL, L: *Economic Optimum in Design of Loaded and Unloaded Telephone Cables.* Ericsson Rev. *40*(1963): 3, pp. 87—92.

The dimensioning of an unloaded telephone cable for physical circuits is dependent on the desired attenuation and the resistance. But an economic optimum problem is also involved, depending on how the cable cost at the desired attenuation varies with the mutual capacitance and conductor resistance.

In the design of a loaded telephone cable consideration must also be paid to a number of technical factors, but an economic optimum problem is again involved. If the plant is treated from this point of view, the dimensioning of the cable can be undertaken separately and on the same principles as for an unloaded cable.

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UDC 621.315.616.96
LME 5546

GUSTAFSSON, B: *SIKATEN — a New Insulating Material.* Ericsson Rev. *40*(1963): 3, pp. 93—98.

Polyethylene is widely used in the manufacture of telephone cable owing to its good electrical properties. Its use in power cables, on the other hand, has been limited by its low melting point, 105–115° C.

By cross-linking of the molecules in the plastic in roughly the same way as in the vulcanization of rubber, a new material has been created, SIKATEN, which does not melt but carbonizes at 250–300° C.

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UDC 621.315.673
LME 7375

ÅBERG, G: *Universal, All-Plastic Cable Terminal Box.* Ericsson Rev. *40*(1963): 3, pp. 99—100.

L M Ericsson's Network Department has developed a new, universal type of cable terminal box which can be used in all climates, on a wall or pole, indoors or outdoors, and is suited both for plastic-insulated and for paper-core lead-covered cables. Requiring no maintenance, and having a wide range of applications, the box is calculated to reduce the total initial and operating costs of a telephone network.

# The Ericsson Group

## *Associated and co-operating enterprises*

• EUROPE •

**Denmark**
L M Ericsson A/S *København F*, Finsensvej 78, tel: Fa 6868, tgm: ericssons

Telefon Fabrik Automatic A/S *København K*, Amaliegade 7, tel: C 5188, tgm: automatic

Dansk Signal Industri A/S *København F*, Finsensvej 78, tel: Fa 6767, tgm: signaler

**Finland**
O/Y L M Ericsson A/B *Helsinki*, Fabianinkatu 6, tel: A8282, tgm: ericssons, telex: 57-12546

**France**
Société des Téléphones Ericsson *Colombes (Seine)*, Boulevard de la Finlande, tel: CHArlebourg 35-00, tgm: ericsson

*Paris 17e*, 147 Rue de Courcelles, tel: CARnot 95-30, tgm: eric

Ateliers Vaucanson, *Paris XX*, B. P. 28.20, tel: MENilmontant 83-40, tgm: atelcanson

**Great Britain**
Swedish Ericsson Company Ltd. *London, W. C. 1*, 329 High Holborn, tel: HOLborn 1092, tgm: teleric

Production Control (Ericsson) Ltd. *London, W. C. 1*, 329 High Holborn, tel: HOLborn 1092, tgm: productrol holb

**Italy**
SETEMER, Soc. per Az. *Roma*, Via G. Paisiello 43, tel: 868.854, 868.855, tgm: setemer

SIELTE, Soc. per Az. *Roma*, C. P. 4024 Appio, tel: 780221, tgm: sielte

FATME, Soc. per Az. *Roma*, C.P. 4025 Appio, tel: 780021, tgm: fatme

**Netherlands**
Ericsson Telefoon-Maatschappij, N.V. *Rijen (N.Br.)*, tel: 01692-555, tgm: erictel, telex: 44-14354

*Voorburg-Den Haag*, 227 Koningin Julianalaan, tel: 81 45 01, tgm: erictel-haag, telex: 31109

**Norway**
A/S Elektrisk Bureau *Oslo NV*, P.B. 5055, tel: Centralbord 46 18 20, tgm: elektriken, telex: 56-1723

A/S Industrikontroll *Oslo 1*, Teatergaten 12, tel: Centralbord 335085, tgm: indtroll

A/S Norsk Kabelfabrik *Drammen*, P. B. 205, tel: 1285, tgm: kabel

A/S Norsk Signalindustri *Oslo*, Bygdø allé 12, tel: Centralbord 56 54 94, tgm: signalindustri

**Portugal**
Sociedade Ericsson de Portugal, Lda. *Lisboa*, 7, Rua Filipe Folque, tel: 57193, tgm: ericsson

**Spain**
Cia Española Ericsson, S. A. *Madrid 13*, Torre de Madrid 3er piso, oficina 9, Plaza de España, tel: 241 1400, tgm: ericsson

**Sweden**
Telefonaktiebolaget L M Ericsson *Stockholm 32*, tel: 19 00 00, tgm: telefonbolaget, telex: 19910

AB Alpha *Sundbyberg*, tel: 282600, tgm: aktiealpha-stockholm

AB Ermi, *Karlskrona 1*, tel: 23010, tgm: ermibolag-karlskrona

AB Rifa *Bromma 11*, tel: 26 26 10, tgm: elrifa-stockholm

AB Svenska Elektronrör *Stockholm 20*, tel: 44 03 05, tgm: electronics

L M Ericssons Driftkontrollaktiebolag *Solna*, tel: 27 27 25, tgm: ericdata-stockholm

L M Ericssons Signalaktiebolag *Stockholm Sv*, tel: 68 07 00, tgm: signalbolaget

L M Ericssons Svenska Försäljningsaktiebolag *Stockholm 1*, Box 877, tel: 22 31 00, tgm: ellem

Mexikanska Telefonaktiebolaget Ericsson *Stockholm 32*, tel: 190000, tgm: mexikan

Sieverts Kabelverk AB *Sundbyberg*, tel: 282860, tgm: sieverts-fabrik-stockholm

Svenska Radioaktiebolaget *Stockholm 12*, Alströmergatan 14, tel: 22 31 40, tgm: svenskradio

**Switzerland**
Ericsson Telephone Sales Corp. AB, Stockholm, Zweigniederlassung Zürich *Zürich*, Postfach Zürich 32, tel: 325184, tgm: telericsson

**West Germany**
Ericsson Verkaufsgesellschaft m. b. H. *Düsseldorf*, Postfach 2925, tel: 844 61, tgm: erictel, telex: 41-8587979

• ASIA •

**India**
Ericsson Telephone Sales Corporation AB *New Delhi 1*, P.O.B. 669, reg. mail: 1/3 Asaf Ali Road (Delhi Estate Building), tel: 272312, tgm: inderic

*Calcutta*, P. O. B. 2324, tel: 45-4494, tgm: inderic

**Indonesia**
Ericsson Telephone Sales Corporation AB *Bandung*, Djalan Dago 151, tel: 8294, tgm: javeric

*Djakarta*, Djalan Gunung Sahari 26, tel: Kota 22255, tgm: javeric

**Lebanon**
Telefonaktiebolaget L M Ericsson, Technical Office *Beyrouth*, Rue du Parlement, Immeuble Bisharat, tel: 252627, tgm: ellem

**Turkey**
Ericsson Türk Ticaret Ltd. Şirketi *Ankara*, Rumeli Han, Ziya Gökalp Cad., tel: 23170, tgm: ellem

*Istanbul*, Istanbul Bürosu, Liman Han, Kat 5, No. 75, Bahçekapi, tel: 22 81 02, tgm: ellemist

• AF

**Egypt (UAR)**
Telefonaktiebolaget LM Ericsson, Egypt Branch *Cairo*, P. O. B. 2084, tel: 497 77, tgm: elleme

**Northern and Southern Rhodesia, Nyasaland**
LM Ericsson Telephone Co. (Pty.) Ltd. (Branch Office of LM Ericsson Telephone Co. Pty. Ltd. in Johannesburg) *Bulawayo, Southern Rhodesia*, P.O.B. 1974, tel: 64 704, tgm: ericsson

**South Africa, South-West Africa**
L M Ericsson Telephone Co. Pty. Ltd. *Johannesburg, Transvaal*, P. O. B. 2440, tel: 975-3615, tgm: ericofon

**Tunisia**
Telefonaktiebolaget LM Ericsson, Technical Office *Tunis*, Boîte Postale 780, tel: 240520, tgm: ericsson

• AMERICA •

**Argentine**
Cia Ericsson S. A. C. I. *Buenos Aires*, Casilla de correo 3550, tel: 33 20 71, tgm: ericsson

Cía Argentina de Teléfonos S. A. *Buenos Aires*, Perú 263, tel: 30 50 11, tgm: catel

Cía Entrerriana de Teléfonos S. A. *Buenos Aires*, Perú 263, tel: 30 50 11, tgm: catel

Industrias Eléctricas de Quilmes S. A. *Quilmes FNGR*, 12 de Octubre 1090, tel: 203-2775, tgm: indelqui-buenosaires

**Brazil**
Ericsson do Brasil Comércio e Indústria S. A. *Rio de Janeiro*, C. P. 3601, tel: 43-0990, tgm: ericsson, telex: Rio 155

**Canada**
LM Ericsson Ltd. *Montreal 9, P.Q.*, 2300 Laurentian Boulevard, City of St. Laurent, tel: 331—3310, tgm: caneric, telex: 1-2307

**Chile**
Cia Ericsson de Chile, S. A. *Santiago*, Casilla 10143, tel: 825 55, tgm: ericsson-santiagodechile

tgm: ericsson

**Ecuador**
Teléfonos Ericsson C. A. *Quito*, Casilla 2138, tel: 16100, tgm: ericsson

*Guayaquil*, Casilla 376, tel: 16892, tgm: ericsson

**Mexico**
Teléfonos Ericsson S. A. *México D.F.*, Apartado 9958, tel: 464640, tgm: coeric

Industria de Telecomunicación S.A. de C.V. *México 6, D.F.*, Londres No. 47, tel: 250405, tgm: industel

**Peru**
Cía Ericsson S. A. *Lima*, Apartado 2982, tel: 34941, tgm: ericsson

Soc. Telefónica del Perú, S. A. *Arequipa*, Apartado 112, tel: 6060, tgm: telefonica

**Uruguay**
Cía Ericsson S. A. *Montevideo*, Casilla de Correo 575, tel: 9-26-11, tgm: ericsson

**USA**
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North Electric Co. *Galion, Ohio*, P. O. B. 417, tel: Howard 8-2420, tgm: northphone-galionohio, telex: 586-U

**Venezuela**
Cía Anónima Ericsson *Caracas*, Apartado 3548, tel: 543121, tgm: ericsson

Teléfonos Ericsson C. A. *Caracas*, Apartado 3548, tel: 543121, tgm: tevela

• AUSTRALIA & OCEANIA •

**Australia**
L M Ericsson Pty. Ltd. *Melbourne C 1 (Victoria)*, 20 Collins Street, tel: 635646, tgm: ericmel

*North Sydney (NSW)*, 182 Blue's Point Road, tel: 92—1147, tgm: ericsyd

Teleric Pty. Ltd. *Melbourne C 1 (Victoria)*, 20 Collins Street, tel: 635646, tgm: teleric

*North Sydney (NSW)*, 182 Blue's Point Road, tel: 92—1147, tgm: teleric

## *Agencies*

• EUROPE •

**Belgium**
Electricité et Mécanique Suédoises *Bruxelles 5*, 56 Rue de Stassart, tel: 111416, tgm: electrosuede

**Greece**
"ETEP" S. A. Commerciale & Technique *Athens 143*, 57, Akadimias Street, tel: 629.971, tgm: aeter-athinai

**Iceland**
Johan Rönning H/F *Reykjavik*, P. O. B. 45, tel: 14320, tgm: rönning

**Ireland**
Communication Systems Ltd. *Dublin 4*, 138 Pembroke Road, Ballsbridge, tel: 680787 tgm: crossbar

**Yugoslavia**
Merkantile Inozemna Zastupstva *Zagreb*, Pošt pretinač 23, tel: 36941, tgm: merkantile, telex: 02-139

• ASIA •

**Burma**
Burma Asiatic Co. Ltd., Ericsson Department *Rangoon*, P.O.B. 1008, tel: 10999, tgm: ericsson

**Cambodia**
The East Asiatic Company Ltd. *Phnom-penh*, P.O.B. 129, tel: 762-1070-1071, tgm: pyramide

**Ceylon**
Vulcan Trading Co. (Private) Ltd. *Colombo 1*, New Caffoor Building, 40, Church Street, tel: 36-36, tgm: vultra

**Cyprus**
Zeno D. Pierides *Larnaca*, P.O.B. 25, tel: 2033, tgm: pierides

**Hong Kong**
The Swedish Trading Co. Ltd. *Hongkong*, P. O. B. 108, tel: 35521-5, tgm: swedetrade

**Iran**
Irano Swedish Company AB, *Teheran*, Khiabane Sevom Esfand 28, tel: 367 61, tgm: iranoswede

**Iraq**
Usam Sharif Company W.L.L. *Baghdad*, Sinak-Rashid Street, tel: 870 31, tgm: alhamra

**Japan**
Gadelius & Co. Ltd. *Tokyo C*, P. O. B. 1284, tel: 408-2131, tgm: goticus, telex: 19079

**Jordan**
The Arab Trading & Development Co., Ltd. *Amman*, P. O. B. 1, tel: 25 981, tgm: aradeve

**Korea**
Gadelius & Co. Ltd. *Seoul*, I. P. O. Box 1421, tel: 2—9866, tgm: gadeliusco

**Kuwait**
Latiff Supplies Ltd. *Kuwait*, P. O. B. 67, tel: 2404, tgm: latisup

**Lebanon**
Swedish Levant Trading (Elie B. Hélou) *Beyrouth*, P. O. B. 931, tel: 231624, tgm: skefko

**Pakistan**
Vulcan Industries Ltd. *Karachi City*, West Pakistan, P. O. B. 4776, tel: 325 06, tgm: vulcan

**Philippines**
U.S. Industries Philippines Inc. *Manila P. R.*, P. O. B. 125, tel: 88 93 51, tgm: usiphil

**Saudi Arabia**
Mohamed Fazil Abdulla Arab *Jeddah*, P. O. B. 39, tel: 2690, tgm: arab

**Singapore and Malaya**
The Swedish Trading Co. Ltd. *Singapore 1*, 42 Chartered Bank Chambers, Battery Road, tel: 94362, tgm: swedetrade

**Syria**
Georgiades, Moussa & Cie *Damas*, Rue Ghassan, Harika, tel: 1-02-89, tgm: georgiades

**Thailand**
Ericsson Agency Office, Telephone Organization of Thailand *Bangkok*, Ploenchitr Road, tel: 57036-8, tgm: telthai

**Vietnam**
Vo Tuyen Dien-Thoai Viet-Nam, *Saigon*, 34 Dai-lo Thong-Nhut, tel: 20805, tgm: telerad

• AFRICA •

**Ethiopia**
Swedish Ethiopian Company *Addis Ababa*, P. O. B. 264, tel: 11447, tgm: etiocomp

**Ghana**
The Standard Electric Company *Accra*, P.O.B. 17, tel: 627 85, tgm: standard

**Kenya, Tanganyika, Uganda, Zanzibar**
Transcandia Ltd. *Nairobi, Kenya*, P. O. B. 5933, tel: 219 31, tgm: transcanda

**Liberia**
Swedish Agencies Liberia Co. *Monrovia*, P.O.B. 506, tel: 745, tgm: salco (Except sales to public institutions)

**Libya**
The Gulf Trading Co. *Tripoli*, P.O.B. 417, tel: 5715, tgm: gultraco

**Mauritius**
Mauritius Trading Co. Ltd. *Port Louis*, P.O.B. 201, tgm: agentou

**Morocco**
Elmar S. A.—SEYRE *Tangier*, Francisco Vitoria, 4, tel: 122-20, tgm: elmar

**Mozambique**
J. Martins Marques *Lourenço Marques*, P. O. B. 456, tel: 5953, tgm: linsmarques

**Nigeria**
I.P.T.C. (West Africa) Ltd. *Lagos*, P.O.B. 2037, tel: 26531, tgm: consult

**Sudan**
TECOMA Technical Consulting and Machinery Co. Ltd. *Khartoum*, P.O.B. 866, tel: 2224, ext. 35, tgm: suteconia

• AMERICA •

**Bolivia**
Johansson & Cía, S. A. *La Paz*, Casilla 678, tel: 2700, tgm: johansson

**Costa Rica**
Tropical Commission Co. Ltd. *San José*, Apartado 661, tel: 3432, tgm: troco

**Curaçao N. W. I.**
S. E. L. Maduro & Sons, Inc. *Curaçao*, P. O. B. 172, tel: 1200, tgm: madurosons-willemstad

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# ERICSSON Review

4
1963

# ERICSSON REVIEW

Vol. XL No. 4 1963

RESPONSIBLE PUBLISHER: HUGO LINDBERG

EDITOR: SIGVARD EKLUND, DHS

EDITOR'S OFFICE: STOCKHOLM 32

SUBSCRIPTIONS: ONE YEAR $ 1.50; ONE COPY $ 0.50


## CONTENTS



On cover: View of the Long Distance Division's Test Room, Telefonaktiebolaget L M Ericsson, Stockholm.

# A United States Air Force Four-wire Electronic Switching Development

F KOZIEN & R C BENOIT, JR., ROME AIR DEVELOPMENT CENTER, GRIFFISS AIR FORCE BASE

UDC 621.395.345
LME 83024

*The Central Offices, Telephone, Electronic AN/FTC-27-29 and AN/TTC-19 & 20 are high speed 4-wire circuit switching equipments which have been implemented by the United States Air Force for universal use in tactical and fixed plant environments. See figs. 1 and 2.*

*Their design is based on the Time-Division-Multiplex Technique and in association with the Highway Switching Principle to provide the switching and transmission network. They are fully transistorized and adaptable for application in local, tandem and long haul switching nodes.*

*The transmission characteristics of this equipment are such that it is directly compatible with any transmission network that consists of HF, VHF, UHF, troposcatter, microwave or metallic circuits with or without carrier multiplex or a combination thereof for processing voice, digital data, graphics, etc., with a quality better than present commercial standards. Its high quality transmission characteristics make it useful for insertion into a military communication system consisting of six tandem links of approximately 6,000 miles, where the length of a typical link may be as much as 2,500 miles.*

*These equipments have been extensively factory and field tested with highly satisfactory results and presently are operational within an integrated system environment performing local and long haul tandem switching functions.*

## Introduction

The requirements and nature of military communications systems are radically changing in light of new technology and operational concepts. Until very recently, practically no automatic switching equipment with alternate routing

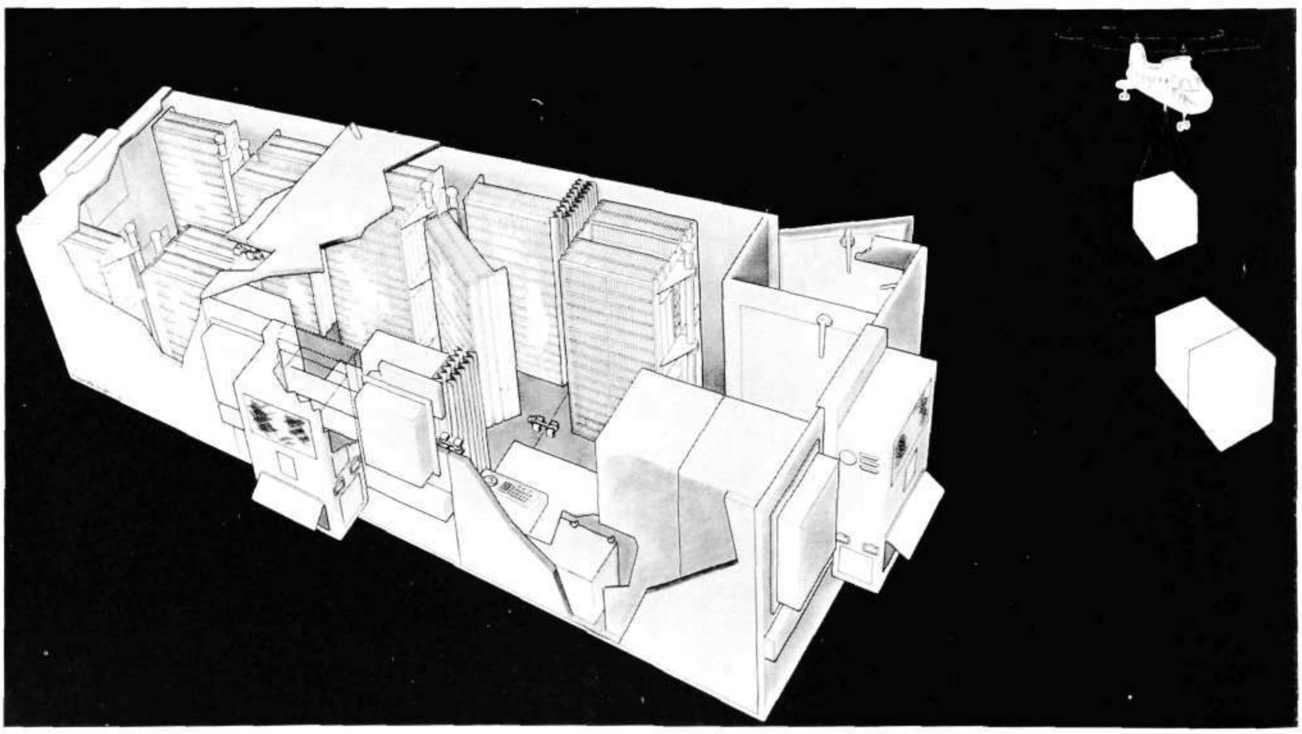


**Fig. 1** X 7891
**Tactical version of Central Office showing shelter design and transportation**

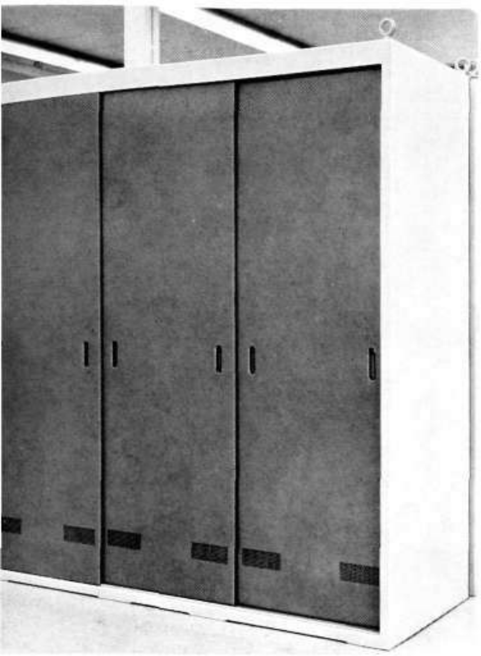


**Fig. 2** X 2751
**Equipment bay housing four racks**

was in operation in the military network. The military network consisted of direct trunks between manual switching centers and point-to-point trunks (hot lines). When alternate routes were found necessary, manual patching or manual re-routing was adopted as the standard mode of operation. Moreover, in the event of critical requirement in the military network, a duplicating alternate back-up facility which duplicated the normal one was provided; one carrying traffic while the other was on stand-by. This mode of operation was slow, unreliable, inefficient and costly and most important, could not cope with the present as well as future tactical and strategic concepts of communication.

Existing commercial equipments did not possess the flexibility, speed, transmission characteristics, features and survivability required to comply with the unique communication requirements for a quick reaction, positive control and real time communication system as imposed by today's nuclear and space age.

To fulfill these requirements, the United States Air Force, in association with the North Electric Co., and its parent organization, L M Ericsson, undertook a task for the design, implementation and production of a fully solid state switching center. The degree of success achieved by this task resulted in the delivery of six fixed plant and nine mobile switching centers for integration into a system complex. At the present time these switching centers are operational in a six-site system configuration and are satisfactorily supporting the intended system operational requirements.

## Discussion

The AN/FTC and AN/TTC series equipments are electrically, operationally and functionally the same, the basic difference being in the packaging and the degree of complement with respect to line terminations, trunk terminations, number of registers, number of highways, etc. The smallest switching center, which is a nominal 100-line system, is a suitably depleted version of the nominal 330 line unit. The largest version provides 504 line appearances, allowing 402 external lines, including trunks. The balance is used for registers, conference circuits, test lines, etc.

## Switching Technique

The switching network utilizes the Time-Division multiplexing technique in combination with the Highway Switching Principle. In accordance with this principle a number of subscriber lines, together with incoming and outgoing trunks, are connected to a common highway by means of individual line contacts. Each incoming highway is interconnected with each outgoing by means of inter-highway contact switches. Switching between any input and output is established by closing the respective line and inter-highway contact switches periodically in synchronism during very short time intervals or time slots. By timesharing the common transmission path in this way, a number of connections corresponding to the number of time slots or pulse positions can be established. A total of 36 line terminations and 20 pulse positions (links) per highway (Full Duplex transmission path) have been found to be suitable from the transmission and traffic handling point of view.

## Transmission

The voice frequency inputs are pulse amplitude modulated (PAM) at a 12.5 kc/s repetition rate which is derived from a 250 kc/s master clock. Each sample is of a 4 microsecond duration and occurs at a frame repetition rate of 80 microseconds. The 4 microsecond sample includes a guard time of 2 microseconds to discharge the highway of any residual charges and ready it for the succeeding pulse position, thus limiting the crosstalk between pulse positions to an absolute minimum. The resonant transfer technique is utilized to transfer energy from input to output with a minimum loss of energy.

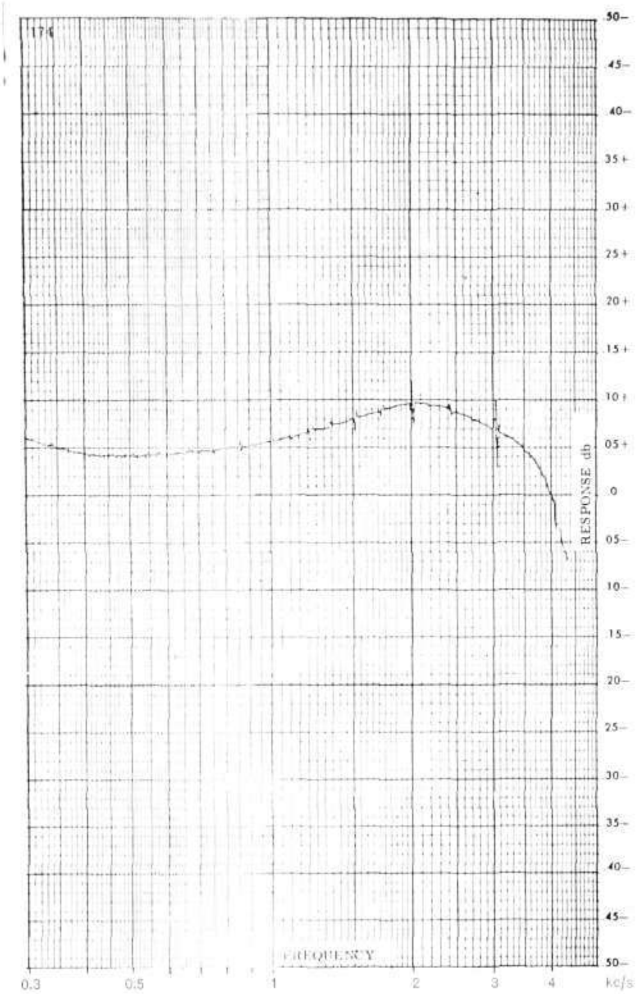



**Fig. 3**
**Response**

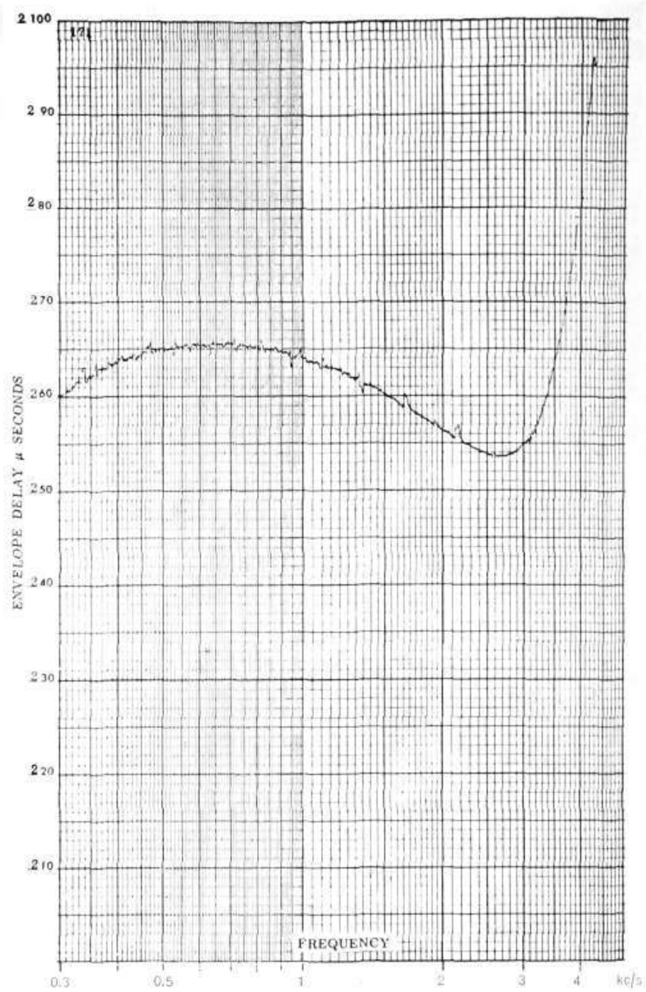



**Fig. 4**
**Delay distortion**

X 7892

## Transmission Characteristics

Typical attenuation distortion (response) and delay distortion curves for a transmission path through the switching center are as shown in fig. 3 and 4.

The attenuation distortion is approximately 0.08 db, while the delay distortion is approximately 10 micro-seconds over the frequency range from 325 to 3,450 c/s.

Insertion loss at 1,000 c/s resulted in a mean value of 0.044 db with a standard deviation of 0.071 db.

An input return loss average of 32.05 db was attained at the low end of the frequency range and 27.23 db at the high end. Corresponding figures for the output return loss were 26.71 db and 39.55 db. It may be mentioned, since these measurements were taken, that additional adjustments of circuit values have further improved the margins at the ends of the frequency band, which are the most critical frequencies for return loss.

Idle channel noise is better than 15 dba (F1A weighting).

Only the worst cases of equal level crosstalk will be mentioned. Other crosstalk levels have been found to be so low that measurement results were obscured by errors in the test equipment. Contrary to what may have been expected, crosstalk from one time slot to the succeeding one is very low (better than 75 db crosstalk attenuation). The worst case encountered is crosstalk between the send and receive circuit of the same connection, often referred to as near-end crosstalk, where the average of 84 measurements was 69 db. The corresponding average figure between other transmission paths in the same or adjacent time slots, but between two highways, was 76.7 db.

Other transmission characteristics that may be of interest are harmonic distortion and intermodulation distortion. The total harmonic distortion at – 4 dbm test tone level averaged – 63 dbm. The r.m.s. sum of intermodulation products due to two equal level test tones of – 7 dbm each, averaged – 57 dbm.

## Functional Capabilities

The specific requirements placed on the equipment have necessitated the incorporation of many special and unique features. A prime feature of the system design as a whole was, however, the degree of reliability and route accessibility which called for a duplication of control equipment and power supplies together with a dispersion of facilities on a number of highways. These and other considerations made the introduction of the following features necessary.

The MDF patching and cross-connection procedures have been superseded by a number group memory of semi-permanent type which allows an arbitrary association of catalogue and exchange line number. The number group also contains code words designating different features which can be associated with a line.

A memory of similar type is used to store routing information for register use. The registers are capable of automatic alternative routing of inter-office calls. One prime and two alternative routes may be provided by the register. At tandem points a restriction code may be introduced to restrict the number of alternatives.

Each trunk group or route may be divided into two parts, one for data transfer and one for normal telephone traffic. This is required due to the incorporation into the system of a data transmission and switching capability.

A feature of the system is that all requests for feature services are checked before execution by the common control equipment. This makes it possible to use only one type of standardized keyset on all telephone instruments, the allocation of facilities being controlled by the number group.

Priority and pre-emption are features which may be allocated any given extension. If all registers are busy, a call from a priority privileged extension will pre-empt a non-priority extension holding a register. Similarily a priority call will pre-empt any non-priority call in progress, should a switching path not be available at the time. Pre-emption extends even to trunks. The priority override and pre-empt feature is only resorted to at the request of the extension at the commencement of a call. All paths and trunks used in a priority connection are priority-marked.

Only one level of priority is allowed.

A short priority pre-empt warning tone is sent to the conversing parties.

A feature of the switching equipment that is unique is the capability for switched hot-line operation used in order to obtain the operational characteristics of a direct connection while retaining the advantages of efficient trunk utilization and alternate routing.

The number of the party to be called from a stored address extension is stored in the number group. This stored address number is transferred to the register immediately the calling party goes off hook, thereby allowing the register to establish an immediate connection with a predetermined subscriber by a direct or alternative route. Extensions programmed for this service are assigned priority privilege and receive priority request from the stored address so as to assure availability of a connection in the event of traffic congestion.

An assistance operator is provided. This service may be accessed by keying 00. From this position foreign networks may be accessed and other operator services performed.

Upon receipt of spurious digits or non-assigned numbers, the calling party is automatically routed to an intercept operator. This also occurs when severe blocking conditions are encountered on trunk calls.

A subscriber may test his own telephone instrument and line equipment by keying a special code (02) which causes the transmit and receive pairs to be interconnected at the exchange. This feature is also used for routine testing of the exchange.

A further feature of the system is its priority ringing signal. The non-priority ringing signal is an intermittent signal while the priority ringing signal is continuous, thus enabling the called party to distinguish between the two. There is also a difference in the phase of the ringing tone but this is used only for interpretation purposes in machine subscriber sets.

All subscribers of the electronic switching center can establish conference calls. Each keyset is equipped with a "C" button which is depressed prior to keying the required subscriber's number. The conference originator controls the conference and can add or change conferees at any time without releasing the conference unit. Conferences may be established either on a priority or non-priority basis. Nine five-party conference circuits are provided.

Conference connections are established through the switching center in the normal way between end instruments and the conference unit. The conference unit is equipped with amplifiers in an active hybrid arrangement, thereby maintaining transmission quality essentially at the same level as that for normal party to party connections.

A portable read-write unit may be connected to the number group or the register translator in order to program the switching center. To enter directory number, class of service and "stored address" information it is connected to the number group, while office code and trunk routing may be entered if it is connected to the register translator. The read-write unit may be used to read, write or erase information in the appropriate memories by operating keys on the control panel.

## Instrumentation

In a system using advanced electronic techniques, the problem of "on-line" maintenance must be given special consideration. This is particularly true when the system, unlike electronic computers, is allowed *no* programmed down-time. To cope with this problem, special emphasis has been given to trouble indication devices and fault location methods. An automatic routine tester is used to continuously monitor the overall performance of the center. It is connected to a line on each highway and sequentially places test calls in all combinations, including simulated trunk calls over a MDF patch loop. It checks levels and frequencies of all supervisory tones encountered and attenuation and phase shift of each established connection, after first testing the noise level on the speech path. Any objectionable crosstalk is also detected in this manner.

Register monitoring equipment enables all registers and receivers to be monitored, tested, blocked and unblocked.

A marker test set is provided to determine the status of the marker at any instant. In the event a marker stops during its program, it will display the address to the instruction memory in the marker at the point of failure. It will also read out the terminal number and directory number of the line involved, and the state of various logic circuits and flip-flop memories, describing the exact state of the equipment at the time of failure. It may also be used to manually step the instruction program and to manually read, write or erase in the contact memory.

While it may appear difficult to trace a call in a TDM switchboard, with the marker test set it is possible to completely trace a call through the center. The marker test set has a built-in search routine which may be applied to the marker. The marker, being able to read the contact memory information, can provide read-outs to the marker test set. Knowing one terminal number to which it is connected, the other may be determined in a matter of seconds as well as the time slot used and other pertinent data.

## Reliability

In order to achieve a high degree of reliability, all common control equipment has been duplicated. In the event of failure of the primary unit, automatic switchover to the standby unit takes place. Included in the common control equipment group for this system are: marker, scanner, number group, pulse distribution, and registers.

## Traffic Metering

An electronic center that uses memory devices is ideally suited for the application of traffic measuring techniques. In this center the line supervision memory contains up-to-date information on the state of any line in the switching center and the number group continuously provides the access number. Advantage is taken of this information storage to provide traffic metering equipment that will, on demand, provide accurate information on the traffic status of the switching center.

## Storage (Memories)

The storage devices are composed of ferrite core matrices. There are two types of memories, the non-destructive and the destructive types.

The non-destructive type is utilized to store semi-permanent information relating to the directory number, class marking, routing, etc., and cannot be destroyed due to power failure or other faulty criteria. The destructive type is utilized to store information which is utilized only for the duration of the call and is erased (cleared) to accept new information for processing new connections. Typical examples are the line supervision memory and the contact memories.

## Numbering Plan

The numbering plan was designed with a maximum number of five digits; the first two for office code and the remaining three digits designating the station number within a particular office.

In order to permit subscribers to key only the 3-digit station code for local calls, the numbering plan was arranged as follows:

| *Office Codes* | *Station Numbers* |
|---|---|
| 5X | 1XX |
| 6X | 2XX |
| 7X | 3XX |
| 8X | 4XX |

*Special Codes*

| | |
|---|---|
| C | Access code for conference |
| P | Code for priority |
| 9X | Reserved for future use (access to foreign networks, etc.) |
| 0X | Access code to operators and special lines |

Note: in the above "X" indicates any digit.

Although 5-digit numbering is needed for inter-office dialling, calls originating and terminating within the same office can be completed by keying either the 3-digit station number or the complete 5-digit directory number.

## Line Signalling and Supervision

Request for service from subscriber lines is accomplished by means of a direct current loop closure as in conventional systems.

Digit signalling from the subscriber instrument to the central office uses multi-frequency tone signals consisting of a dual-frequency tone for each digit and auxiliary signal. The frequencies used are from two groups of frequencies as follows:

| *Group I* | *Group II* |
|---|---|
| 1,020 c/s | 1,620 c/s |
| 1,140 c/s | 1,740 c/s |
| 1,260 c/s | 1,860 c/s |
| 1,380 c/s | 1,980 c/s |

The above frequencies are combined (one frequency from each group) to represent the digits (0–9) in addition to the auxiliary signals in accordance with the following table.

*Table I*

| Digit or Auxiliary Signal | Frequency (c/s) | Comments |
|---|---|---|
| 1 | 1,020 plus 1,620 | |
| 2 | 1,020 » 1,740 | |
| 3 | 1,020 » 1,860 | |
| 4 | 1,140 » 1,620 | |
| 5 | 1,140 » 1,740 | |
| 6 | 1,140 » 1,860 | |
| 7 | 1,260 » 1,620 | |
| 8 | 1,260 » 1,740 | |
| 9 | 1,260 » 1,860 | |
| 0 | 1,380 » 1,620 | |
| P | 1,380 » 1,740 | Priority Request Signal |
| C | 1,380 » 1,860 | Conference Access Signal |

To gain freedom from the d.c. circuit limitations of metallic circuits and for compatibility with non-metallic circuits, d.c./tone signalling converters are provided. These converters automatically detect seize and release signals and convert them to their respective modes.

## Trunk Signalling and Supervision

To handle inter-office calls requiring trunk connections, each trunk line is provided with a voice frequency signal detector in lieu of d.c. loop detecting means. This enables non-physical circuits to be used for trunking. By proper selection of the trunk supervisory signal and by careful design of the voice guard circuit, a single frequency supervision signal has been adopted for both seizure and release between switchboards. The chosen frequency and its characteristic is as follows:

| | |
|---|---|
| Signal | – Frequency 2,400 c/s |
| Seize Signal | – 80 ms plus/minus 20 ms |
| Release Signal | – 600 ms plus/minus 75 ms |

The seizure signal is transmitted as a continuous tone until an acknowledgement re-start or proceed-to-send signal is received. The register will then proceed to transmit the digital information. Each digit is initiated either by a re-start signal or a proceed signal from the receiving center. The proceed signal indicates that the next digit in the sequence shall be transmitted and the re-start signal indicates that the number shall be retransmitted from the beginning. The inter-register digit signals are the same as those used for the subscriber key sets. Upon receipt of a digit the receiving register sends the frequency complement to the originating register by way of acknowledgement.

The complementary acknowledgement and the proceed-to-send signals for each individual digit provides a means of error detecting and checking and insures that the digit has been correctly received. By this means a digit signal which is faulty when received may be called for repeatedly until correctly received. The employment of specific proceed-to-send signals enables the signalling facility to detect missing digits due to premature or faulty dialling or other anomalies, such as fadeouts. In addition to these safeguards, the uniform two-element content of the two-out-of-eight frequency codes is self-checking in itself because the absence of one of the frequency elements or the presence of a third indicates a false signal. The digit frequencies are the same as outlined under line signalling.

## Terminal Instruments

A variety of subscriber sets are being provided together with the electronic switchboard. These subscriber sets are designed to satisfy the specific demands of the various users. A desk subscriber set with push button dialling and tone ringing will normally serve the administrative requirements of the system. Priority ring signal is distinguished as a continuous rather than interrupted signal. This is, however, a feature of the switching center rather than the end instrument (fig. 5). The set will have a priority button so that priority calls can be originated, and a conference button which provides the user with access to the conference facility in the switchboard.

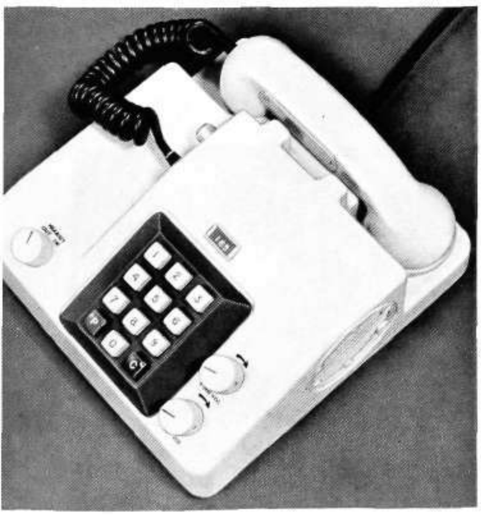


**Fig. 5**
**Desk subscriber set**

X 2752

The second subscriber set is called a field subscriber set, fig. 6, and has all the features of the desk set in addition to being ruggedized to meet all the environmental requirements of a military communication system. In addition, the field subscriber set may be equipped with a local battery for direct point-to-point operation.

The third subscriber set is tailored for radar console usage, fig. 7. It is called a console subscriber set and will be mounted as an integral part of a console. It consists of two parts: a control panel in an island in the center shelf of the console, and a central facility mounted inside the console itself. The control panel provides the operator with a series of push buttons which give him complete control of the audio input and output to his position. The

**Fig. 6** X 8447
**Field subscriber set**
Interior view

central facility houses all the electronics controlled by the operator. The console subscriber set uses a modularized construction in keeping with the remainder of the consoles. The extent of the communication requirement in each console is therefore governable by the task which the console operator has to fulfill. The control panel can have up to seven lines terminating at the switchboard. Two of the lines are for normal telephone calls. The others are reserved for ground-to-air radio sets at any remote location. Associated with each radio line unit will be the stored address of the radio set and the switchboard to which it is connected. When placing a call to an aircraft, the operator will have a visual display of the site from which he can best communicate. He will then select the line unit reserved for that site and push the stored address button for his prime radio set. In the event of radio equipment failure he may instead select a multi-channel radio set at that site by using another stored address for an alternate radio set. He will then use his key punch to channel

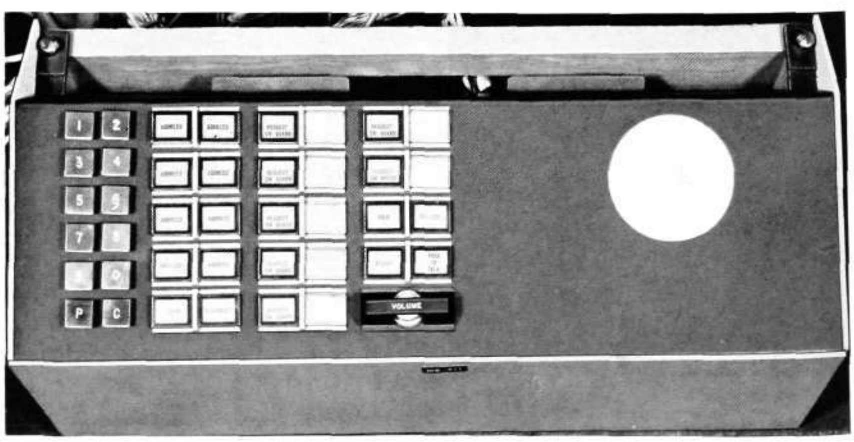


**Fig. 7** X 8448
**Radar console subscriber set**
Control panel


X 8449

**Fig. 8**
**Machine subscriber set**

the radio set to the frequency of his choice. When calls originate from an aircraft, they will always appear at a line unit which is associated with a particular site.

In addition to those stored addresses already mentioned, the console operator may store up to eight other addresses of parties frequently called. The stored address feature will allow ringing to start at the called party within one second from the time the button is depressed. For calls other than those for which an address has been stored, a key punch is provided. The console operator may also elect to place priority calls and conference calls as explained before. He will have a push-to-talk button for radio sets and a special identification code lamp for radio sets which assures that equipment is ready for use. In addition, he will have a hold and a release button.

At a radio set a special device is necessary to take the place of an operator. We call this device a machine subscriber set, fig. 8. When a call comes in from an aircraft, the ground receiver squelch or carrier operated relay will send a signal to the machine subscriber set which in turn will send an off-hook signal to the switchboard. The line circuit in the switchboard will have a stored address for that console subscriber set which is responsible for that radio set. When a ring trip is returned, a special identification code signal will be exchanged. If a ring trip signal and the identification code are not received within five seconds, an alarm will sound at the machine subscriber set so that an attendant may assist. When a call is placed from a console subscriber set, the machine subscriber set will detect ringing, return ring trip, and exchange the identification code. The machine subscriber set also has two detectors for carrier-on, carrier-off control generated by the push-to-talk button in the console subscriber set.

# Crossbar P.A.X. for 16 and 30 Extensions

G STEIMAR, TELEFONAKTIEBOLAGET L M ERICSSON, STOCKHOLM

UDC 621.395.2
LME 8354

*The high reliability and speed of the crossbar switch has made it one of the most important components both in public and private telephone exchanges. L M Ericsson has used the crossbar switch in its 16 and 30 line P.A.X., denoted ARD 624 and ARD 636.*

P.A.X. types *ARD 624* and *ARD 636* require little maintenance and are simple to install. Being silent in operation and taking up little space, they can be placed in any office room. Normal dial telephones are used with these P.A.X.

*ARD 624* (fig. 1) is designed for 16 extensions and two connecting circuits.

*ARD 636* (fig. 2) is designed for 30 extensions and four connecting circuits.

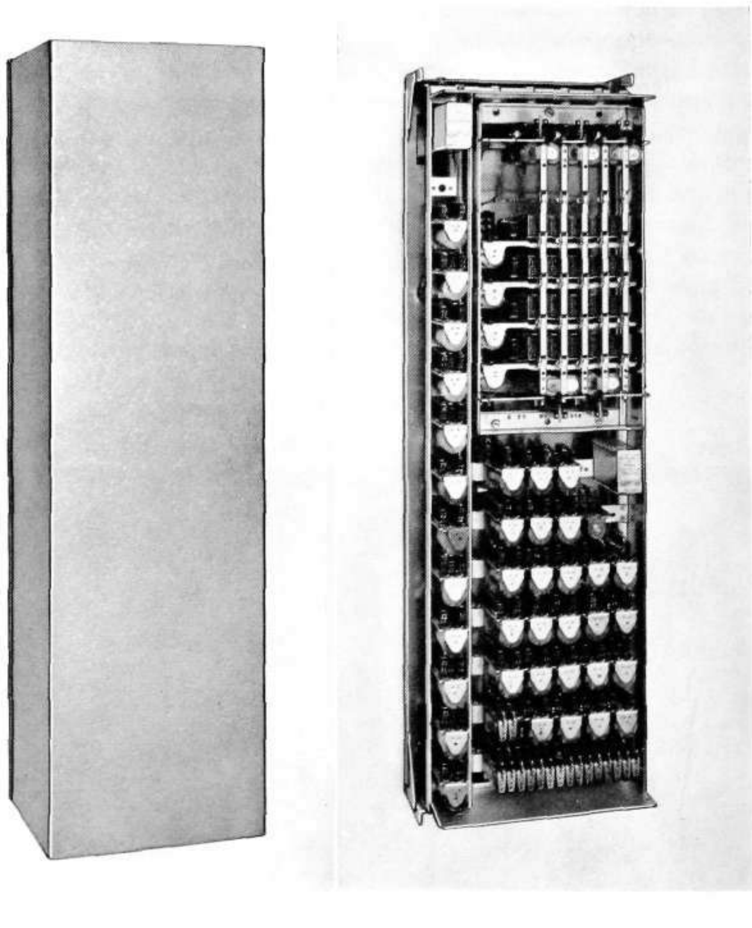


**Fig. 1**
**P.A.X. ARD 624**
**(right) with cover removed**

X 8451

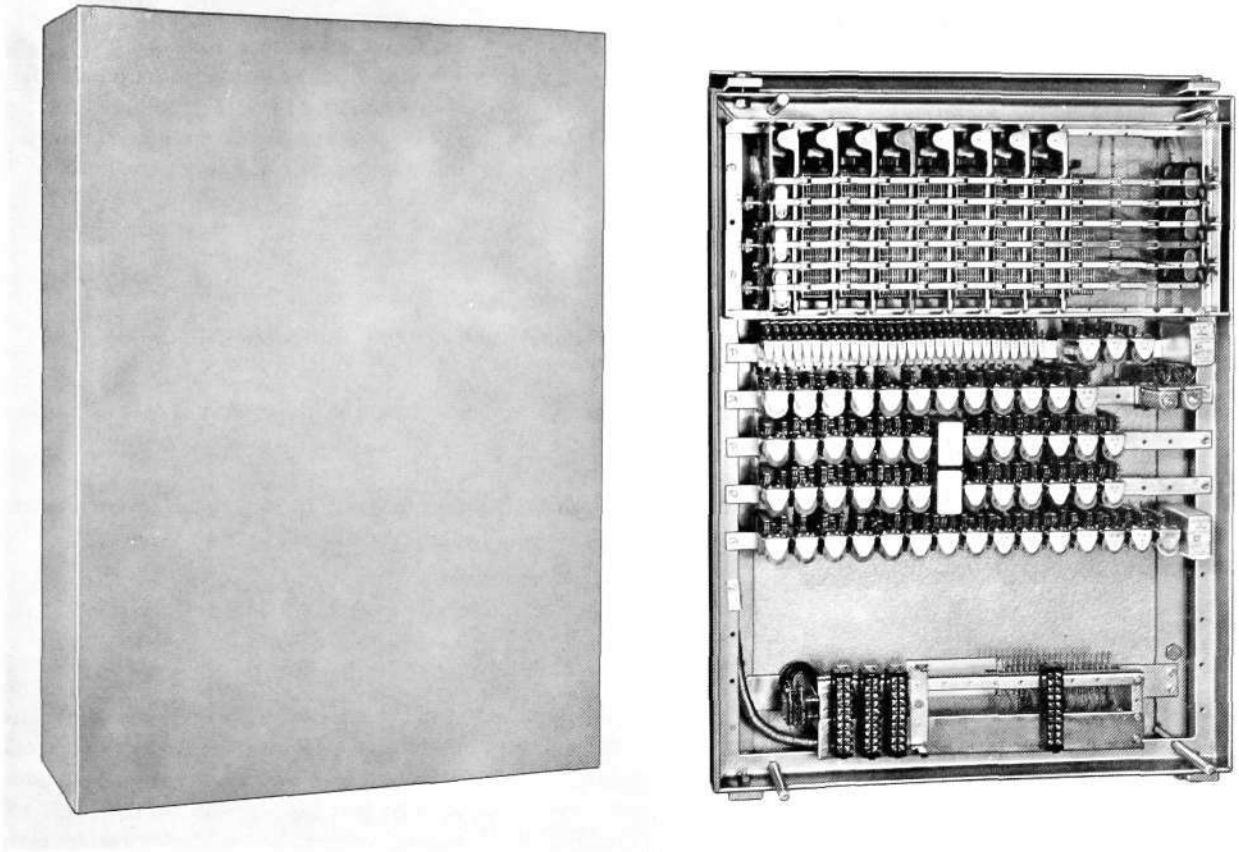


Fig. 2
P.A.X. ARD 636
(right) with cover removed

X 7890

In their standard form these P.A.X. are equipped for the following facilities:

Ordinary *dialled* calls

*Immediate access* to extensions 30 and 34–39 in the 30-line system by dialling the last digit alone. The extension numbers in the 16-line system are 2–9, 11–18, and in the 30-line system 10–39. The single digit numbers for immediate access should be allotted to extensions who receive large numbers of calls.

*Priority*, i.e. the facility of entering an engaged circuit. Can be provided for any required number of extensions by simple strapping arrangements.

*First party release*, implying that an extension is free for a new call as soon as he replaces his handset.

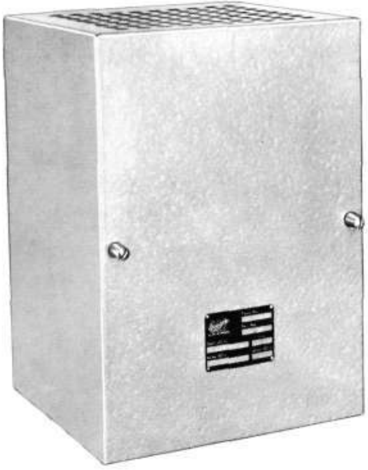
The following additional facilities can also be provided:

*Tie lines (FDR-X)* to other private automatic exchanges. Tie line calls are preceded by a single-digit code.

*Voice paging*, requiring the addition of a relay set *PSR*.

*Triangular calls*. One or more extensions can be equipped with a relay set *KFR*, permitting the entry of a third party into an established connection (conference calls). This facility occupies one line position in the multiple, and an extension possessing the facility must have an earth button.

In the course of a conversation he can ring up a third party on the extra line by pressing the earth button, and all three extensions can then converse with one another.



## Mechanical Design

The components—crossbar switches, relays, capacitors, etc.—are of the same design and high quality as in L M Ericsson's public telephone exchanges. The components are mounted on a wall rack with hinged frame (figs. 1–2) protected by an enamelled steel cover. Owing to the accessibility of the components and the small dimensions of the racks, the switchboards are permanently wired in the factory.

The dimensions of the switchboard are:

*ARD 624:* height 860 mm, depth 205 mm, width 260 mm

*ARD 636:* height 840 mm, depth 200 mm, width 620 mm

Fuses and terminal blocks for jumpering and strapping are assembled on a single bar.

All details of the switchboard are designed to withstand severe climatic conditions. All cabling consists of plastic-insulated wire.

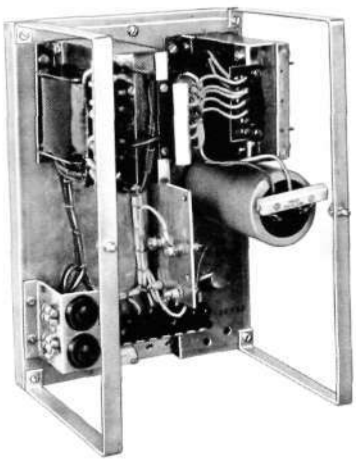


**Fig. 3** X 2747 X 2748

**Battery eliminator BMN 2424**

**(below) with cover removed**

## Power Equipment

The operating voltage, 48 V, is normally obtained from a battery eliminator which also produces the necessary buzzer tone (100 cycles) and ringing current. A suitable battery eliminator is *BMN 2424* (fig. 3), which delivers a voltage of 48 V and a maximum current of 2 A. The unit has tappings for 110, 127, 150 and 220 V, 50–60 c/s. The 90 V ringing voltage is obtained from an extra winding on the unit's transformer. If desired, the P.A.X. can be operated off a battery and charging unit for 48 V, in which case a ringing voltage unit will be required in addition.

## Operation

When an extension raises his handset, his line is identified by *ID* and is connected via an *SNR* to *REG* (fig. 4), which returns dial tone. If dialling does not start within 5 seconds, or if the time between the first and second digits exceeds 5 seconds, *REG* is released and busy tone is returned to the extension via *SNR*.

After the number has been dialled, *REG* ascertains whether the called extension is free or engaged. If free, it is connected via *LV* to the connecting circuit, *REG* is released and the first ringing signal is sent. This is followed by intermittent ringing signals, and the caller hears ringing tone. When the call is answered, the ringing signals cease and connection is established. If the extension is engaged, *REG* is released and busy tone is returned to the caller from *SNR*.

If a priority extension calls an engaged extension, *REG* releases and busy tone is returned as before, but the caller can enter the connection by dialling an additional digit. A warning tone is then sent to all three parties. If the priority extension replaces his handset, the warning tone ceases and the original conversation can continue.

Since the exchanges are designed for first party release, an extension is free for a new call immediately after replacing his handset.

On tie line calls *SNR* is through connected and the current feed is taken over by *FDR-X*.

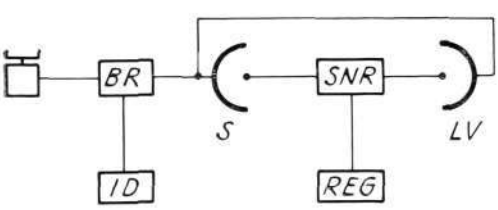



**Fig. 4** X 2750

**Switching diagram**

**BR** Cut-off relay
**ID** Identifier
**REG** Register
**SNR** Connecting circuit
**S** Finder
**LV** Final selector

## Installation and Maintenance

These exchanges with their small dimensions and permanent cabling are very simple to install. The backplate is first erected on the wall and the equipment frame is then screwed onto it. The power leads and extension lines are connected to easily accessible terminal blocks. Once the necessary strapping has been done according to the customer's wishes, the P.A.X. is ready for testing and putting into service.

Switchboards with mechanical selectors require regular preventive maintenance if they are to operate satisfactorily. Preventive maintenance is unnecessary with crossbar switchboards and their maintenance costs are therefore very low. If the P.A.X. has been thoroughly tested at the time of installation, the only maintenance required under normal conditions should be an annual inspection and check-up of the power equipment.

## Technical Data

The *operating voltage* for the switchboards is 48 V, but voltage fluctuations between 42 and 56 V can be admitted without jeopardizing their operation.

*Current consumption* about 0.4 A per conversation. Maximum current consumption during switching 1 A.

*Line data.* The loop resistance may be 1,100 Ω including the resistance of the telephone instrument.

The *leakage resistance* between the two legs of a line or between one leg and earth may be as low as 25,000 Ω.

*Feed*

The feed coils have a resistance of 2 × 400 Ω, which can be adjusted to 2 × 250 Ω.

## Main Features of P.A.X. types ARD 624 and ARD 636

1. High traffic handling capacity and rapid switching
2. Practically no maintenance
3. Silent operation
4. Priority for any desired number of extensions
5. Connection of tie lines
6. Voice paging
7. Triangular conversations, i.e. entry of a third party into an established connection
8. Immediate access to certain extensions by dialling one digit
9. Wall mounted
10. Supplied by battery eliminator
11. Simple wiring.

# Transistorized Repeaters for Physical Circuits

L E LARSSON, TELEFONAKTIEBOLAGET L M ERICSSON, STOCKHOLM

UDC 621.375:621.395
621.382.3
LME 84111

*Different types of repeaters for physical circuits have been included in L M Ericsson's manufacturing program for a long time. The new repeater which has been developed differs from the earlier ones in that the units have been built up on printed wiring boards and the amplifiers have been transistorized. The layout of a bay with new repeaters has been adapted for use in loaded trunk lines in a network with subscriber trunk dialling.*

*Repeaters for loaded trunk lines have been in use in the Swedish telecommunications network for a long time. The specifications for this repeater have therefore been worked out in intimate collaboration with the Swedish Board of Telecommunications. In addition, the repeater fulfills the recommendations of CCITT, where applicable.*

## Arrangement

Repeaters for two-wire physical circuits can be divided into two types depending on their use.

The first type consists of repeaters for long rural lines. The feature of this type is that the amplifier gain should be high. These repeaters are most suitably designed as 2 wire/2 wire (2 W/2 W) intermediate repeaters, see fig. 1.

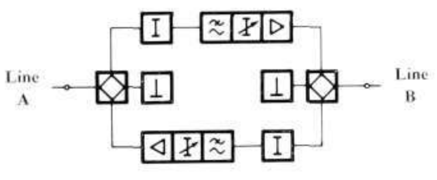



**Fig. 1** X 2728
**2 W/2 W intermediate repeater**

The second type consists of repeaters for the physical circuits which are included in a trunk connection. The feature of this type is that the amplifier gain should be relatively low. The importance of this group increases at the same rate as subscriber trunk dialling is introduced. In the case of automatic operation over trunks, the requirement that the equivalent of transit routes shall be low is made more stringent.

In general only one repeater is required per line. The best location of such a repeater is usually at one of the ends of the line. There is thus a demand for terminating repeaters. In the case of 4-wire operation in transit exchanges, the hybrid and balance network which would otherwise be nearest the exchange are omitted. Such a repeater is called 2 wire/4 wire (2 W/4 W) terminating repeater, see fig. 2. A 2 W/2 W terminating repeater is shown in fig. 3.

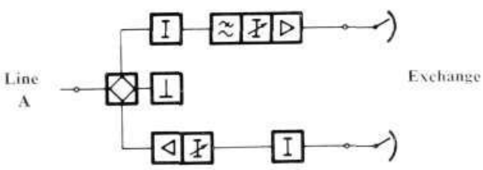



**Fig. 2** X 2729
**2 W/4 W terminating repeater**

In order to satisfy the demand for these two types economically, the new repeater can either be mounted in a bay or in independent shelves.

A bay for up to sixty terminating repeaters, see fig. 4, has been arranged with a view to its use in trunk circuits.

A shelf accommodating two intermediate repeaters, see fig. 5, has been arranged with a view to its use in rural circuits. The shelves can be assembled in bays or wall-mounted frames together with power supply equipment.

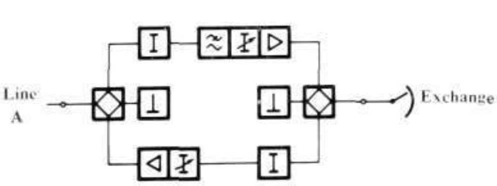



**Fig. 3** X 2730
**2 W/2 W terminating repeater**

In order that the field of use of the repeaters shall be as universal as possible, no special type of signalling repeater has been included in the repeater equipment. A facility has instead been provided of connecting the signalling equipment to the capacitors at the middle of the centre tapped transformers.

Line transformers are normally used to match the impedance of the line to the exchange or to make use of the phantom circuit in quad cables. Difficulties may arise when adjusting the amplifier balance if amplification is to be introduced into a circuit with line transformers. In general, an extra line transformer must be included between the hybrid and balancing unit. In the new repeaters, the need for line transformers has been avoided by matching the line and balance windings of the centre tapped transformers direct to the line impedance. To obtain sufficient balancing for the phantom circuit, the transformers have been wound so as to be double balanced. Such a transformer is termed a line and hybrid transformer. The circuit diagram for a transformer with centre tap for direct connection to the phantom circuit is shown in fig. 7. Fig. 8 shows the circuit diagram for a transformer with capacitors at the centre tappings of the line and balance windings. Such a transformer is used in those cases when one has to extract sub-audio frequency signals to a signalling repeater. The output for the phantom circuit is obtained in this case from the signalling repeater.

The line and hybrid transformers are mounted on printed wiring boards with aluminium dust covers occupying one width module, see fig. 6. The transformers are wound on toroidal cores and two transformers are cast in one plastic block.

The maximum amplification which can be used in a repeater is mainly determined by the capacitive crosstalk in the cables. In practice, not more than about 18 db (2.1 N) gain can be introduced in the case of a 2 W/2 W intermediate repeater or about 9 db (1 N) gain in the case of a terminal repeater. With a hybrid loss of 3 db (0.4 N), the amplifier in a 2 W/2 W repeater has to have 24 db (2.9 N) gain and 12 db (1.4 N) gain in the case of 2 W/4 W repeater. If the 2 W/4 W repeater is to be used with pad switching to provide excess gain toward the unamplified network, then in this case there is also a use for amplifiers with 24 db gain. The amplifier used in the repeater has a maximum gain of 24 db. The gain can be varied in steps of 0.1 N in the range 19 db to 24 db by using U-links. Coarse regulation of the gain can be made with fixed pads in the bay side.

For equalizing the line attenuation at high frequencies the amplifier feedback circuit has been made frequency dependent so that the gain increases at high frequencies. This increase of gain can be regulated by using U-links.

The frequency characteristics of the amplifier with and without the equalizing circuits are shown in fig. 12. When changing from one equalization graph to another, the gain at 800 c/s remains practically constant.

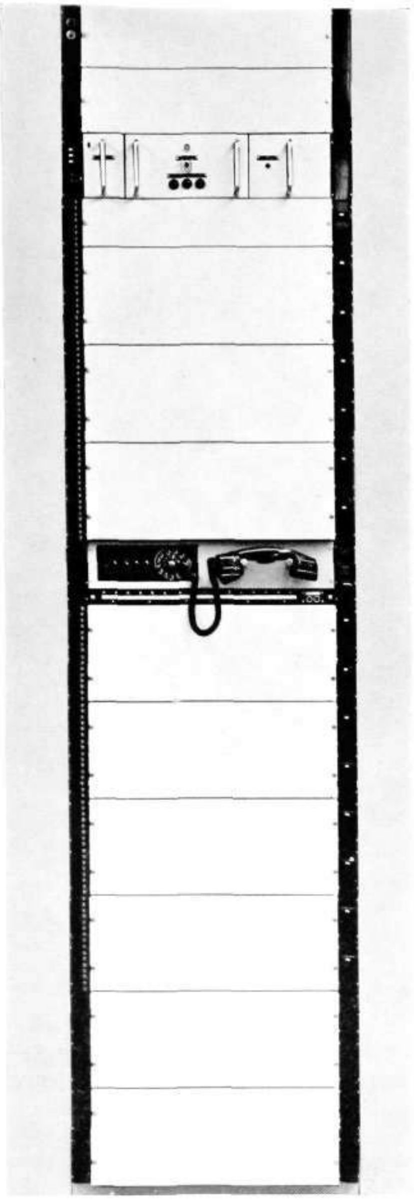


**Fig. 4** X 2731
**Repeater bay ZDA 801**

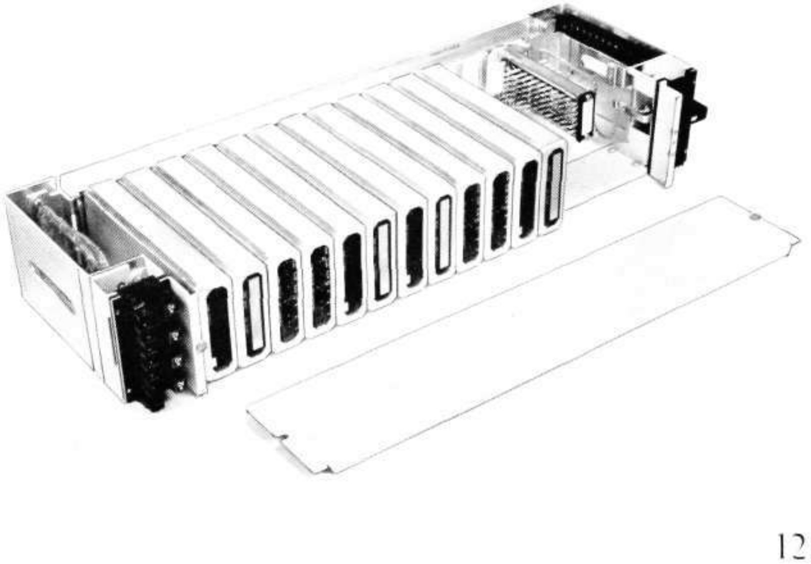


**Fig. 5** X 8436
**Repeater shelf ZDA 6401**

Fig. 6 X 8437

Line and hybrid transformer

The amplifier unit also contains a low-pass filter for giving the repeater a suitable upper cut-off frequency related to the cut-off frequency of the line. This is designed so that the two amplifiers in an intermediate repeater must be provided with filters. In a terminating repeater where the possible gain obtainable in practice is less, only one amplifier need be provided with a low-pass filter.

The frequency responses of the different filters are shown in fig. 13.

An amplifier with filter is shown in fig. 9. On the short side of the unit will be seen the U-links for adjustment of the amplifier gain and for the equalizing circuits.

From the technical point of view, the amplifier can be described as a two-stage d.c. coupled transistorized amplifier with bridge negative feedback at the input and output. Not only the gain but also the input and output impedances are thereby stabilized.

The adjustment of the balance has been made particularly clear by its method of mounting on a printed wiring board. It is built as a Hoyt type balance where the values of the different components can be varied by means of straps, see fig. 10 b. The range of adjustment of all components except the inductance is so large that it covers all practical applications. The range of adjustment of the inductance values corresponds to the most usual loading values.




Fig. 7 X 2735

Circuit diagram for line and hybrid transformer without capacitor at centre tap

In the case of 2 W/2 W terminating repeater, the hybrid transformer lying on the exchange side need not fulfill such stringent requirements as the line and hybrid transformer on the line side. Furthermore the balance need not have the same strapping facilities as a Hoyt Balance. For this case a 4 W terminating unit having 600 ohms impedance toward the exchange side with a built-in compromise balance is available.

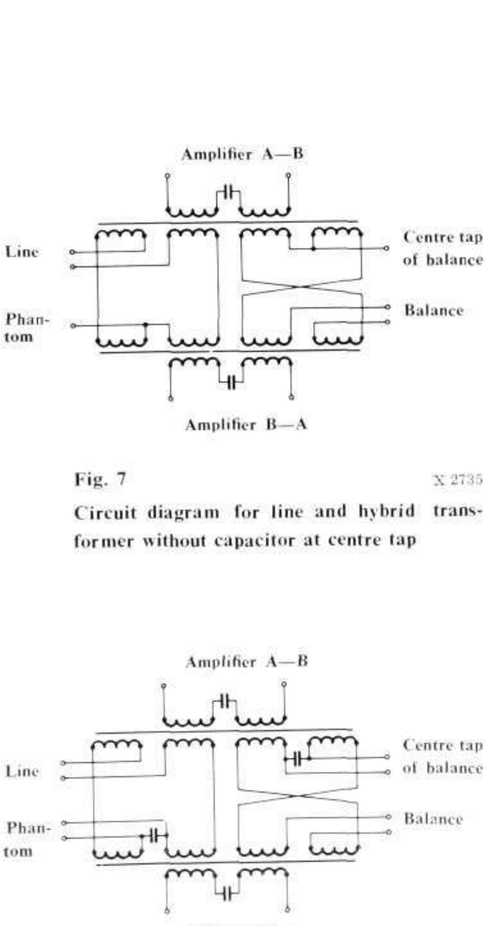



Fig. 8 X 2736

Circuit diagram for line and hybrid transformer with capacitor at centre tap

## The Bay

The repeater equipment in the bay (fig. 4) occupies fifteen shelves containing sixty 2 W/4 W terminating repeaters and four shelves containing supplementary equipment. A picture showing details of a shelf with terminal repeaters is shown

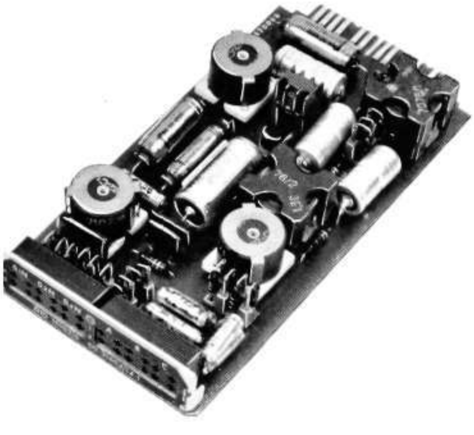


**Fig. 9** X 2732
**Amplifier**

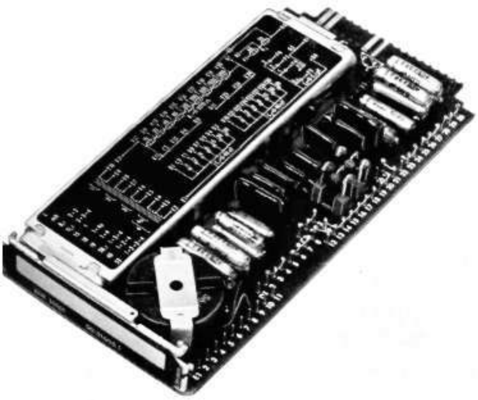


**Fig. 10 a** X 2733
**Balancing unit**

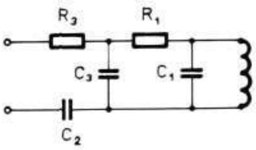



**Fig. 10 b** X 2737
**Circuit diagram of balancing network**

in fig. 11. Each shelf contains four repeaters. The pads for coarse adjustment of the gain are located at the left hand side of the bay front. To the left of these are located test jacks for checking the gain of the repeater amplifiers or for monitoring purposes. The common fuse for all repeaters in one shelf is located at the right hand side of the bay front.

If the repeaters are to be arranged as 2 W/2 W terminating repeaters, the 4 W terminating units must be placed in the shelves for supplementary equipment. This does not cause any inconvenience as the wiring from the four-wire side of the 2 W/4 W repeaters is cabled via these shelves. Connection is thus made at the same time as the 4 W terminating unit is plugged into its position in the bay. The 2 W/2 W intermediate repeater can be built up in two ways. The first way is to connect two 2 W/4 W terminal repeaters together. This connection is obtained by replacing the amplifiers in one of the repeaters by a special dummy unit. In this arrangement the bay only can accommodate thirty intermediate repeaters. The second way is to place the line and hybrid transformers in the shelves for supplementary equipment. The 2 W/4 W repeaters are thereby supplemented with line and hybrid transformers on the four-wire side. In this case the extra balances must be placed outside the bay.

As mentioned previously the hybrid transformers are also designed as line transformers. This means that the wires in each incoming quad must be kept together right through to the transformers. The wiring to the transformers in the bay has therefore been made with quadded cable.

In addition to the repeater equipment the bay contains a telephone unit, speaker circuit jacks, alarm unit, terminal strips and power supply equipment.

## Shelf

The shelf fig. 5 provides space for mounting two 2 W/2 W intermediate repeaters. A 2 W/2 W terminating repeater is obtained by replacing one of the line and hybrid transformers in a repeater by a 4 W terminating unit and a 2 W/4 W terminating repeater is obtained by replacing one of the transformers by a dummy unit. The shelf can be mounted in a bay or on a wall-mounting frame with power supply equipment.

## Supervision and Test Facilities

Test equipment is available for checking of balance so as to assist the putting into service of the repeaters. This equipment is in principle designed so that gain is introduced into the repeater until singing occurs.

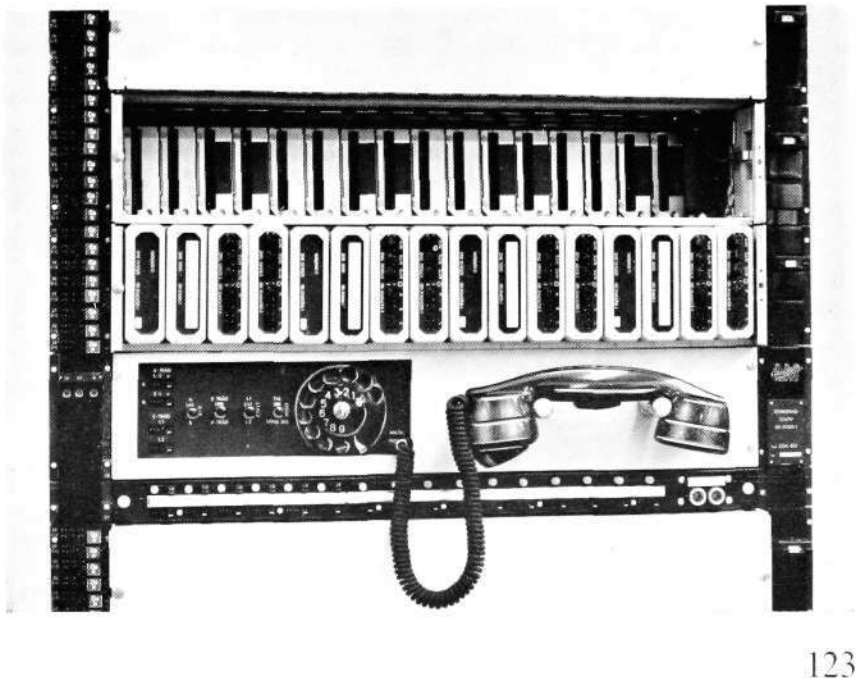


**Fig. 11** X 8438
**Part of the repeater bay**

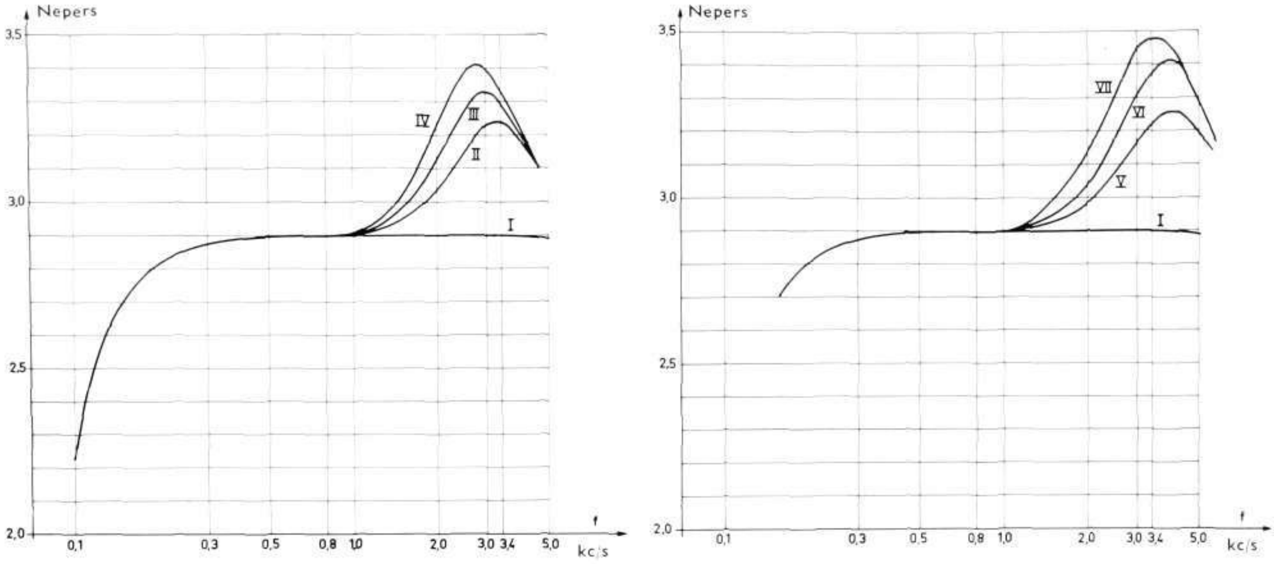



**Fig. 12**

X 8439
X 8440

**Gain of amplifier without filter**

I. without correction
II—IV. with correction together with filters I—V
V—VII. with correction together with filters VI

The balance checking equipment permits the introduction of this gain without having to change the normal setting of the amplifier. The singing margin can therefore be read off directly as the additional gain introduced.

Measuring equipment for checking of gain is also available to assist in maintenance of the repeater. This equipment is designed so that tests can be made without having to remove the amplifiers from service, i.e. they can be made as bridging measurements. So as not to cause interference with a call in progress the measurement is made for a short duration (pulse). Furthermore, the input and output of the test equipment are selective and arranged so that the impedance is low at the test frequency and high at other frequencies. In this way the interference effect of the test signal is further reduced.

## Technical Data

*Bay capacity*

Alternative 1. 2 W/4 W terminating repeaters .... 60
Alternative 2. 2 W/2 W terminating repeaters .... 60
Alternative 3. 2 W/2 W intermediate repeaters .... 30 or 60

*Shelf capacity*

2 W/4 W or 2 W/2 W repeaters .................. 2

*Gain*

2 W/4 W repeater ............................ up to 2.5 N
2 W/2 W repeater ............................ up to 2.1 N
in steps of 0.1 N

*Crosstalk*

Effective crosstalk attenuation between two repeaters
is greater than ................................ 8.5 N

*Power supply*

Alternative 1. Mains supply .................... 127, 220 V, 50—60 c/s
Alternative 2. Battery supply .................... 24 V d.c.
Alternative 3. Battery supply .................... 36 V d.c.
Power consumption per repeater (24 V supply) .... 1.2 W

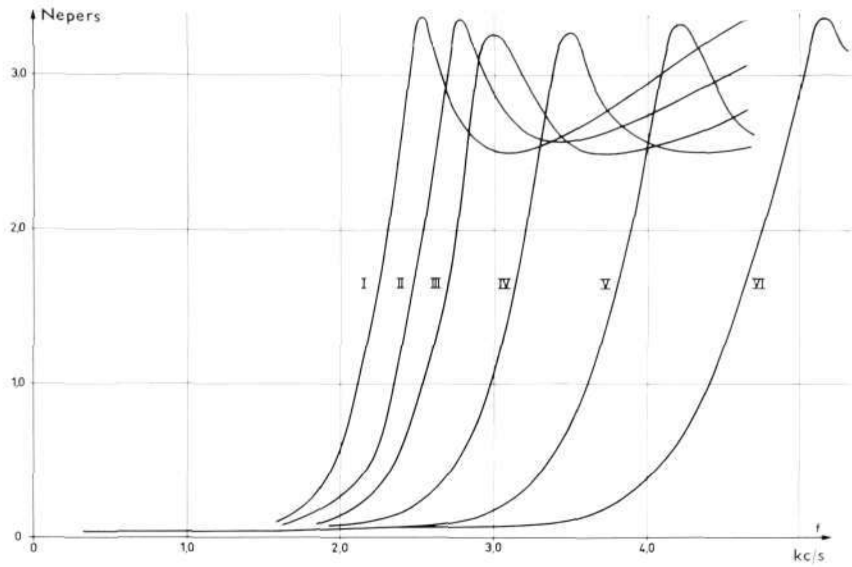



**Fig. 13** X 8441

**Frequency response of the low pass filters of the different amplifier variants**

- **I** 300—2,000 c/s
- **II** 300—2,200 c/s
- **III** 300—2,400 c/s
- **IV** 300—2,800 c/s
- **V** 300—3,400 c/s
- **VI** 300—4,100 c/s

*Amplifier*

| | |
|---|---|
| Gain | 2.2—2.9 N |
| Frequency range | |
| Amplifier without filter | 300—4,100 c/s |
| Amplifier with filter, either of alternatives: | 300—2,000 c/s, 300—2,200 c/s, 300—2,400 c/s, 300—2,800 c/s, 300—3,400 c/s, 300—4,100 c/s |
| Output power at 5 % harmonic distortion is greater than | 50 mW |
| Input/output impedance | 600 ohms |

*Line and hybrid transformer*

| | |
|---|---|
| Frequency range | 300—3,400 c/s |
| Line impedances, either of the alternatives: | 400, 600, 800, 1,200, 1,600, 2,400 ohms |
| Impedance to amplifiers | 600 ohms |
| Attenuation, line to amplifier | 0.38 N |
| Crosstalk attenuation, side-phantom is not less than | 11 N |

*4 W terminating unit*

| | |
|---|---|
| Frequency range | 300—3,400 c/s |
| Impedance, exchange side and amplifier side | 600 ohms |
| Attenuation, line to amplifier | 0.38 N |

*Balancing unit* (see fig. 10 b)

| | |
|---|---|
| $R_1$ | 0—3,210 ohms |
| $C_1$ and $C_3$ | 0—90 nF |
| $C_2$ | 0—5.5 $\mu$F |
| $R_3$ | 25—107 ohms |
| $L$ | 8.5, 11.5, 18, 19, 28.5, 40, 53 mH |

# Loading Equipment

J FRENNING & W RAUB, TELEFONAKTIEBOLAGET L M ERICSSON, STOCKHOLM

UDC 621.3.054.3
LME 8414

*The development of improved soft magnetic ferrite material has provided an opportunity for a thorough redesign of loading equipment made by the L M Ericsson Telephone Company. The use of ferrite pot cores and new methods of manufacturing coil windings and coil units has resulted in great savings in weight and volume of the loading equipment. The following article contains a survey of the new designs and diagrams to assist in the design of loaded cables.*

L M Ericsson's first designs of loading coils which were made at the end of the 1920's consisted of a ring core of pressed fine grain soft magnetic iron dust. The magnetic characteristics of the core material led to coil designs having large volume and great weight, in particular for coils intended for the loading of long distance cables.

In subsequent years great improvements were made in the magnetic characteristics of the core material and the methods of manufacturing cores and coils. This resulted in the reduction of the loading coil volume and weight in different stages so that the coils which were made in the beginning of the 1950's had a volume and weight which were only a fifth of those for loading coils of the 1920's and in addition they had better technical characteristics from most points of view.

The technical and practical requirements for design improvements in loading coils built on a ring core were thereby mainly completely exploited.

The rapid development of soft magnetic ferrite material which occurred in the years after World War II has opened up new possibilities also in the field of design of loading coils. Especially in the most recent years, ferrite material has been produced having such magnetic properties that it is particularly suitable for cores of loading coils.

Soft magnetic ferrite material is produced by high temperature sintering of a mixture of extremely finely divided metallic oxides, usually oxides of iron, zinc and manganese.

The sintered ferrite material has high permeability ($\mu = 2\,000$—$2\,500$) and relatively low losses.

L M Ericsson has developed a new series of loading coils intended for loading of cables, based on cores of ferrite material. This series comprises the following three different types of coil:

1. Coil type *REG 18*, intended for loading long distance cables. It is designed as a coil for loading pair or star quad cables or as a set of coils for loading the side and phantom circuits of multiple twin cables.
2. Coil type *REG 16*, intended for loading of toll and short distance pair cables and star quad cables.
3. Coil type *REG 14*, intended for loading of subscribers' cables.

## Cores and Coils

When using ferrite material in cores for loading coils, an air gap must be introduced into the magnetic circuit which reduces the effective permeability to about a tenth of that of the material alone. The reasons for this are the low loss resistance and high magnetic stability which are demanded of the loading coils. For reasons of crosstalk the air gap must be introduced as symmetrically as possible in relation to all the winding sections which leads to a

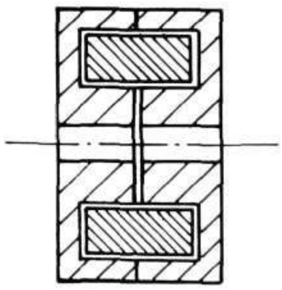


**Fig. 1** X 2717
**Section of a ferrite pot core with coil**

pot type core being the best solution. The pot type cores which are used in the new coil designs are included in the pot core series with optimum sizes agreed upon by the International Electrotechnical Commission (IEC). A cross-section of a pot core with coil in position is shown in fig. 1 with the air gap placed symmetrically in the centre limb of the core.

The sections of the coil are also wound using a new method which permits the lowest possible effective capacitance in the coil circuits for a given symmetry and balance requirement. The schematic design of the four sections of a loading coil for a phantom circuit is shown in fig. 2. The greater the number of mutual transpositions between coil sections, the better is the side symmetry and thereby the higher the crosstalk attenuation between the three speech circuits of the coil. At the same time the effective capacitance in the speech circuits increases, which is a drawback from the transmission point of view. The number of transpositions is therefore limited as far as the crosstalk attenuation permits and thereby the effective capacitance is reduced. The greatest effect from the point of view of symmetry is obtained if transpositions are made at the points of the coil body which are most affected by the magnetic leakage field from the pot core i.e. nearest to the transition between the cylindrical part of the core and its flat surface and also in the neighbourhood of the air gap in the centre limb.

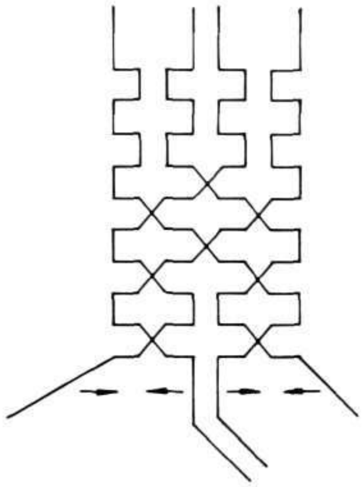


**Fig. 2** X 2718
**Winding diagram of a phantom coil**

The three different types of coil are shown in fig. 3. The main difference between the different types of coil is in the d.c. resistance and hysteresis factor; other things being equal, these properties determine the coil volume, the requirements in this aspect are however different for coils intended for different uses. For long distance cables with low attenuation requirements, thick copper conductors are as a rule used in the line cable and it is then justifiable to use loading coils having low loss resistance. For short cable circuits, however, thinner copper conductors are used in the cables and these can with advantage be loaded with coils having a fairly high loss resistance, as the resistance of the loading coils is only a few percent of the resistance of the line cable. A subscriber cable having a copper conductor diameter of 0.4 mm has its line resistance increased by only two percent when loaded with 30 mH/km and loading coils of type *REG 14*.

A lower cost of loading is obtained by such a differentiation of the coil characteristics and suiting these to the requirements for different fields of use. The d.c. resistance and hysteresis factor of the different types of coil are given in table 1.

**Table 1. d.c. resistance and hysteresis factor for different types coil.**

| Coil type | d.c. resistance (Ω/H) | Hysteresis factor according to CCITT (Ω/H · mA at 800 c/s) |
|---|---|---|
| *REG 18* | 35 | $10\sqrt{L}$ |
| *REG 16* | 70 | $17\sqrt{L}$ |
| *REG 14* | 175 | $30\sqrt{L}$ |

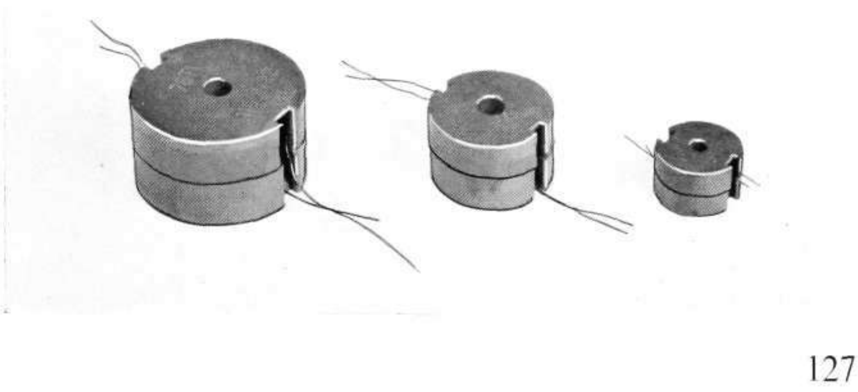


**Fig. 3** X 8429
**Loading coils with ferrite pot cores**
**L. to r., types REG 18, REG 16 and REG 14**

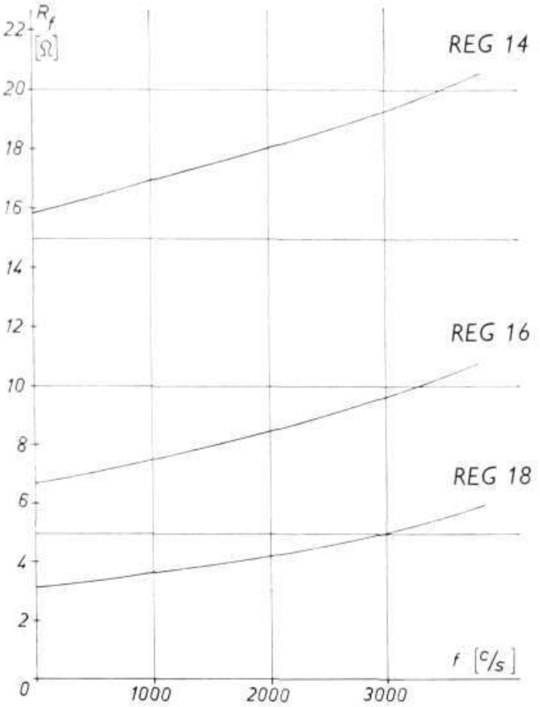



**Fig. 4** X 2719

**Loss resistance at different frequencies for an 88 mH loading coil of three different types**

Current = 1 mA

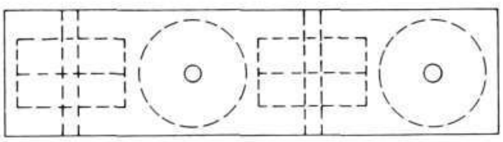


**Fig. 5** X 2720

**Schematic diagram showing location of the coils in a coil unit type ZLB 344**

Fig. 4 shows the increase in loss resistance with frequency for an 88 mH coil of the three different types.

All types of coil are manufactured in a large range of values of inductance from 20 mH to 177 mH. A special design of type *REG 18* with extremely low hysteresis factor is manufactured for values of inductance between 4 and 14 mH for loading of lines intended for distribution of broadcast radio programs.

## Coil Units

Three loading coils are needed at each loading point when loading a multiple twin cable, one in each side circuit and one in the phantom circuit. These three coils must be matched to each other as far as crosstalk is concerned and it is therefore necessary to combine the three coils into one mechanically coherent unit, a quad coil unit.

On the other hand, loading coils for pair cables or side circuits in star quads can technically be made so that each coil forms a separate unit. From the manufacturing economics point of view, it is however, more advantageous to combine a number of these coils into one mechanical unit, a coil unit. Only for special purposes is it suitable to use coil units containing only one or two coils.

Loading coil units are cast in an epoxy resin which after curing forms a solid mechanical protection round the coils and also makes them practically insensitive to moisture.

Coils in a unit are located so that the centre axes of two adjacent coils are always at right angles. In this way, the magnetic coupling between the coils is reduced without the need of having special screening arrangements and the crosstalk attenuation is greatly improved. In addition, this location of the coils permits trimming of their inductance values by means of a ferrite rod which is pushed into the centre hole of the core after being cast in the coil units. The spread in inductance values can thereby be maintained within very close limits.

An example of the location of the coils in a unit is shown in fig. 5.

The outside dimensions of the unit have been determined from a module system. This has great advantages in that the method used for mounting the units in loading coil cases is the same for all types of unit and that one can mount several coil unit types in the same loading box simply. This is desirable for aerial cables containing long distance lines as well as local lines.

The weight and volume of the new coil units is only about a quarter of those of the previous design. Three different coil units are shown in fig. 6.

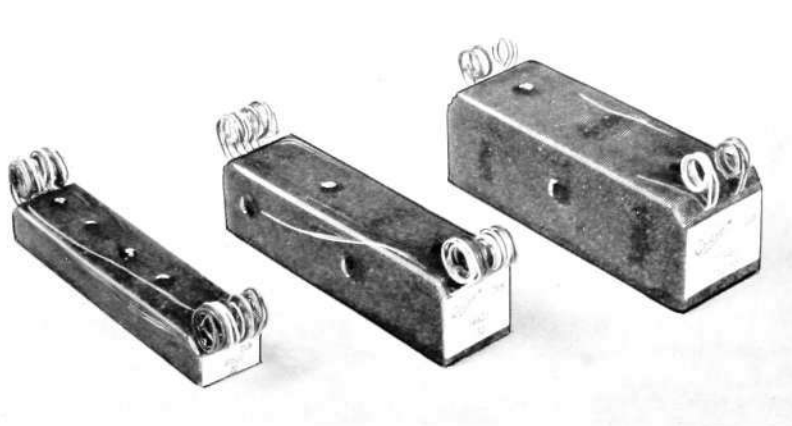


**Fig. 6** X 8430

**Coil units**

L. to r., types ZLB 405, ZLB 344 and ZLB 114

**Fig. 7** X 4885
**Loading coil case with joint box, earlier design**

The different types of coil unit are given in table 2.

**Table 2. Type designations for different coil unit**

| Unit type | Contains the following coils | |
|---|---|---|
| | Qty | Type |
| *ZLB 112** | 2 | *REG 18* |
| *ZLB 113* | 3 | *REG 18* |
| *ZLB 114*** | 3 | *REG 18* |
| *ZLB 341* | 1 | *REG 16* |
| *ZLB 342* | 2 | *REG 16* |
| *ZLB 344* | 4 | *REG 16* |
| *ZLB 405* | 5 | *REG 14* |

* Broadcast radio program coils
** Side circuit/phantom coil unit for multiple twin cable.

## Loading Coil Cases

The great reduction in weight and volume of the loading coil units due to the introduction of ferrite pot cores means that loading coil cases can be designed using other principles than those used previously.

### *Loading Coil Cases for Burying in the Ground*

The earlier design of loading coil cases for cable plant buried in the ground consisted of a cast iron lower part in which the loading coil units were housed and an upper part of tinned sheet brass and shaped as a joint sleeve. In this sleeve the line cable conductors were connected to the conductors of the stub cable leading to the coil units in the lower part of the loading coil case. A cast iron protector was mounted outside the sleeve and this also served to secure the line cable to the loading coil case.

This type of loading coil case design is shown in fig. 7.

The new type of coil case design for buried cables is shown in fig. 8.

This coil case consists of an inner part, the joint sleeve, of tinned sheet brass in which the loading coil units are mounted in a cradle secured by screws in the bottom of the lower part of the joint sleeve. The joint sleeve is designed with connecting muffs for the line cable and a longitudinal soldering channel for sealing with solder after jointing of the line cable has been completed. The outer casing of the loading coil case is made of sheet steel and provides mechanical protection for the joint sleeve and at the same time secures the line cable to the case.

Fig. 9 shows a case of this design jointed to a line cable. The outer casing of the box has been removed. The two ends of the line cable are connected to the lead-in wires on either side of the loading coil unit assembly.

The coil units are mounted in this assembly so that the axes of adjacent coils in different coil units are at right angles as shown in fig. 10. To make jointing more easy the lower part of the jointing sleeve can be removed from the assembly during this operation. The lid of the jointing sleeve is provided

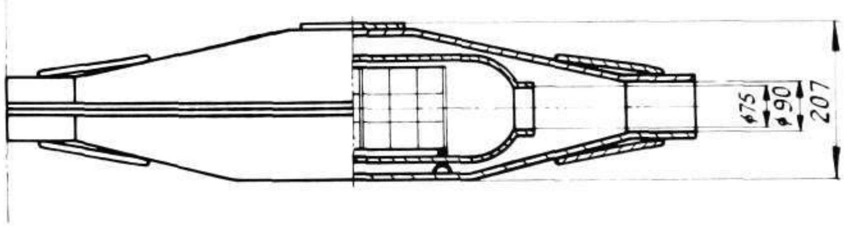



**Fig. 8** X 8431
**Torpedo type loading coil case**
**Dimensions in mm**

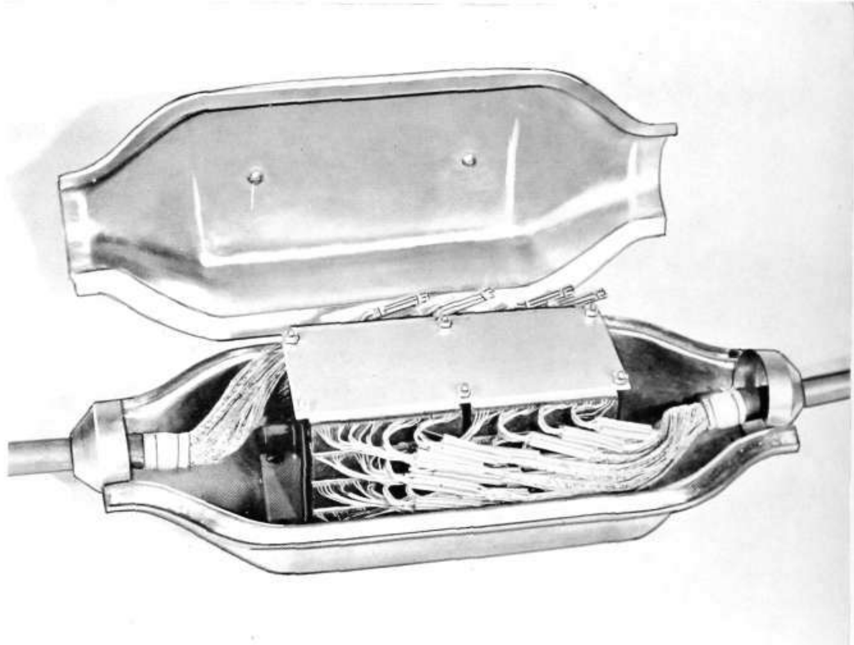


Fig. 9 X 8432

**Torpedo type loading coil case jointed into a cable**

The external sheet protection removed and the case lid lifted

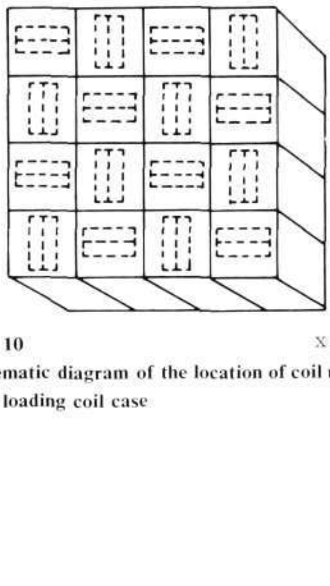


Fig. 10 X 2721

**Schematic diagram of the location of coil units in a loading coil case**

with a tapped hole to permit connection of pressurized gas and manometer for pressure test after sealing the whole loading coil joint. No insulation compound is used in the joint. The case design used for cable plant with gas pressure control is available in four different sizes, the largest of which can house up to 512 coils type *REG 16*.

The new loading case design has several important advantages over the earlier design. The shape and small size of the cases require very much smaller holes in the ground where they are to be installed—a particularly favourable feature when located in rocky terrain. If a coil is damaged by a lightning hit or similar in the cable, it can be easily changed on site without having to remove the case from the cable. The case weight is very low, one case containing 250 coils type *REG 16* weighs only 51 kg whereas the corresponding case of earlier design weighed 180 kg.

## *Loading Coil Cases for Mounting in Footway Manholes or on Poles*

Loading coil cases placed in footway manholes or on poles are, as a rule, manufactured with one or two stub cables which are joined to the line cable in a T-joint or in two through joints, respectively. The previous designs of case for these purposes used cast iron.

Fig. 11 X 8433

**Loading coil cases for mounting in footway manholes or on poles**

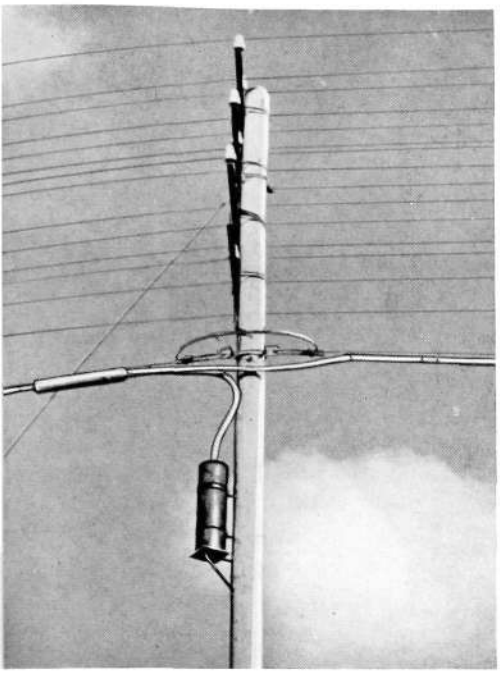


**Fig. 12** X 2722
**Loading coil case installed in an aerial cable**

The new case designs for placing in manholes or on poles are all shaped as cylindrical tinned brass tube. Owing to the low weight and volume of the loading coil units, it has been possible to use this case design in practice for up to 720 coils type *REG 16*. The box is hermetically sealed and may be used for cable plant with gas pressure control.

The stub cable has copper conductors insulated with two layers of paper. The conductors are either of multiple twin type or in pairs, depending on whether the loading coil case contains coils for side-phantom loading or individual coils for loading of the pairs. The cable sheath is of lead alloy and is of extra thickness to be able to withstand the rough treatment to which it is exposed during installation. There is a polythene sheath on the outside of the lead sheath to act as a corrosion protector.

Fig. 11 shows two different sizes of loading coil cases.

Fig. 12 shows one of these loading coil cases mounted on a pole and jointed to the aerial cable.

In a special design of these types of case, the case of the loading coil case consists of a polythene tube and the stub cable has polythene insulated conductors and polythene sheath, intended for jointing to a cable having plastic insulated conductors and polythene sheath.

## Joint Case Loading

When loading a cable having a few circuits it is an economic advantage to place the loading coil units in the jointing tubes used for joining lengths of the cable instead of using a separate loading coil case. The small dimensions of the new loading coil units make this method of loading suitable for up to 50 coils type *REG 16* in the same joint.

## Design of Loaded Telephone Cable Plant

Loading of a cable reduces its attenuation in the voice frequency band.

Two typical examples of this effect are shown in fig. 13. The amount of reduction in attenuation is dependent on how the loading is carried out and what transmission properties are otherwise required of the loaded line. The deciding factors for the transmission quality of the loaded cable are its attenuation, cut-off frequency and velocity of propagation. When the permissible values of these primary data have been decided upon, the requisite values of loading coil inductance, distance between coils, cable capacitance and conductor diameter can be calculated.

A diagram is shown in fig. 14 from which can be read the necessary design of the cable and loading to obtain stated cable primary constants and vice versa.

The following symbols are used in the diagram

$f_0$ = cut-off frequency in kc/s
$s$ = distance between loading coils in km
$v$ = propagation velocity in km/s
$c$ = cable capacitance in nF/km
$l$ = amount of loading in mH/km
$Z$ = characteristic impedance of the loaded line
$\alpha$ = attenuation of the loaded line at 800 c/s in mN/km
$\text{Ø}_{Cu}$ = cable conductor diameter in mm

## *Examples*

A: A telephone line with

$Z = 1\,600\ \Omega,\ f_0 = 4\,000$ c/s
$v = 15\,000$ km/s, $\alpha < 35$ mN/km

Diagram 1: $l = 107$ mH/km
$c = 42$ nF/km

Diagram 2: $s = 1.2$ km
i.e. loading coil inductance $L = l \times s = 128$ mH

Diagram 3: $\varnothing_{Cu} = 0.7$ mm

B. Given a cable having $c = 35$ nF/km and $\varnothing_{Cu} = 0.9$ mm, determine the attenuation constant when $v = 25\,000$ km/s

Diagram 1: $Z = 1\,140\ \Omega$
Diagram 3: $\alpha = 25$ mN/km

What distance $s$ between loading coils shall be used with $L = 88$ mH?

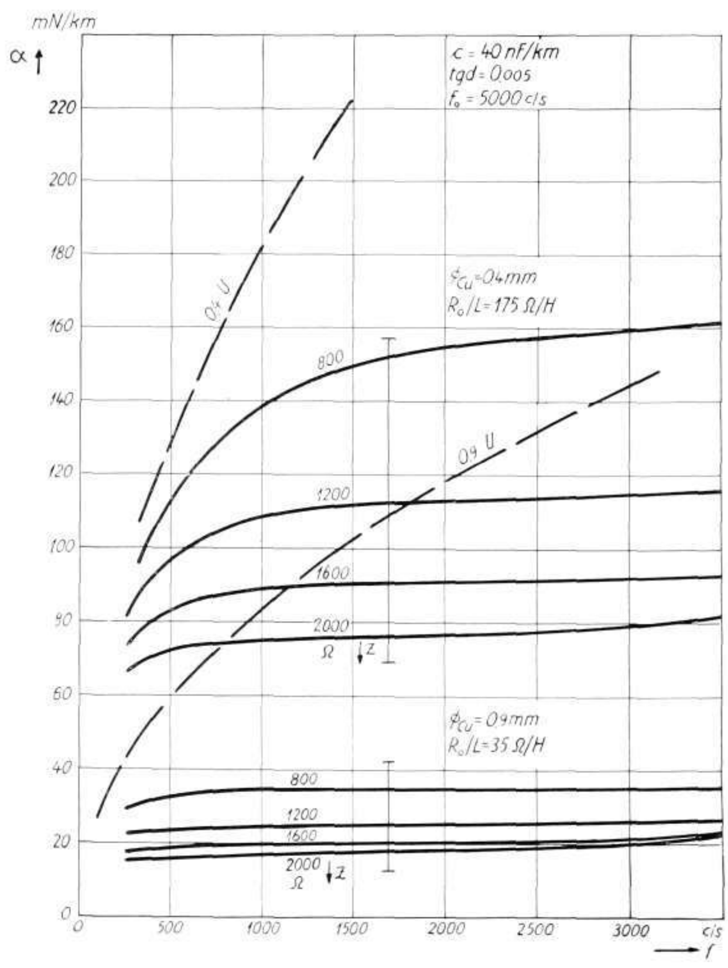
Diagram 1: $l = 46$ mH/km
$s = L/l = 88/46 = 1.91$ km

What is the cut off frequency $f_0$?

Diagram 2: $f_0 = 4\,200$ c/s

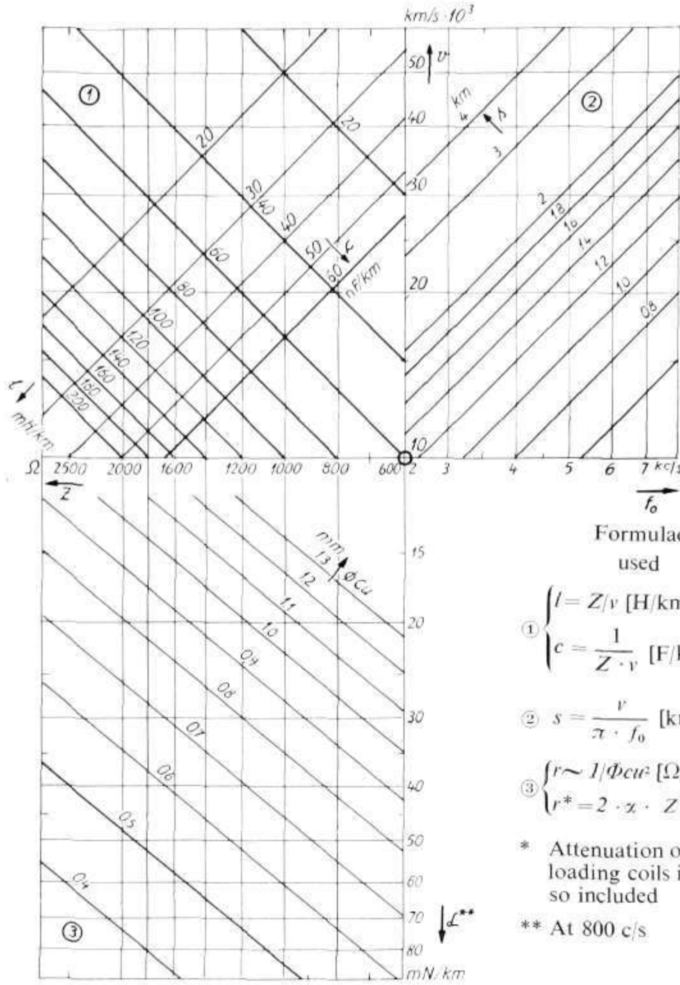
It will be seen that in the formulae for diagram 3, the attenuation which arises due to dielectric losses in the cable is not included in the stated attenuation graphs. This attenuation lies between 0.5 and 1.0 mN/km at 800 c/s for normal paper insulated cables.

The diagram can be used to advantage when making economic decisions in the design of a loaded cable network, when the consequences of tightening or relaxing the transmission requirements can be read off and applied to the




X 8443

**Fig. 13**
**Attenuation in loaded cables**
U = unloaded cables




Formulae used

① $\begin{cases} l = Z/v \text{ [H/km]} \\ c = \dfrac{1}{Z \cdot v} \text{ [F/km]} \end{cases}$

② $s = \dfrac{v}{\pi \cdot f_0}$ [km]

③ $\begin{cases} r \sim 1/\Phi cu^2 \text{ [}\Omega\text{/km]} \\ r^* = 2 \cdot \alpha \cdot Z \text{ [}\Omega\text{/km]} \end{cases}$

* Attenuation of the loading coils is also included

** At 800 c/s

**Fig. 14** X 8444
**Diagram used for the design of loading on cables**

factors which decide the cost i.e. cable design, distance between loading coil cases and the cost of installation of the loaded cable network.

Certain practical limitations should be respected when making a design. The characteristic impedance of the loaded line should not be greater than 2 000 ohms. For values higher than this, problems of crosstalk arise which are expensive to solve. Extreme values of cable conductor diameter and capacitance should be avoided.

## Patents

1. Swedish patent 173 372
   "Method of winding an inductance coil having two or more winding arms, and the inductance coil wound using said method."
2. Swedish patent application 473/62
   "Loading coil case arranged in a casting resin."
3. Swedish patent application 534/62
   "Method of procedure for impregnation of coils and their casting in hardening resins."

# New Overvoltage Protectors for Subscribers' Installations

A HENCKEL, TELEFONAKTIEBOLAGET L M ERICSSON, STOCKHOLM

UDC 621.316.93
LME 7392

*The continued spread of the telephone into remote and isolated places has brought the question of the reliability and safety of line plant into new prominence. This factor, and the increased demands of subscribers for quick service in the repair of faults, has necessitated modern and efficient means of protection for subscribers' installations, which are described in this article.*

With the increasing substitution of open wire by cable plant the need for overvoltage protection of subscribers' installations has greatly diminished in cities, especially in the central districts. The conditions are otherwise in the countryside. Even if open wire lines are disappearing there as well and being replaced by overhead cable, damage to telephone sets by lightning or by overvoltages induced from power lines is still very common in rural areas. And there is the attendant risk of fire and danger to human life unless adequate protection is provided.

This, to be sure, is no new phenomenon. Damage to telephone plant by lightning has been known, and lightning protection in one form or another has existed, as long as the telephone itself. But experience has shown that the protection provided has not always been adequate. Modern protector apparatus has therefore been developed which provides a far better guarantee than hitherto of good telephone service and reduces damage from overvoltages to a minimum.

In the telephone set the main risk is breakdown of the insulation in a capacitor or springset, but trouble may occur also in the induction coil, receiver, bell etc. The cause of these faults is usually a potential difference *between* the two legs of the telephone line. When fire has broken out, it has generally been because of flashover between the instrument cord and, for instance, a radiator, which has set fire to a curtain or the like.

For the protection of telephone sets a *transversal overvoltage protector* has been designed. This consists of a combination of a gas discharge tube and a low pass filter (fig. 1). The low pass filter, which is connected between the gas discharge tube and the telephone set, protects the telephone apparatus against high frequency transient oscillations of high amplitude which may be set up when the overvoltage protector comes into operation. The gas discharge tube, a rare gas tube, ignites when the overvoltage between the line legs attains or exceeds the striking voltage level and short-circuits the line. As soon as the overvoltage has been eliminated, the rare gas tube is extinguished, the short-circuit is removed and the line is restored to use. The rare gas tube withstands several hundred striking operations at heavy overvoltage and therefore has a considerable working life. As will be seen from fig. 1, the transversal overvoltage protector is connected *across* the two legs of the line—hence its name.

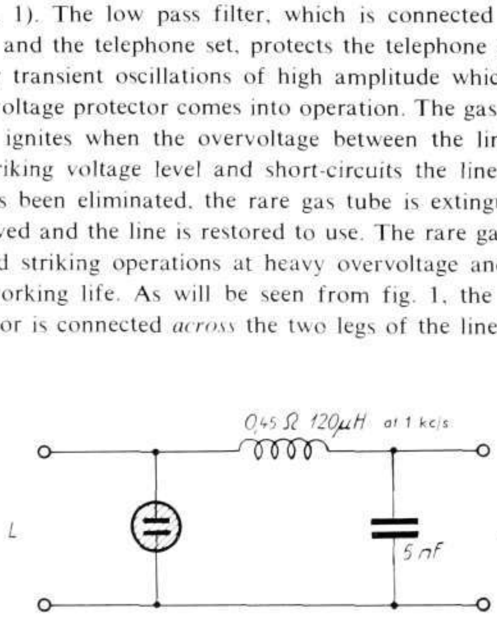



**Fig. 1** X 2742

**Circuit diagram of subscriber's overvoltage protector NFD 50101**

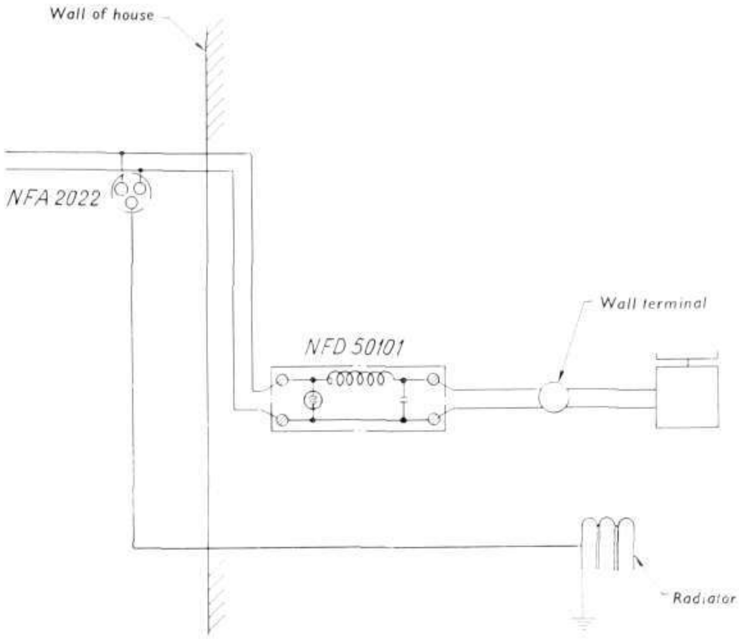
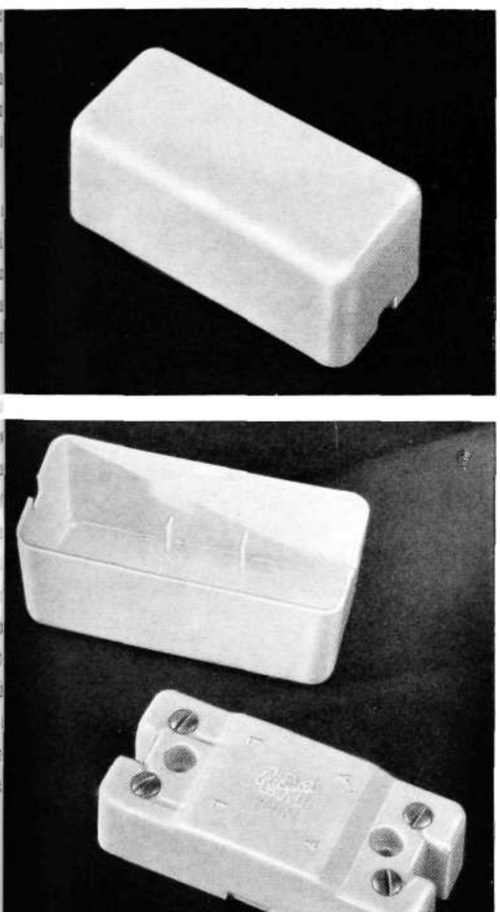



**Fig. 2** X 8445

**Circuit diagram of combination of heavy duty protector and transversal overvoltage protector**



X 2743
X 2744

**Fig. 3**

**Transversal overvoltage protector NFD 50101**

Especially when there are earthed objects such as a radiator, water pipe or power conductor in the immediate vicinity of the telephone set, the transversal overvoltage protector should be supplemented by a 3-pole heavy duty protector (fig. 2), placed out-of-doors, to protect the subscriber's installation against high longitudinal overvoltages between either or both legs of the line and earth. The heavy duty protector operates only at voltages of more than three thousand volts. Its earth electrode should be connected to the same point as other earthed objects through which discharge may take place.

## Transversal Overvoltage Protector NFD 50101

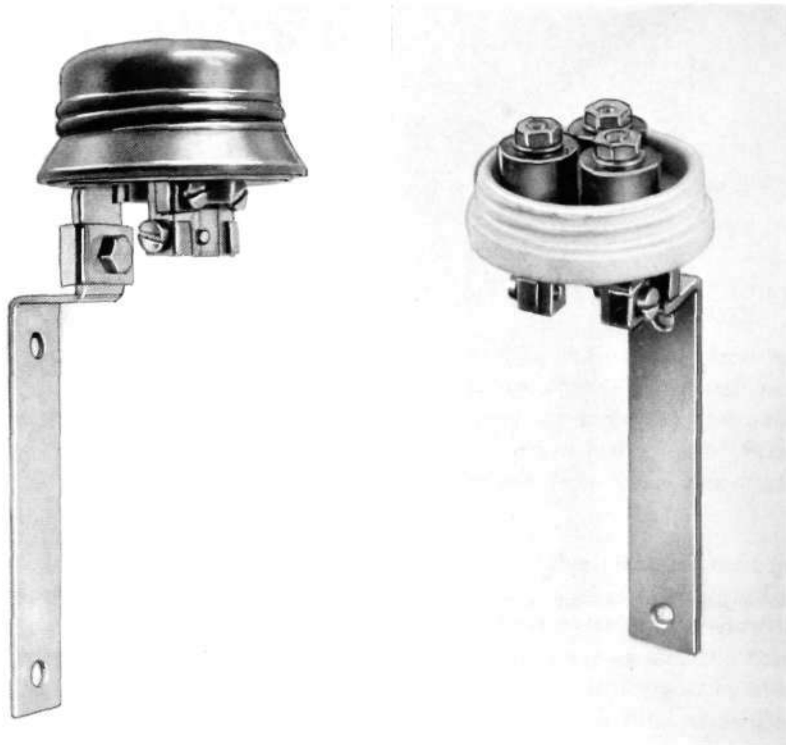
Fig. 3 shows a transversal overvoltage protector *NFD 50101*, the circuit diagram of which is shown in fig. 1. It consists of a block of ivory-white epoxy resin, 8.5 × 4 × 2.5 cm, in which the rare gas tube and the filter circuit elements are embedded. *NFD 50101* has two screw terminals marked 'L' for connection to the line and two marked 'A' for connection to the subscribers apparatus. The unit has a styrene dust-cover. It is fitted close to the telephone wall terminal and is connected between the latter and the line.

## Heavy Duty Protector NFA 2022

This longitudinal protector *NFA 2022* is shown in fig. 4. It consists essentially of three cylindrical electrodes separated by air gaps. The electrodes are made of a copper alloy which is especially resistant to high power flashover. Should the electrodes nevertheless be deformed by a heavy flashover, they can quickly be rendered operative again. They need merely be unscrewed and turned until new and effective spark gaps are formed between unburnt portions of their surfaces, and are then screwed tight again. If the flashover was so heavy as to weld the electrodes together, new electrodes can be inserted. All this can be done on site without needing to take down the protector from its mounting.

## High Protection—Low Maintenance Cost

As we have seen, subscribers may be exposed to the risk of serious disturbances or even personal injury from atmospheric or other overvoltages induced in their telephone sets. If transversal overvoltage protectors *NFD 50101*



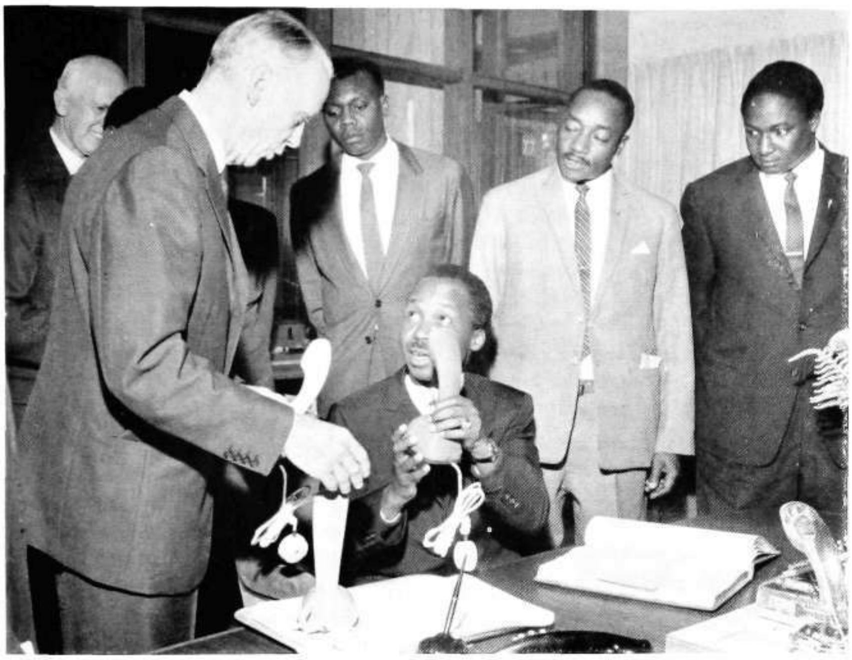
X 2745
X 2746

**Fig. 4**

**Heavy duty protector NFA 2022**
*right) with cover removed*

—supplemented, if necessary, by heavy duty protectors *NFA 2022*—are fitted at the subscribers' premises, the subscribers will be guaranteed the best possible protection against service failure and against danger to life and property. The maintenance costs of the telephone administration are also reduced. Rural subscribers are often remote from their telephone exchange or district maintenance service, and the cost of each service turn-out is high. If the telephone itself is damaged by lightning and, consequently, the fire brigade or other urgent assistance cannot be summoned in time, the effect may be catastrophic. The form of protection described can save much time and money. An investment of this kind is always warranted, and the question for the telephone administration, therefore, is generally not: "Can we afford this investment?"—but: "Can we afford to be without modern and efficient subscriber's protector units?"

# Ericsson LM NEWS *from* *All Quarters of the World*



## President Nyerere at L M Ericsson

Dr. Julius K. Nyerere, President of Tanganyika, made an official visit to Sweden in September, in the course of which he called on L M Ericsson at Midsommarkransen.

Mr. Sven T. Aberg bid the President and his suite—which included a Swede, Barbro Johansson, member of the Tanganyikan parliament—welcome to L M Ericsson. After a brief account of the Ericsson group and the development of telephony, the visitors were shown over the exhibition. At the conclusion of his visit the President was presented with three Ericofons in white, blue and red.

(Above) Mr. Aberg greeting President Nyerere on his arrival. (Left) The President tries out an Ericofon.

## African Monarch Visits L M Ericsson

King Mwambutsa IV of Burundi paid a call at L M Ericsson, Midsommarkransen, during his official visit to Sweden. Mr. Sven T. Aberg greeted the King on his arrival (photo, right) and, after a brief presentation of L M Ericsson's activities, the King and his suite were shown round the Exhibition Room. They also made a tour of the factory; the picture below shows Mr. Eric Lundqvist explaining a detail of the manufacture to the King. At the end of his visit the King was presented with an Ericofon.

# L M Ericsson Factory Opened at Visby

L M Ericsson's new factory at Visby on the island of Gotland was opened on June 28. The ceremony was presided over by the chairman of the county council, Martin Wahlbäck, in the presence of the entire staff and some 40 guests.

The Visby plant is the 19th of the group's Swedish factories outside the Stockholm area. It is a new example of the policy of decentralization pursued by the company for many years.

Its operations will include cable forming; wiring and testing of relay sets; winding, mounting and testing of relays, serial production of mechanical parts, enamelling and electroplating.

The Visby factory—45th of all Ericsson factories—covers more than 100 000 sq.ft. on one level. The area of the site is over 500 000 sq.ft.

In a speech at the opening ceremony, Mr. Hugo Lindberg—in thanking all those who had cooperated in the undertaking—stated that the establishment of a factory in Gotland had aroused some surprise since the island was earlier thought to be more or less "impossible" as an industrial location. But L M Ericsson has every reason to be satisfied with its choice, and the factory will be a valuable asset to the local community. With its 550 employees it will be Gotland's largest industry.

## Appointment to North Electric

Brigadier-General John A. Mc David joined L M Ericsson's subsidiary, North Electric Company, Galion, Ohio, on September 1 as assistant to the president.

Brigadier McDavid recently retired on pension from the United States Air Force, in which he had been Director for Communications-Electronics. He is therefore an extremely valuable asset to the North Electric organization in which he will be in charge of special missions, directly responsible to the president.

# Rural Automatization in Lebanon

Lebanon was declared an independent state in 1946 and has undergone a rapid development since that time. It possesses a particular importance as financial centre for the Middle East. It is not only its mountains that have earned it the reputation of being the Switzerland of the Middle East.

The rapidity of progress is well illustrated by the development of telecommunications. In 1950 Lebanon had about 13 300 telephones, all connected to manual exchanges. The first automatic exchange was opened in 1954, an Ericsson 500-selector exchange. Since 1950 the number of telephones has been more than quintupled, being 68 500 on January 1, 1962, of which 94.4 per cent automatic. Lebanon occupies a foremost position in telephony among Asiatic countries.

An extensive project of rural automatization is now under way. The project will comprise some 30 Ericsson ARK crossbar exchanges. At the same time the trunk network is being successively expanded, and in December 1963 it is expected that direct connections will be opened between Beirut and Tripoli.

**A new automatic exchange (2 000 lines AGF) has been opened at Zahlé. The Director General of the Lebanese P.T.T., M. Chemali, looks on while the Prime Minister, M. Karamé, cuts the symbolic tape, accompanied by the Minister of Communications, M. René Mouawad (behind the Prime Minister, right) and the Minister of Agriculture, M. Joseph Skaff (behind Prime Minister, left), and other prominent persons.**

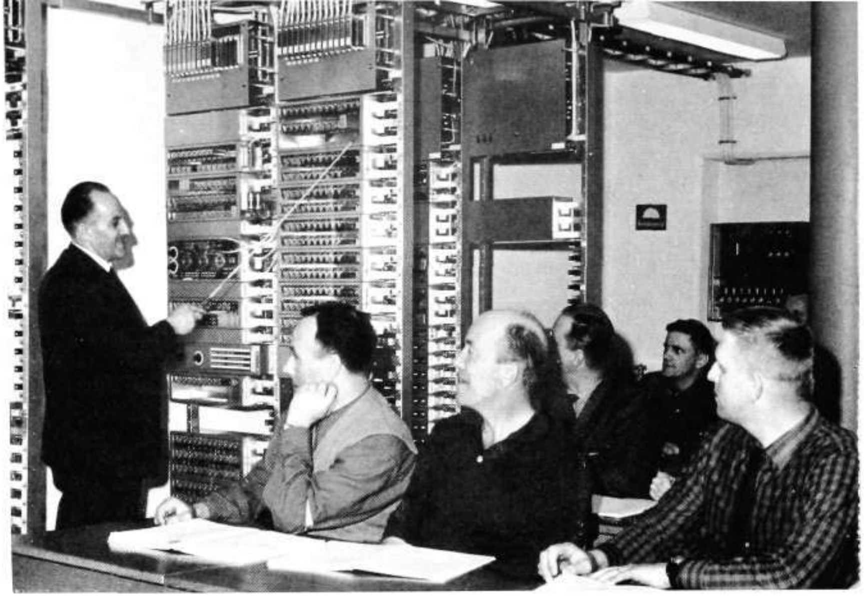
(Below) In conjunction with the opening of the Opera exchange Mr. Stein made a visit to UARTO's central archive for installation and maintenance documents. This archive is exemplary in its organization and Mr. Stein was greatly impressed with the meticulous order maintained in this important function.

# New Automatic Exchange Opened in United Arab Republic

Telecommunications in the United Arab Republic are in a state of rapid development. A further advance was made in July with the opening of a new 10 000-line Ericsson crossbar automatic exchange, Opera, in Cairo. The switchroom (above) is being inspected by H. E. the Minister of Communications, Dr. Mustafa Khalil, the Director General of UARTO, Dr. Mahmoud Mohamed Riad, and Mr. Arne Stein, L M Ericsson.

In August L M Ericsson received a visit from General Pachirn Nimibutr, head of Telephone Organization of Thailand, on a journey with his family to Sweden and other countries. General Nimibutr is seen above signing his name in the visitors' book.

Below are seen the Ethiopian Ambassador to Sweden, Mr. Abate Agede (centre), and Counsellor Assefa Temtim, who were given a glimpse into telephone history by Mr. E. Lundqvist during a visit to L M Ericsson's headquarters.



## Training in C. T. C.

The Swedish Railways have very extensive facilities for training their personnel. Training in signalling technique is given at the Signals School at Ängelholm, where entire interlocking plants have been installed and various types of signalling equipment have been got together.

The railway signalling course includes the remote control of signals by C.T.C. The training of personnel for C.T.C. maintenance was previously done at L M Ericssons Signalaktiebolag in Stockholm, but since 1963 the courses have been arranged at Ängelholm. The Swedish Railways have purchased from L M Ericsson a demonstration plant for teaching the methods of fault tracing and maintenance of C.T.C. equipment and also for instructing traffic and engineering personnel in C.T.C. operation.

(Left) Mr. Sigvard Nilsson of the Swedish Railways instructing a group of signal repairmen in C.T.C.

# Equipment for Long Distance Carrier Circuit in Brazil

After lengthy planning work by L M Ericsson and the Brazilian telephone company TELEOESTE, one of the longest open wire carrier circuits in the world has been opened between Campo Grande and São Paulo.


The carrier system is type ZAA 8 for eight telephone channels. Over a distance of nearly 500 miles the circuit runs on the only open-wire pair that exists between Campo Grande and Baurú. This line belongs to the railway and was built for telegraphy; it is an entirely untransposed 3.2 mm copper wire line with the wires spaced about 16 inches apart and follows the railway through the most desolate country.

From Baurú to São Paulo, Brazil's second city, a distance of some 220 miles, the circuit runs on open wires of very good quality belonging to Companhia Telefonica Brasileira (CTB).

The circuit is now being prolonged by the addition of a ZAAF 4 system for four telephone channels, also supplied by L M Ericsson. It is to be installed between Campo Grande and Corumba, about 300 miles, again on the railway's open wire line. With this latter section a direct connection will be obtainable from Brasilia via Rio de Janeiro and São Paulo to Corumba on the Bolivian border, a distance of almost 2 500 miles.

There have been many difficulties to overcome on the Baurú–Corumba section. No less than 115 filters had to be connected along the line to avoid disturbance of the railway telegraphy. Eight diesel generators were installed for the intermediate repeater stations.

Through precision in planning and installation the quality of the telephone channels has been brought up to international standard, which is a great advance on what would be expected with untransposed line of this type and over such distances.

**Mesbla is the name of the largest chain of department stores in Brazil, with branches in all important towns. L M Ericsson has delivered to the main store in Rio de Janeiro a 400-line crossbar P.A.X., system ARD 231. (Photo right).**

UDC 621.395.345
LME 83024

KOZIEN, F & BENOIT, R C JR.: *A United States Air Force Four-wire Electronic Switching Development*. Ericsson Rev. *40*(1963): 4, pp. 106—115.

The Central Offices, Telephone, Electronic AN/FTC-27-29 and AN/TTC-19 & 20 are high speed 4-wire circuit switching equipments which have been implemented by the United States Air Force for universal use in tactical and fixed plant environments. The design of the equipments is based on the Time-Division-Multiplex Technique and in association with the Highway Switching Principle to provide the switching and transmission network. They are fully transistorized and adaptable for application in local, tandem and long haul switching nodes. The equipments have been extensively factory and field tested with highly satisfactory results and presently are operational within an integrated system environment performing local and long haul tandem switching functions.

UDC 621.395.2
LME 8354

STEIMAR, G: *Crossbar P.A.X. for 16 and 30 Extensions*. Ericsson Rev. *40*(1963): 4, pp. 116—119.

The high reliability and speed of the crossbar switch has made it one of the most important components both in public and private telephone exchanges. L M Ericsson has used the crossbar switch in its 16 and 30 line P.A.X. ARD 624 and ARD 636, which are described in this article.

UDC 621.375:621.395
621.382.3
LME 84111

LARSSON, L E: *Transistorized Repeaters for Physical Circuits*. Ericsson Rev. *40*(1963): 4, pp. 120—125.

Different types of repeaters for physical circuits have been included in L M Ericsson's manufacturing program for a long time. The new repeater which has been developed differs from the earlier ones in that the units have been built up on printed wiring boards and the amplifiers have been transistorized. The layout of a bay with new repeaters has been adapted for use in loaded trunk lines in a network with subscriber trunk dialling. Repeaters for loaded trunk lines have been in use in the Swedish telecommunications network for a long time. The specifications for this repeater have therefore been worked out in intimate collaboration with the Swedish Board of Telecommunications. In addition, the repeater fulfills the recommendations of CCITT, where applicable.

UDC 621.3.054.3
LME 8414

FRENNING, J & RAUB, W: *Loading Equipment*. Ericsson Rev. *40*(1963): 4, pp. 126—133.

The development of improved soft magnetic ferrite material has provided an opportunity for a thorough redesign of loading equipment made by the L M Ericsson Telephone Company. The use of ferrite pot cores and new methods of manufacturing coil windings and coil sets has resulted in great savings in weight and volume of the loading equipment. The article contains a survey of the new designs and diagrams to assist in the design of loaded cables.

UDC 621.316.93
LME 7392

HENCKEL, A: *New Overvoltage Protectors for Subscribers' Installations*. Ericsson Rev. *40*(1963): 4, pp. 134—136.

The continued spread of the telephone into remote and isolated places has brought the question of the reliability and safety of line plant into new prominence. This factor, and the increased demands of subscribers for quick service in the repair of faults, has necessitated modern and efficient means of protection for subscribers' installations, which are described in this article.

# The Ericsson Group

## Associated and co-operating enterprises

• EUROPE •

**Denmark**
L M Ericsson A/S *København F*, Finsensvej 78, tel: Fa 6868, tgm: ericssons

Telefon Fabrik Automatic A/S *København K*, Amaliegade 7, tel: C 5188, tgm: automatic

Dansk Signal Industri A/S *København F*, Finsensvej 78, tel: Fa 6767, tgm: signaler

**Finland**
O/Y L M Ericsson A/B *Helsinki*, Fabianinkatu 6, tel: A8282, tgm: ericssons, telex: 57-12546

**France**
Société des Téléphones Ericsson *Colombes (Seine)*, Boulevard de la Finlande, tel: CHArlebourg 35-00, tgm: ericsson

*Paris 17e*, 147 Rue de Courcelles, tel: CARnot 95-30, tgm: eric

Ateliers Vaucanson, *Paris XX*, B. P. 28.20, tel: MENilmontant 83-40, tgm: atelcanson

**Great Britain**
Swedish Ericsson Company Ltd. *London, W. C. 1*, 329 High Holborn, tel: HOLborn 1092, tgm: teleric

Production Control (Ericsson) Ltd. *London, W. C. 1*, 329 High Holborn, tel: HOLborn 1092, tgm: productrol holb

**Italy**
SETEMER, Soc. per Az. *Roma*, Via G. Paisiello 43, tel: 868.854, 868.855, tgm: setemer

SIELTE, Soc. per Az. *Roma*, C. P. 4024 Appio, tel: 780221, tgm: sielte

FATME, Soc. per Az. *Roma*, C.P. 4025 Appio, tel: 780021, tgm: fatme

**Netherlands**
Ericsson Telefoon-Maatschappij N.V. *Rijen (N.Br.)*, tel: 01692-555, tgm: erictel, telex: 44-14354

*Voorburg-Den Haag*, 227 Koningin Julianalaan, tel: 81 45 01, tgm: erictel-haag, telex: 31109

**Norway**
A/S Elektrisk Bureau *Oslo NV*, P.B. 5055, tel: Centralbord 46 18 20, tgm: elektriken, telex: 56-1723

A/S Industrikontroll *Oslo 1*, Teatergaten 12, tel: Centralbord 335085, tgm: indtroll

A/S Norsk Kabelfabrik *Drammen*, P. B. 205, tel: 1285, tgm: kabel

A/S Norsk Signalindustri *Oslo*, Bygdø allé 12, tel: Centralbord 56 54 94, tgm: signalindustri

**Portugal**
Sociedade Ericsson de Portugal, Lda. *Lisboa*, 7, Rua Filipe Folque, tel: 57193, tgm: ericsson

**Spain**
Cia Española Ericsson, S. A. *Madrid 13*, Torre de Madrid 3er piso, oficina 9, Plaza de España, tel: 241 14 00, tgm: ericsson

**Sweden**
Telefonaktiebolaget L M Ericsson *Stockholm 32*, tel: 19 00 00, tgm: telefonbolaget, telex: 19910

AB Alpha *Sundbyberg*, tel: 282600, tgm: aktiealpha-stockholm

AB Ermi, *Karlskrona 1*, tel: 23010, tgm: ermibolag-karlskrona

AB Rifa *Bromma 11*, tel: 26 26 10, tgm: elrifa-stockholm

AB Svenska Elektronrör *Stockholm 20*, tel: 44 03 05, tgm: electronics

L M Ericssons Driftkontrollaktiebolag *Solna*, tel: 27 27 25, tgm: ericdata-stockholm

L M Ericssons Signalaktiebolag *Stockholm Sv*, tel: 68 07 00, tgm: signalbolaget

L M Ericssons Svenska Försäljningsaktiebolag *Stockholm 1*, Box 877, tel: 22 31 00, tgm: ellem

Mexikanska Telefonaktiebolaget Ericsson *Stockholm 32*, tel: 190000, tgm: mexikan

Sieverts Kabelverk AB *Sundbyberg*, tel: 282860, tgm: sieverts-fabrik-stockholm

Svenska Radioaktiebolaget *Stockholm 12*, Alströmergatan 14, tel: 22 31 40, tgm: svenskradio

**Switzerland**
Ericsson Telephone Sales Corp. AB, Stockholm, Zweigniederlassung Zürich *Zürich*, Postfach Zürich 32, tel: 325184, tgm: telericsson

**West Germany**
Ericsson Verkaufsgesellschaft m. b. H. *Düsseldorf*, Postfach 2925, tel: 844 61, tgm: erictel, telex: 41-8587979

• ASIA •

**India**
Ericsson Telephone Sales Corporation AB *New Delhi 1*, P.O.B. 669, reg.mail: 1/3 Asaf Ali Road (Delhi Estate Building), tel: 272312, tgm: inderic

*Calcutta*, P. O. B. 2324, tel: 45-4494, tgm: inderic

**Indonesia**
Ericsson Telephone Sales Corporation AB *Bandung*, Djalan Dago 151, tel: 8294, tgm: javeric

*Djakarta*, Djalan Gunung Sahari 26, tel: Kota 22255, tgm: javeric

**Lebanon**
Telefonaktiebolaget L M Ericsson, Technical Office *Beyrouth*, Rue du Parlement, Immeuble Bisharat, tel: 252627, tgm: ellem

**Turkey**
Ericsson Türk Ticaret Ltd. Şirketi *Ankara*, Rumeli Han, Ziya Gökalp Cad., tel: 23170, tgm: ellem

*Istanbul*, Istanbul Bürosu, Liman Han, Kat 5, No. 75, Bahçekapi, tel: 22 81 02, tgm: ellemist

• AF

**Egypt (UAR)**
Telefonaktiebolaget LM Ericsson, Egypt Branch *Cairo*, P. O. B. 2084, tel: 497 77, tgm: elleme

**Northern and Southern Rhodesia, Nyasaland**
LM Ericsson Telephone Co. (Pty.) Ltd. (Branch Office of LM Ericsson Telephone Co. Pty. Ltd. in Johannesburg) *Bulawayo, Southern Rhodesia*, P.O.B. 1974, tel: 64 704, tgm: ericsson

**South Africa, South-West Africa**
L M Ericsson Telephone Co. Pty. Ltd. *Johannesburg, Transvaal*, P. O. B. 2440, tel: 975-3615, tgm: ericofon

**Tunisia**
Telefonaktiebolaget LM Ericsson, Technical Office *Tunis*, Boite Postale 780, tel: 240520, tgm: ericsson

• AMERICA •

**Argentine**
Cía Ericsson S. A. C. I. *Buenos Aires*, Casilla de correo 3550, tel: 33 20 71, tgm: ericsson

Cía Argentina de Teléfonos S. A. *Buenos Aires*, Perú 263, tel: 30 50 11, tgm: catel

Cía Entrerriana de Teléfonos S. A. *Buenos Aires*, Perú 263, tel: 30 50 11, tgm: catel

Industrias Eléctricas de Quilmes S. A. *Quilmes FNGR*, 12 de Octubre 1090, tel: 203-2775, tgm: indelqui-buenosaires

**Brazil**
Ericsson do Brasil Comércio e Indústria S. A. *Rio de Janeiro*, C. P. 3601, tel: 43-0990, tgm: ericsson, telex: Rio 155

**Canada**
LM Ericsson Ltd. *Montreal 9, P.Q.*, 2300 Laurentian Boulevard, City of St. Laurent, tel: 331—3310, tgm: caneric, telex: 1-2307

**Chile**
Cía Ericsson de Chile, S. A. *Santiago*, Casilla 10143, tel: 825 55, tgm: ericsson-santiagodechile

tgm: ericsson

**Ecuador**
Teléfonos Ericsson C. A. *Quito*, Casilla 2138, tel: 16100, tgm: ericsson

*Guayaquil*, Casilla 376, tel: 16892, tgm: ericsson

**Mexico**
Teléfonos Ericsson S. A. *México D.F.*, Apartado 9958, tel: 464640, tgm: coeric

Industria de Telecomunicación S.A. de C.V. *México 6, D.F.*, Londres No. 47, tel: 250405, tgm: industel

**Peru**
Cía Ericsson S. A. *Lima*, Apartado 2982, tel: 34941, tgm: ericsson

Soc. Telefónica del Perú, S. A. *Arequipa*, Apartado 112, tel: 6060, tgm: telefonica

**Uruguay**
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**USA**
The Ericsson Corporation *New York 17, N. Y.*, 100 Park Avenue, tel: Murray Hill 5-4030, tgm: erictel, telex: NY 224135

North Electric Co. *Galion, Ohio*, P. O. B. 417, tel: Howard 8-2420, tgm: northphone-galionohio, telex: 586-U

**Venezuela**
Cía Anónima Ericsson *Caracas*, Apartado 3548, tel: 543121, tgm: ericsson

Teléfonos Ericsson C. A. *Caracas*, Apartado 3548, tel: 543121, tgm: tevela

• AUSTRALIA & OCEANIA •

**Australia**
L M Ericsson Pty. Ltd. *Melbourne C 1 (Victoria)*, 20 Collins Street, tel: 63 5646, tgm: ericmel

*North Sydney (NSW)*, 182 Blue's Point Road, tel: 92—1147, tgm: ericsyd

Teleric Pty. Ltd. *Melbourne C 1 (Victoria)*, 20 Collins Street, tel: 63 5646, tgm: teleric

*North Sydney (NSW)*, 182 Blue's Point Road, tel: 92—1147, tgm: teleric

## Agencies

• EUROPE •

**Belgium**
Electricité et Mécanique Suédoises *Bruxelles 5*, 56 Rue de Stassart, tel: 111416, tgm: electrosuede

**Greece**
"ETEP" S. A. Commerciale & Technique *Athens 143*, 57, Akadimias Street, tel: 62 99 71-75, tgm: aeter-athinai

**Iceland**
Johan Rönning H/F *Reykjavik*, P. O. B. 45, tel: 10632 tgm: rönning

**Ireland**
Communication Systems Ltd. *Dublin 4*, 138 Pembroke Road, Ballsbridge, tel: 680787 tgm: crossbar

**Yugoslavia**
Merkantile Inozemna Zastupstva *Zagreb*, Pošt pretinać 23, tel: 36941, tgm: merkantile, telex: 02-139

• ASIA •

**Burma**
Burma Asiatic Co. Ltd., Ericsson Department *Rangoon*, P.O.B. 1008, tel: 10999, tgm: ericsson

**Cambodia**
The East Asiatic Company Ltd. *Phnom-penh*, P.O.B. 129, tel: 762-1070-1071, tgm: pyramide

**Ceylon**
Vulcan Trading Co. (Private) Ltd. *Colombo 1*, New Caffoor Building, 40, Church Street, tel: 36-36, tgm: vultra

**Cyprus**
Zeno D. Pierides *Larnaca*, P.O.B. 25, tel: 2033, tgm: pierides

**Hong Kong**
The Swedish Trading Co. Ltd. *Hongkong*, P. O. B. 108, tel: 35521-5, tgm: swedetrade

**Iran**
Irano Swedish Company AB. *Teheran*, Khiabane Sevom Esfand 28, tel: 367 61, tgm: iranoswede

**Iraq**
Usam Sharif Company W.L.L. *Baghdad*, Sinak-Rashid Street, tel: 870 31, tgm: alhamra

**Japan**
Gadelius & Co. Ltd. *Tokyo C*, P. O. B. 1284, tel: 408-2131, tgm: goticus, telex: 22-675

**Jordan**
The Arab Trading & Development Co., Ltd. *Amman*, P. O. B. 1, tel: 25 981, tgm: aradeve

**Korea**
Gadelius & Co. Ltd. *Seoul*, I. P. O. Box 1421, tel: 2—9866, tgm: gadeliusco

**Kuwait**
Latiff Supplies Ltd. *Kuwait*, P. O. B. 67, tel: 2404, tgm: latisup

**Lebanon**
Swedish Levant Trading (Elie B. Hélou) *Beyrouth*, P. O. B. 931, tel: 231624, tgm: skefko

**Malaysia**
The Swedish Trading Co. Ltd. *Singapore 1*, 42 Chartered Bank Chambers, Battery Road, tel: 94362, tgm: swedetrade

**Pakistan**
Vulcan Industries Ltd. *Karachi City*, West Pakistan, P. O. B. 4776, tel: 325 06, tgm: vulcan

**Philippines**
U.S. Industries Philippines Inc. *Manila P. R.*, P. O. B. 125, tel: 8893 51, tgm: usiphil

**Saudi Arabia**
Mohamed Fazil Abdulla Arab *Jeddah*, P. O. B. 39, tel: 2690, tgm: arab

**Syria**
Georgiades, Moussa & Cie *Damas*, Rue Ghassan, Harika, tel: 1-02-89, tgm: georgiades

**Thailand**
Ericsson Agency Office, Telephone Organization of Thailand *Bangkok*, Ploenchitr Road, tel: 57036-38, tgm: telthai

**Vietnam**
Vo Tuyen Dien-Thoai Viet-Nam, *Saigon*, 34 Dai-lo Thong-Nhut, tel: 20805, tgm: telerad

• AFRICA •

**Ethiopia**
Swedish Ethiopian Company *Addis Ababa*, P. O. B. 264, tel: 11447, tgm: etiocomp

**Ghana**
The Standard Electric Company *Accra*, P.O.B. 17, tel: 627 85, tgm: standard

**Kenya, Tanganyika, Uganda, Zanzibar**
Transcandia Ltd. *Nairobi, Kenya*, P. O. B. 5933, tel: 219 31, tgm: transcanda

**Liberia**
Swedish Agencies Liberia Co. *Monrovia*, P.O.B. 506, tel: 745, tgm: salco (Except sales to public institutions)

**Libya**
The Gulf Trading Co. *Tripoli*, P.O.B. 417, tel: 5715, tgm: gultraco

**Mauritius**
Mauritius Trading Co. Ltd. *Port Louis*, P.O.B. 201, tgm: agentou

**Morocco**
Elmar S. A. — SEYRE *Tangier*, Francisco Vitoria, 4, tel: 122-20, tgm: elmar

**Mozambique**
J. Martins Marques *Lourenço Marques*, P. O. B. 456, tel: 5953, tgm: tinsmarques

**Nigeria**
I.P.T.C. (West Africa) Ltd. *Lagos*, P.O.B. 2037, tel: 26531, tgm: consult

**Sudan**
TECOMA Technical Consulting and Machinery Co. Ltd. *Khartoum*, P.O.B. 866, tel: 2224, ext. 35, tgm: sutecoma

• AMERICA •

**Bolivia**
Johansson & Cía, S. A. *La Paz*, Casilla 678, tel: 2700, tgm: johansson

**Costa Rica**
Tropical Commission Co. Ltd. *San José*, Apartado 661, tel: 3432, tgm: troco

**Curaçao N. W. I.**
S. E. L. Maduro & Sons, Inc. *Curaçao*, P. O. B. 172, tel: 1200, tgm: madurosons-willemstad

**Dominican Republic**
Garcia & Gautier, C. por A. *Santo Domingo*, Apartado 771, tel: 3645, tgm: gartier

**Guatemala**
Nils Pira *Ciudad de Guatemala*, Apartado 36, tel: 62258, tgm: nilspira-guatemala

**Honduras**
Quinchón León y Cía *Tegucigalpa*, Apartado 85, tel: 1229, tgm: quinchon

**Jam**

Morr

354,

**Nicaragua**
Edmundo Tefel *Managua, D.N.*, Apartado Postal 24, tel: 3401, tgm: edfelco

**Panama**
Sonitel, S. A. *Panama, R. de P.*, Apartado 4349, tel. 5-3640, tgm: sonitel

**Paraguay**
S. A. Comercial e Industrial H. Petersen *Asunción*, Casilla 592, tel: 9868, tgm: pargtrade

**Puerto Rico**
Splendid Inc. *San Juan*, P. O. B. 4568, tel: 3-4095, tgm: splendid

**El Salvador**
Dada-Dada & Co. *San Salvador*, Apartado 274, tel: 4860, tgm: dada

**Surinam**
C. Kersten & Co. N. V. *Paramaribo*, P. O. B. 1808, tel: 4444, tgm: kersten

**Trinidad, W. I.**
Leon J Aché Ltd. *Port-of-Spain*, 100 Frederick Street, tel: 32357 tgm: achegram

**USA**
Clark Walter Corporation *Newark 2, N. J.*, 744 Broad Street, tel: Mitchell 3-7333, tgm: wirewalter-newarknj. (For intercom)

State Labs. Inc. *New York 3, N. Y.*, 215 Park Avenue South, tel: Oregon 7-8400, tgm: statelabs (For electron tubes)

• AUSTRALIA & OCEANIA •

**New Zealand**

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614,

Esselte, Sthlm 63